3.4.3 Number of research papers published per teacher in the Journals as notified on UGC CARE list during the last five years											
	Title of paper	**Name of the author/s**	**Department of the teacher**	**Name of journal**	**Year of publication**	**ISSN number**	**Link to the recognition in UGC enlistment of the Journal**				
Sl. No.							**Link to website of the Journal**	**Link to article/paper/abstract of the article**	**Is it listed in UGC Care list**	**Scopus**	**Web of Science**
1	The characteristic length scales in direct mode of drop formation from the edges of spinning discs with different surface wetting characteristics	Dr K Sahoo	Chemical Engg.	Chemical Engineering Science	2021		Chemical Engineering S	https://doi.org/10.1016/j.ces.2022.118068		Scopus	**Web of Science**
2	Analysis of Iron Ore Pellets properties Concerning Raw Material Mineralogy for Effective Utilization of Mining Waste	Mr K Barik	Chemical Engg.	Powder Technology	2021		Powder Technology | Journal | ScienceDirect.com by Elsevier	https://doi.org/10.1016/j.powtec.2022.117259		**Scopus**	**Web of Science**
3	Atomization characteristics of a spinning disc in direct drop mode	Dr Chandra Nayak	Chemical Engg.	Industrial & Engineering Chemistry Research	2021		Industrial & Engineering Chemistry Research Journal - ACS Publications	https://doi.org/10.1021/acs.iecr.1c02172		**Scopus**	
4	Dried ridge gourd: an excellent source for ecofriendly activated carbon	Mr K Barik	Chemical Engg.	Indian Journal of Chemical Technology	2021		Indian Journal of Chem	http://nopr.niscair.res.in/handle/123456789/57455		**Scopus**	
5	Dynamics of drop release from the edge of a spinning disc	Dr K Sahoo	Chemical Engg.	Industrial & Engineering Chemistry Research	2021		Industrial & Engineering Chemistry Research Journal - ACS Publications	https://doi.org/10.1021/acs.iecr.1c02172			
6	Effect of superficial gas velocity and ratio of bed volume to reactor volume of inverse fluidized bed biofilm reactor on the removal of ammonia-nitrogen from wastewater	Dr Anup Kumar Swain	Chemical Engg.	Indian Journal of Chemical Technology	2021	0975-0991	op.niscair.res.in			**Scopus**	
7	Experimental Design of Solid Particle Wear Behavior of Ni-Based Composite Coatings	Dr H Sutar , R. Murmu	Chemical Engg.	Journal of Composites Science	2021		Journal of Composites Science | An Open Access Journal from MDPI	https://doi.org/10.3390/jcs5050133		**Scopus**	
8	Experimental Design of Solid Particle Wear Behavior of Ni-Based Composite Coatings	Dr H Sutar , R. Murmu	Chemical Engg.	Journal of Composites Science	2021		Journal of Composites Science | An Open Access Journal from MDPI	https://doi.org/10.3390/jcs5050133		**Scopus**	
9	Graphene, Graphene-Derivatives and Composites: Fundamentals, Synthesis Approaches to Applications.	Dr H Sutar , R. Murmu	Chemical Engg.	Journal of Composites Science	2021		Journal of Composites Science | An Open Access Journal from MDPI	https://doi.org/10.3390/jcs5070181		**Scopus**	
10	Graphene, Graphene-Derivatives and Composites: Fundamentals, Synthesis Approaches to Applications.	Dr H Sutar , R. Murmu	Chemical Engg.	Journal of Composites Science	2021		Journal of Composites Science | An Open Access Journal from MDPI	https://doi.org/10.3390/jcs5070181		**Scopus**	

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	Title of paper	**Name of the author/s**	**Department of the teacher**	**Name of journal**	**Year of publication**	**ISSN number**	**Link to the recognition in UGC enlistment of the Journal**					
11	Green synthesized Ag-TiO2 for degradation of organic dye through visible light driven photo-rector and its kinetics	Dr S Banerjee	Chemical Engg.	Int. J. Chem. React. Eng.	2021		http://www.bepress	DOI:10.1515/ijcre-2021-0111		**Scopus**	
12	Investigation on Loss on Ignition to Study the Effect of Iron Ore Mineralogy in Green Pellet Growth Kinetics	Mr K Barik	Chemical Engg.	IIM Transactions of The Indian Institute of Metals	2021		Home | Transactions o	https://doi.org/10.1007/s12666-021-02449-6		**Scopus**	**Web of Science**
13	Mechanical, Thermal, and Morphological Properties of Graphene Nanoplatelet-Reinforced Polypropylene Nanocomposites: Effects of Nanofiller Thickness	Dr H Sutar , R. Murmu	Chemical Engg.	Journal of Composites Science	2021		ttps://www.mdpi.com/	https://doi.org/10.3390/jcs5010024		**Scopus**	
14	Mechanical, Thermal, and Morphological Properties of Graphene Nanoplatelet-Reinforced Polypropylene Nanocomposites: Effects of Nanofiller Thickness	Dr H Sutar , R. Murmu	Chemical Engg.	Journal of Composites Science	2021		ttps://www.mdpi.com/	https://doi.org/10.3390/jcs5010024		**Scopus**	
15	Preparation and characterization of the SPEEK/PVA/Silica hybrid membrane for direct methanol fuel cell (DMFC)	Dr H Sutar , R. Murmu	Chemical Engg.	Polymer Bulletin	2021		Home | Polymer Bullet	https://doi.org/10.1007/s00289-021-03602-3		**Scopus**	**Web of Science**
16	Preparation and characterization of the SPEEK/PVA/Silica hybrid membrane for direct methanol fuel cell (DMFC)	Dr H Sutar , R. Murmu	Chemical Engg.	Polymer Bulletin	2021		Home | Polymer Bullet	https://doi.org/10.1007/s00289-021-03602-3		**Scopus**	**Web of Science**
17	Effect of Annealing Temperature on Copper-Doped Nickel Oxide Nanomaterials for Efficient Degradation of Methylene Blue Under Solar Irradiation	Debakanta Tripathy, Binod Bihari Panda, Niladri Maity	Chemistry	Journal of Electronic Materials	2021	0361-5235	Home | Journal of Elec	DOI https://doi.org/10.1007/s11664-022-09591-x		**Scopus**	**Web of Science**
18	Electrodeposited mixed ZnS–CdS photoelectrode for natural dye-sensitized solar cells (NDSSC)	Binod Bihari Panda, P. K. Mahapatra, M. K. Ghosh	Chemistry	Indian Journal of Physics	2021	0973-1458	Home | Indian Journal	DOI https://doi.org/10.1007/s12648-020-01902-4		**Scopus**	**Web of Science**
19	Synthesis, characterization and molecular docking study of Nitro(4′-(2-pyridyl)-2,2′:6′, 2″-terpyridyl) Palladium(II) nitrate	DebakantaTripathy, Amlan K.Pal, Soumya LipsaRath, Garry S. Hanan, Binod B.Panda, Dillip K.Chand	Chemistry	Inorganic Chemistry Communications	2021	1387-7003.	Inorganic Chemistry Co	http://dx.doi.org/10.1016/j.inoche.2021.108494		**Scopus**	**Web of Science**
20	Durability properties of concrete with silica fume and rice husk ash	SmitaSahoo, Pravat KumarParhi, BikashChandra Panda	CIVIL	Cleaner Engineering and Technology	2021	2666-7908	Cleaner Engineering and Technology | Journal | ScienceDirect.com by Elsevier	https://doi.org/10.1016/j.clet.2021.100067		Scopus	Web of science
21	Performance Analysis of Offshore Riser System	RAMBABU NIMMA	CIVIL	International Research Journal of Engineering and Technology (IRJET)	2021	ISSN 2278-3075	https://www.irjet.net/	https://www.irjet.net/archives/V8/i4/IRJET-V8I493.pdf		Scopus	
22	A Machine Intelligence Based Model for the Classification of Odia Printed and Handwritten Images	Sahu, A., Mishra, S., & Jena, K. K.	CSE	Elementary Education Online,	2021	20(5), 3733-3744.(Scopus, UGC)	Elementary Education (	doi: 10.17051/ilkonline.2021.05.410	UGC Care	Scopus	

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	Title of paper	**Name of the author/s**	**Department of the teacher**	**Name of journal**	**Year of publication**	**ISSN number**	**Link to the recognition in UGC enlistment of the Journal**				
23	A Machine Intelligence Based Model for the Classification of Odia Printed and Handwritten Images	Sahu, A., Mishra, S., & Jena, K. K.	CSE	Elementary Education Online,	2021	20(5), 3733-3744.(Scopus, UGC)	Elementary Education (	doi: 10.17051/ilkonline.2021.05.410	UGC Care	Scopus	
24	A Comprehensive Examination of Bandgap Semiconductor Switches	S Siva Subramanian, R Saravanakumar, Bibhu Prasad Ganthia, S Kaliappan, Surafel Mustefa Beyan, Maitri Mallick, Monalisa Mohanty, G Pavithra	EE	Advances in Materials Science and Engineering, Hindawi	2021	Article ID 318850	https://www.proquest.com/	https://doi.org/10.1155/2021/3188506		Scopus	
25	A novel application of ALO-based fractional order fuzzy PID controller for AGC of power system with diverse sources of generation	Nimai Charan Patel, Binod Kumar Sahu, Durgesh Prasad Bagarty, Pranati Das, Manoj Kumar Debnath	EE	The International Journal of Electrical Engineering & Education	2021	2050-4578	https://journals.sagepub.com/	https://doi.org/10.1177/0020720919829710		Scopus	
26	A Real Time Implementation of ANN Controller to Track Maximum Power Point in Solar Photovoltaic System	K Thenmalar, K Kiruba, Praveen Raj, Bibhu Prasad Ganthia	EE	Annals of the Romanian Society for Cell Biology	2021		Annals of the Romanian Society for Cell Biology (annalsofrscb.ro)	ttps://annalsofrscb.ro/index.php/journal/article/view/7465		Scopus	
27	Ann Based Speed Control of Brush less DC Motor Using DC DC Converter	M Sivaramkrishnan, M Veerasundaram, Lizi Joseph, Bibhu Prasad Ganthia, M Anand	EE	Design Engineering	2021		thedesignengineering.com	http://thedesignengineering.com/index.php/DE/article/view/1901		Scopus	
28	Bridgeless Ac/Dc Converter & Dc-Dc Based Power Factor Correction with Reduced Total Harmonic Distortion	N Praneeth, Bibhu Prasad Ganthia, Makarand Upadhyaya	EE	Design Engineering	2021		thedesignengineering.com	http://thedesignengineering.com/index.php/DE/article/view/1902		Scopus	
29	Explicit model predictive controller for power control of molten salt breeder reactor core	Subrat Kumar Pradhan, Dushmanta Kumar Das	EE	Nuclear Engineering and Design	2021	1872-759X	Nuclear Engineering and Design | Journal | ScienceDirect.com by Elsevier	10.1016/j.nucengdes.2021.111492		Scopus	**Web of Science**
30	Grid Tied PV with Reduced THD Using NN and PWM Techniques	Praveen Mannam, YV Siva Reddy, Saritha Manchireddy, Bibhu Prasad Ganthia	EE	Design Engineering	2021		thedesignengineering.com	http://thedesignengineering.com/index.php/DE/article/view/1903		Scopus	
31	H∞ Load Frequency Control Design Based on Delay Discretization Approach for Interconnected Power Systems with Time Delay	Subrat Kumar Pradhan, Dushmanta Kumar Das	EE	Journal of Modern Power Systems and Clean Energy	2021	2196-5420	IEEE Xplore: Journal of Modern Power Systems and Clean Energy	10.35833/MPCE.2019.000206		Scopus	**Web of Science**
32	H∞ Performance-Based Sliding Mode Control Approach for Load Frequency Control of Interconnected Power System with Time Delay	Subrat Kumar Pradhan, Dushmanta Kumar Das	EE	Arabian Journal for Science and Engineering	2021	2193-567X	Home | Arabian Journal for Science and Engineering (springer.com)	10.1007/s13369-020-05178-y		Scopus	
33	Hardware in Loop (THIL 402) Validated Type-I Fuzzy Logic Control of Type-III Wind Turbine System under Transient	Bibhu Prasad Ganthia, Subrat Kumar Barik, Byamakesh Nayak	EE	Journal of Electrical Systems, Engineering and Scientific Research Groups (ESRGroups)	2021		https://journal.esrgroups.org/	https://journal.esrgroups.org/jes/papers/17_1_3		Scopus	

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34	Low voltage ride through capability enhancement using series connected fact devices in wind energy conversion system	Bibhu Prasad Ganthia, Subrat Kumar Barik, Byamakesh Nayak	EE	Journal of Engineering Science and Technology, Taylor University	2021		Journal of Engineering Science and Technology (JESTEC) (taylors.edu.my)	FORMAT INSTRUCTIONS FOR SOMChE 2004 PAPERS (taylors.edu.my)		Scopus	Web of Science
35	Matlab/Simulink Based THD Reduction Using Active Power Filters	PV Ashwathy Devraj, S Siva Subramanian, Udayakumar Durairaj, Bibhu Prasad Ganthia, Makarand Upadhyaya	EE	Design Engineering	2021		thedesignengineering.com	http://thedesignengineering.com/index.php/DE/article/view/1900		Scopus	
36	Research on frequency parameter detection of frequency shifted track circuit based on nonlinear algorithm	Hui Xie, Yatao Wang, Zhiliang Gao, Bibhu Prasad Ganthia, Chinh V Truong	EE	Nonlinear Engineering, De Gruyter	2021		https://www.degruyter.com/	https://doi.org/10.1515/nleng-2021-0050		Scopus	Web of Science
37	Predictive Analysis for Cancer and Diabetes Using Simplex Method Based Social Spider Optimization Algorithm	Monalisa Nayak , Soumya Das , Urmila Bhanja , Manas Ranjan Senapati	ETC	IETE Journal of Researc	2021		IETE Journal of Researc	https://doi.org/10.1080/03772063.2022.2027276			**Web of Science**
38	Predictive Analysis for Cancer and Diabetes Using Simplex Method Based Social Spider Optimization Algorithm	Monalisa Nayak , Soumya Das , Urmila Bhanja , Manas Ranjan Senapati	ETC	IETE Journal of Researc	2021		IETE Journal of Researc	https://doi.org/10.1080/03772063.2022.2027276			**Web of Science**
39	Ambiguity Function Analysis for Orthogonal-LFM Waveform Based Multistatic Radar	Dillip Dash J. Valarmathi	ETC	IEEE Sensor Letters	2021	2475-1472	IEEE Xplore: IEEE Sensc	https://doi.org/10.1109/LSENS.2021.3129081		Scopus	Web of Science
40	Design and Analysis of Complex Data Security Algorithm Using Cryptography and Steganography Techniques	Paresh Kumar Pasayat, Soumya Ranjan Panigrahi, Chandan Kumar Padhy, Manaswini Mishra, Trupti Mishra, Ajay Kumar Manadhata	ETC	International Journal of Innovative Research in Computer and Communication Engineering	2021	e-ISSN: 2320-9801, p-ISSN: 2320-9798	::International Journal of Innovative Research in Computer and Communication Engineering:: (ijircce.com)	https://ssrn.com/abstract=4245367	UGC Care		
41	High selectivity and sharp roll-off filtenna array for Ku-band application	Soumya Ranjan Mishra, Bikash Chandra Sahoo & Sheeja K L	ETC	International Journal of Electronics	2021	1362-3060	International Journal o	https://doi.org/10.1080/00207217.2021.1941290		Scopus	
42	High selectivity and sharp roll-off filtenna array for Ku-band application	Soumya Ranjan Mishra, Bikash Chandra Sahoo & Sheeja K L	ETC	International Journal of Electronics	2021	1362-3060	International Journal o	https://doi.org/10.1080/00207217.2021.1941290		Scopus	
43	ISS criterion for Lipschitz nonlinear interfered fixed-point digital filters with saturation overflow arithmetic	J Rout and H. Kar	ETC	Circuits Systems and Signal Processing	2021	NA	Home | Circuits, Syster	https://doi.org/10.1007/s00034-021-01823-5		Scopus	Web of Science
44	Metamaterial inspired pin wheel fractal shaped antenna using parasitic split ring resonator for modern wireless applications	Ashish Kumar, Bikash Chandra Sahoo, Gurmeet Singh	ETC	International Journal of Electronics and Communications	2021	2798-2610	AEU - International Journal of Electronics and Communications | ScienceDirect.com by Elsevier	https://doi.org/10.1016/j.aeue.2021.153931		Scopus	Web of Science
45	Effect of second order slip and heat source on dissipative MHD flow of blood through a permeable capilary in stretching motion	M.M.BISWAL,B.K. SWAIN & G.C.DASH	Mathematics	International Journal of Ambient Energy	2021		International Journal o	https://doi.org/10.1080/01430750.2021.1979649		Scopus	

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	Title of paper	**Name of the author/s**	**Department of the teacher**	**Name of journal**	**Year of publication**	**ISSN number**	**Link to the recognition in UGC enlistment of the Journal**				
46	EOQ model for cubic deteriorting items carry forward with weibull demand and without shortages.	Chandan Ku. Sahoo, Kailash Ch. Paul	Mathematics	IJREI	2021		International Journal o	https://doi.org/10.36037/IJREI.2021.5510		Scopus	
47	Heat and mass transfer in MHD stagnation-point flow toward an inclined stretching sheet embedded in a porous medium.	M.M.BISWAL,B.K. SWAIN,M. DAS & G.C. DASH	Mathematics	Heat transfer	2021		Heat Transfer - Wiley O	https://doi.org/10.1002/htj.22525		Scopus	
48	Mass transfer effect on viscous dissipative MHD flow of nano fluid over a stretching sheet embdded in a porous medium	Bikash Ch. Parida, Bharat Keshari Swain, Nityananda Senapati	Mathematics	JNAME	2021		Bangladesh Journals O	https://doi.org/10.3329/jname.v18i1.53380		Scopus	
49	Design and fabrication of a solar portable refrigerator	Sabyasachi Aich, Jayashree Nayak	Mechanical	Materials Today: Proceedings	2021		Materials Today: Proceedings | Journal | ScienceDirect.com by Elsevier	https://doi.org/10.1016/j.matpr.2020.08.442		Scopus	Web of Science
50	Design and fabrication of a solar portable refrigerator	Sabyasachi Aich , Jayashree Nayak	Mechanical	Material Today proceedings	2021		Materials Today: Proceedings | Journal | ScienceDirect.com by Elsevier	https://doi.org/10.1016/j.matpr.2020.08.442		Scopus	Web of Science
51	Humanoid NAO: A Kinematic Encounter	Sahu, C., Parhi, D. R., Kumar, P. B., Muni, M. K., Chhotray, A., & Pandey, K. K	Mechanical	Robotica	2021		Robotica | Cambridge (	DOI: https://doi.org/10.1017/S0263574721000096		Scopus	
52	Hybrid IWD-GA: an approach for path optimization and control of multiple mobile robot in obscure static and dynamic environments	Kumar, S., Parhi, D. R., Pandey, K. K., & Muni, M. K.	Mechanical	Robotica	2021		Robotica | Cambridge (	DOI: https://doi.org/10.1017/S0263574721000114		Scopus	
53	Navigation of a wheeled mobile robotic agent using modified grey wolf optimization controller	Paital, C., Kumar, S., Muni, M. K., Parhi, D. R., & Dhal, P. R.	Mechanical	International Journal of Intelligent Unmanned Systems.	2021		International Journal of Intelligent Unmanned Systems | Emerald Insight	10.1108/IJIUS-06-2020-0023		Scopus	
54	Navigation of a wheeled mobile robotic agent using modified grey wolf optimization controller	Paital, C., Kumar, S., Muni, M. K., Parhi, D. R., & Dhal, P. R.	Mechanical	International Journal of Intelligent Unmanned Systems.	2021		International Journal of Intelligent Unmanned Systems | Emerald Insight	10.1108/IJIUS-06-2020-0023		Scopus	
55	On Crack Detection in a Laminated Glass/Epoxy Composite Beam under Free Vibration with Fuzzy Logic Aid	Das, P., Muni, M. K., & Sahu, S. K.	Mechanical	International Journal of Structural Stability and Dynamics	2021		International Journal o	https://doi.org/10.1142/S0219455421501765		Scopus	
56	Soil stabolization by industrial waste (GGBS and stone dust)	C K Behera, S Senapati	Mechanical	Intewrnational journal of engineering research & technology	2021	2278-0181	IJERT – International Journal of Engineering Research & Technology	**10.17577/IJERTV10IS090154**		Scopus	
57	Static and dynamic path optimization of multiple mobile robot using hybridized fuzzy logic-whale optimization algorithm.	Kumar, S., Parhi, D. R., Kashyap, A. K., & Muni, M. K	Mechanical	Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science	2021		Proceedings of the Inst	DOI: https://doi.org/10.1177/0954406220982641		Scopus	

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	Title of paper	**Name of the author/s**	**Department of the teacher**	**Name of journal**	**Year of publication**	**ISSN number**	**Link to the recognition in UGC enlistment of the Journal**				
58	Water cycle algorithm: an approach for improvement of navigational strategy of multiple humanoid robots	Muni, M. K., Kumar, S., Parhi, D. R., & Pandey, K. K.	Mechanical	Robotica	2021		Cleaner Engineering and Technology | Journal | ScienceDirect.com by Elsevier	DOI: https://doi.org/10.1017/S0263574721000837		**Scopus**	**Web of Science**
59	Enhanced biodegradation of total petroleum hydrocarbons by implementing a novel two steps bioaugmentation Strategy indigenous bacterial consortium	Ipsita Dipamitra Behera, M R Nayak, S Biswas, B C Meikap, R k Sen	MME	Journal of Environmental Management	2021		Journal of Environmental Management | ScienceDirect.com by Elsevier	https://doi.org/10.1016/j.jenvman.2021.112746		**Scopus**	**Web of Science**
60	Strategic implementation of integrated bioaugmentation nand bio stimulation for efficient mittigation of petroleum hydorcarbon pollutants from terrestrial and aquatic environment	Ipsita Dipamitra Behera, M R Nayak, A Mishra, B C Meikap	MME	Marine pollution Bulletin	2021		Marine Pollution Bulletin | Journal | ScienceDirect.com by Elsevier	https://doi.org/10.1016/j.marpolbul.2022.113492		**Scopus**	
61	Accelerating models with a hybrid scale factor in extended gravity	B. Mishra, S. K. Tripathy and S. Tarai	Physics	Journal of Astrophysics and Astronomy	2021	0250-6335	Home | Journal of Astr	https://doi:10.1007/s12036-020-09655-6		**Scopus**	**Web of Science**
62	Bouncing Models in extended gravity theory	S. K. Tripathy, B. Mishra, S. Ray and R. Sengupta	Physics	Chinese Journal of Physics	2021	0577-9073		https://doi.org/10.1016/j.cjph.2021.03.026			
63	Cosmological models with Big rip and Pseudo rip in extended theory of gravity	P. P. Ray, S. Tarai, B. Mishra and S. K. Tripathy	Physics	Fortschritte der Physik (Progress of Physics)	2021	0015-8208 (print)		NA			
64	Cosmological models with hybrid scale factor	S. K. Tripathy, B. Mishra, M. Khlopov and S. Ray	Physics	International Journal of Modern Physics D	2021	0218-2718 | ISSN (online): 1793-6594		http://dx.doi.org/10.1142/S0218271821400058			
65	Dynamical System Analysis for accelerating models in f (Q) gravity	S. A. Narawade,L. Pati, B. Mishra and S. K. Tripathy	Physics	Physics of Dark Universe	2021	ISSN: 2212-6864	Physics of the Dark Uni	https://doi.org/10.1016/j.dark.2022.101020		**Scopus**	**Web of Science**
66	Dynamics of quasi de Sitter and linear combination of exponential models in extended gravity	B. Mishra, E. Gadia and S. K. Tripathy	Physics	International Journal of Geometrical Methods in Modern Physics	2021	0219-8878 (print); 1793-6977 (web)	International Journal o	https://doi.org/10.1142/S0219887821501681		**Scopus**	
67	Gravitational Baryogenesis Models comparison in f(R)	S. Agrawal, S. K. Tripathy and B. Mishra	Physics	Chinese Journal of Physics	2021	0577-9073	Chinese Journal of Phy	https://doi.org/10.1016/j.cjph.2021.03.004		**Scopus**	**Web of Science**
68	Matter Bounce Scenario and the dynamical aspects in f(Q, T) gravity	A. A. S. Agrawal, L. Pati, S. K. Tripathy and B. Mishra	Physics	Physics of the Dark Universe	2021	ISSN: 2212-6864	Physics of the Dark Uni	https://doi.org/10.1142/S0219887821501681		**Scopus**	**Web of Science**
69	Modelling Casimir wormholes in extended gravity	S. K. Tripathy	Physics	Physics of the Dark Universe	2021	2212-6864	Physics of the Dark Uni	https://doi.org/10.1016/j.dark.2020.100757		**Scopus**	**Web of Science**
70	Modelling of Accelerating Universe with Bulk Viscous Fluid in Bianchi-V spacetime	G. K. Goswami, A. K. Yadav, B. Mishra and S. K. Tripathy	Physics	Fortschritte der Physik (Progress of Physics)	2021	0015-8208	Fortschritte der Physik	https://doi.org/10.1002/prop.202100007		**Scopus**	
71	Nuclear Symmetry Energy Parameters from the neutron skin thickness in 208Pb and the electric dipole polarizability in 68Ni, 120Sn and 208Pb	D. Behera, S. K. Tripathy, T. R. Routray and B. Behera	Physics	Physica Scripta	2021	1402-4896	Physica Scripta - IOPsci	DOI 10.1088/1402-4896/abd8a4		**Scopus**	**Web of Science**

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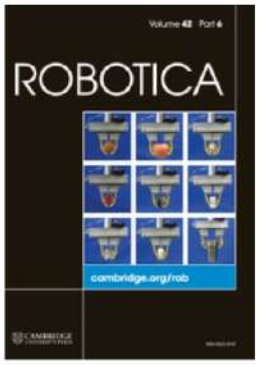
72	Nuclear Symmetry Energy Parameters from the neutron skin thickness in 208Pb and the electric dipole polarizability in 68Ni, 120Sn and 208Pb	D. Behera, S. K. Tripathy, T. R. Routray and B. Behera	Physics	Physica Scripta	2021	1402-4896	Physica Scripta - IOPsci	DOI 10.1088/1402-4896/abd8a4		**Scopus**	**Web of Science**
73	Rip cosmological models in extended symmetric teleparallel gravity	L Pati, S. A. Kadam, S. K. Tripathy and B. Mishra	Physics	Physics of the Dark Universe	2021	ISSN: 2212-6864	Physics of the Dark Uni	https://doi.org/10.1016/j.dark.2021.100925		**Scopus**	**Web of Science**
74	Stability Analysis of two fluid dark energy models	B. Mishra, F. Md. Esmaeli, P. P. Ray and S. K. Tripathy	Physics	Physica Scripta	2021	1402-4896	Physica Scripta - IOPsci	https://doi.org/10.1088/1402-4896/abdf82		**Scopus**	**Web of Science**
75	Structural and Elastic properties of Binary semiconductors from Energy gap	A.Pattanaik, S. K. Tripathy, P. Naik and D. Meher	Physics	Journal of Applied Physics A	2021	0947-8396	Home | Applied Physic	DOI: https://doi.org/10.1007/s00339-020-04159-0		**Scopus**	**Web of Science**
76	Structural and elastic properties of binary semiconductors from energy gaps	Anup Pattanaik, Sunil K. Tripathy, Poonam Naik, Deepak K. Meher	Physics	Applied Physics A	2021	**0947-8396**	Home | Applied Physic	DOI: 10.1007/s00339-020-04159-0		**Scopus**	**Web of Science**
77	Study of the open circuit voltage dependence on incident light intensity of planar heterojunction organic solar cell	Anukul Prasad Parhi	Physics	Materials Today: Proceedings	2021	2214-7853	Materials Today: Proceedings | Journal | ScienceDirect.com by Elsevier	https://doi.org/10.1016/j.matpr.2020.08.682		**Scopus**	**Web of Science**
78	Wormhole solutions in f(R) gravity	B. Mishra, A. S. Agrawal, S. K. Tripathy and S. Ray	Physics	International J. Of Modern Physics B	2021	0218-2718	International Journal o	https://doi.org/10.1142/S0218271821500619		**Scopus**	



Water cycle algorithm: an approach for improvement of navigational strategy of multiple humanoid robots

Published online by Cambridge University Press: **23 June 2021**

Manoj Kumar Muni, Saroj Kumar, Dayal R. Parhi and Krishna Kant Pandey

Show author details

Abstract

This paper presents an efficient water cycle algorithm based on the processes of

Chinese Journal of Physics

Volume 71, June 2021, Pages 333-340

Gravitational baryogenesis models comparison in $f(R)$ gravity

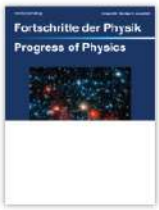
A.S. Agrawal [a] ✉, S.K. Tripathy [b] ✉, B. Mishra [a] ✉

https://doi.org/10.1016/j.cjph.2021.03.004 ↗

Highlights

- Framing of an anisotropic model in f(R) gravity

Fortschritte der Physik
Progress of Physics



Volume 69, Issue 6
June 2021
2100007

Original Paper

Modeling of Accelerating Universe with Bulk Viscous Fluid in Bianchi V Space-Time

G. K. Goswami, Anil Kumar Yadav, B. Mishra, S. K. Tripathy

First published: 03 March 2021 | https://doi.org/10.1002/prop.202100007 | Citations: 13

Abstract

In this paper, we have investigated a bulk viscous anisotropic Universe and constrained its model parameters with recent $H(z)$ and Pantheon compilation data. Using cosmic chronometric technique, we estimate the present value of Hubble's constant as $H_0 = 69.39 \pm 1.54\ km\ s^{-1} Mpc^{-1}$, $70.016 \pm 1.65\ km\ s^{-1} Mpc^{-1}$ and $69.36 \pm 1.42\ km\ s^{-1} Mpc^{-1}$ by bounding our derived model with recent $H(z)$ data, Pantheon and joint $H(z)$ and Pantheon data respectively. The present age of the Universe is specified as $t_0 = 0.9796 H_0^{-1} \sim 13.79$ Gyrs. The model favours a transitioning Universe with the transition red-shift as $z_t = 0.73$. We have

PAPER

Nuclear symmetry energy parameters from neutron skin thickness in ^{208}Pb and electric dipole polarizability in ^{68}Ni , ^{120}Sn and ^{208}Pb

Dipanjali Behera[1,2], S K Tripathy[4,1], T R Routray[3] and B Behera[3]

Published 14 January 2021 • © 2021 IOP Publishing Ltd

Physica Scripta, Volume 96, Number 3

Citation Dipanjali Behera *et al* 2021 *Phys. Scr.* **96** 035302

DOI 10.1088/1402-4896/abd8a4

Abstract

materialstoday: PROCEEDINGS

Volume 38, Part 3, 2021, Pages 1267-1271

Study of the open circuit voltage dependence on incident light intensity of planar heterojunction organic solar cell

Anukul Prasad Parhi [a], Durgesh C. Tripathi [b], Devika Kataria [c]

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https://doi.org/10.1016/j.matpr.2020.08.682 ↗ Get rights and content ↗

THERMODYNAMICS, TRANSPORT, AND FLUID MECHANICS | April 13, 2021

Atomization Characteristics of a Spinning Disc in Direct Droplet Mode

Kshetramohan Sahoo, and Sanjeev Kumar*

Industrial & Engineering Chemistry Research

Cite this: *Ind. Eng. Chem. Res.* 2021, 60, 15, 5665−5673

https://doi.org/10.1021/acs.iecr.1c00407

Published April 13, 2021

Article

Dynamics of Drop Release from the Edge of a Spinning Disc

November 2021 · Industrial & Engineering Chemistry Research XXXX(XXX)
DOI: 10.1021/acs.iecr.1c02172

Kshetramohan Sahoo · Sanjeev Kumar

Abstract

DOI: 10.1515/ijcre-2021-0111 • Corpus ID: 235799266

Green synthesized Ag-TiO2 for degradation of organic dye through visible light driven photo-reactor and its kinetics

Titikshya Mohapatra, Sakshi Manekar, Vijyendra Kumar Sahu, Ashwini Soni, Sudipta Banerjee, P. Ghosh less •

Published in International journal of... 13 July 2021 • Chemistry, Environmental Science, Materials Science

Abstract This study reports a green approach for the modification of titanium dioxide (TiO2) nanoparticles with immobilization of silver nanoparticles. One of the natural sources i.e., Mangifera indica leaf extract was utilized as reducing and capping agent for the fabrication of Ag-TiO2 nanocatalyst. Further, the surface morphology and band-gap energy of prepared Ag-TiO2 were analyzed by Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDS) and UV–Vis spectroscopy. Also, it was characterized by X-ray Powder Diffraction (XRD) which provides the information regarding the crystallinity of the Ag-TiO2. Subsequently, photo activity of Ag-TiO2 was investigated for the degradation of methylene blue (MB) dye wastewater through visible light driven photoreactor. The Ag-TiO2 provided highest (68%) of photo-degradation efficiency within 110 min for 7.81 × 10−5 mol/L initial MB concentration at pH 8 by using 0.19 g/L photocatalyst. Further, addition of 10 mM H2O2 boost up the MB photodegradation to 74%. The kinetic study confirmed the

Inorganic Chemistry Communications

Volume 126, April 2021, 108494

Short communication

Synthesis, characterization and molecular docking study of Nitro(4′-(2-pyridyl)-2,2′:6′,2″-terpyridyl) Palladium(II) nitrate

Debakanta Tripathy [a b c], Amlan K. Pal [b d], Soumya Lipsa Rath [e], Garry S. Hanan [b], Binod B. Panda [c], Dillip K. Chand [a]

International Journal of Electrical Engineering & Education

Restricted access | Research article | First published online February 11, 2019

A novel application of ALO-based fractional order fuzzy PID controller for AGC of power system with diverse sources of generation

Nimai Charan Patel, Binod Kumar Sahu, Durgesh Prasad Bagarty, Pranati Das, and Manoj Kumar Debnath (-2) View all authors and affiliations

Volume 58, Issue 2 | https://doi.org/10.1177/0020720919829710 | View expression of concern / retraction

Abstract

The operation and control of the modern power system has become complex and difficult due to the incessant penetration of nonconventional energy sources integrated to the power grid and the structural variation of power system with continuing escalation of power demand in recent years. This entails the implementation of intelligent control strategy for satisfactory operation of the power system. Hence, a fractional order fuzzy proportional integral derivative (FOFPID) controller is suggested in this article for automatic generation control of two unequal area interconnected power system with diverse generating units such as thermal, hydro, diesel and wind power plants. The

Ann Based Speed Control of Brush less DC Motor Using DC DC Converter

M. Sivaramkrishnan, P. Ramesh, M. Veerasundaram, Lizi Joseph, Bibhu Prasad Ganthia, Dr. M. Anand

PDF

ABSTRACT

This paper implements a Brushless DC drive that uses an Artificial Neural Network PFC. A DC capacitor controls the speed. In order to obtain the full Power Factor, a Cuk power rectifier is fed into a brushless DC motor DC converter. This process of running three modes of operation in discontinuous mode and finding the approach that creates the most Power

ower Factor thereby reducing

HOW TO CITE

M. Sivaramkrishnan, P. Ramesh, M. Veerasundaram, Lizi Joseph, Bibhu Prasad Ganthia, Dr. M. Anand. (2021). Ann Based Speed Control of Brush less DC Motor Using DC DC Converter. *Design Engineering*, 1998 - 2011. Retrieved from http://thedesignengineering.com/index.php/DE/article/view/1901

Bridgeless Ac/Dc Converter & Dc-Dc Based Power Factor Correction with Reduced Total Harmonic Distortion

Dr. S. Kaliappan, Dr. V. Parimala, Akshay S., N. Praneeth, Bibhu Prasad Ganthia, Dr. Makarand Upadhyaya

ABSTRACT

The amount of DC power used in certain electrical and computer devices is greater than in most locations across the world. The supply that supplies electricity to the load is added to the power suppliers. Unbalanced non-directed, non-linear, non-scheduled demands in the machine Just a couple of new approaches have found their way into the literature recently released methods to fix power factor and reduce harmonic distortion. For

CONTACT US

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Address: 4143 Danforth Avenue Toronto, ON M4K 1A6.
Email: editor@thedesignengineering.com

Grid Tied PV with Reduced THD Using NN and PWM Techniques

Dr. Praveen Mannam, Dr. Y. V. Siva Reddy, Saritha Manchireddy, Bibhu Prasad Ganthia, Jayakumar N., Dr. Makarand Upadhyaya

PDF

ABSTRACT

Modulation of the PV inverters has been shown to significantly minimize the harmonic distortions found with Pulse. For three phase squirrel cage induction motors, Harmonic Tuning is important. Reducing the THD in the three phase squirrel cage induction motor allows for improvement in motor output. This study looked at the three-phase induction motor's harmonic distortion in terms of simulating it with the sinusoidal feedback,

HOW TO CITE

Dr. Praveen Mannam, Dr. Y. V. Siva Reddy, Saritha Manchireddy, Bibhu Prasad Ganthia, Jayakumar N., Dr. Makarand Upadhyaya. (2021). Grid Tied PV with Reduced THD Using NN and PWM Techniques. *Design Engineering*, 2019 - 2027. Retrieved from http://thedesignengineering.com/index.php/DE/article/view/1903

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Editorial Office of Design Engineering.
Address: 4143 Danforth Avenue Toronto, ON M 1A6.
Email: editor@thedesignengineering.com

Matlab/Simulink Based THD Reduction Using Active Power Filters

Dr. V. Parimala, P. V. Ashwathy Devraj, Dr. S. Siva Subramanian, Dr. Udayakumar Durairaj, Bibhu Prasad Ganthia, Dr. Makarand Upadhyaya

ABSTRACT

Harmonic current load style causes non-sinusoidal voltage distortion. Harmonic distortion is thought to be inherent in nonlinear control systems. The harmonics created by nonlinear loads can cause additional damages, overheating, and interfere with most notably with capacitors,

Ambiguity Function Analysis for Orthogonal-LFM Waveform Based Multistatic Radar

Publisher: IEEE

Dillip Dash ; Valarmathi Jayaraman **All Authors**

Abstract:

Over the last decade, research on multistatic radar waveform design has attracted significant consideration among the radar system designers.Among the waveform design techniques, linear frequency modulated waveforms are widely used, but the problem associated with it is range Doppler coupling and complexity in achieving adequate pulse-to-pulse diversity. In this letter, an

Research Articles

High selectivity and sharp roll-off filtenna array for Ku-band application

Soumya Ranjan Mishra, Bikash Chandra Sahoo & Sheeja K L

Pages 748-773 | Received 18 Jul 2020, Accepted 02 May 2021, Published online: 15 Jul 2021

Cite this article | https://doi.org/10.1080/00207217.2021.1941290 | Check for updates

ABSTRACT

AEU - International Journal of Electronics and Communications

Volume 139, September 2021, 153931

Regular paper

Metamaterial inspired pin wheel fractal shaped antenna using parasitic split ring resonator for modern wireless applications

Ashish Kumar [a], Gurmeet Singh [b], Bikash Chandra Sahoo [c]

https://doi.org/10.1016/j.aeue.2021.153931

International Journal of Ambient Energy >
Volume 43, 2022 - Issue 1

Research Article

Effect of the second-order slip and heat source on dissipative MHD flow of blood through a permeable capillary in stretching motion

Bharat Keshari Swain, Manasa Manjari Biswal & G. C. Dash

Pages 5768-5779 | Received 26 Apr 2021, Accepted 01 Sep 2021, Published online: 07 Oct 2021

Cite this article https://doi.org/10.1080/01430750.2021.1979649 Check for updates

HEAT TRANSFER

Volume 51, Issue 6
September 2022
Pages 4837-4857

ORIGINAL ARTICLE

Heat and mass transfer in MHD stagnation-point flow toward an inclined stretching sheet embedded in a porous medium

Manasa M. Biswal, Bharat K. Swain ✉, Manjula Das, Gouranga Charan Dash

First published: 28 March 2022 | https://doi.org/10.1002/htj.22525 | Citations: 2

Read the full text >

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Abstract

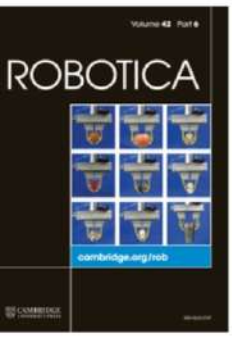
The present study elucidates the magnetohydrodynamics boundary layer free convective stagnation-point flow toward an inclined nonlinearly stretching sheet embedded in a porous medium. The recent search explores the consequence of permeability of the medium, thermal as well as mass buoyancy, most importantly obliqueness, and thermal slip at the bounding surface. The solutions of the essential equations are achieved with MATLAB'S inbuilt solver bvp4c. The novelty of the present study is to account for the effect of dissipative heat, nonuniform space-dependent volumetric heat power, and a linear first-order chemical reaction of diffusive species and convective flow phenomena on an inclined plate subjected to thermal slip and space-dependent transverse magnetic field acting at a distance. The important findings are laid down as follows: The oblique-surface reduces the effect of body forces, low permeability of the medium causes instability in the flow due to sudden fall in velocity, Biot number contributes to the Newtonian cooling of the surface, these may be of use in a design requirement of the

References Related Informat

Recommended

MHD stagnation point viscoelastic fluid flow and heat transfer on a thermal forming stretching sheet with viscous dissipation

Kai-Long Hsiao



Humanoid NAO: A Kinematic Encounter

Published online by Cambridge University Press: **02 March 2021**

Chinmaya Sahu, Dayal R. Parhi, Priyadarshi Biplab Kumar, Manoj Kumar Muni, Animesh Chhotray and Krishna Kant Pandey

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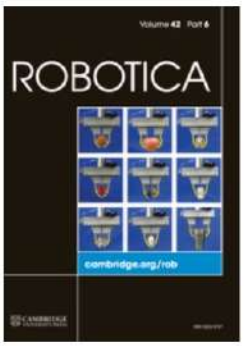

Robotica

Article contents

Summary

Hybrid IWD-GA: An Approach for Path Optimization and Control of Multiple Mobile Robot in Obscure Static and Dynamic Environments

Published online by Cambridge University Press: **24 February 2021**

Saroj Kumar, Dayal Ramakrushna Parhi, Krishna Kant Pandey and Manoj Kumar Muni

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Navigation of a wheeled mobile robotic agent using modified grey wolf optimization controller

Chittaranjan Paital, Saroj Kumar, Manoj Kumar Muni, Dayal R. Parhi, Prasant Ranjan Dhal

International Journal of Intelligent Unmanned Systems
ISSN: 2049-6427
Article publication date: 4 October 2021

Issue publication date: 10 April 2023

International Journal of Structural Stability and Dynamics | Vol. 21, No. 13, 2150176 (2021)

| Research Paper

On Crack Detection in a Laminated Glass/Epoxy Composite Beam under Free Vibration with Fuzzy Logic Aid

Priyadarshi Das, Manoj Kumar Muni, and Shishir Kumar Sahu

https://doi.org/10.1142/S0219455421501765 | **Cited by:** 4 **(Source: Crossref)**

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Abstract

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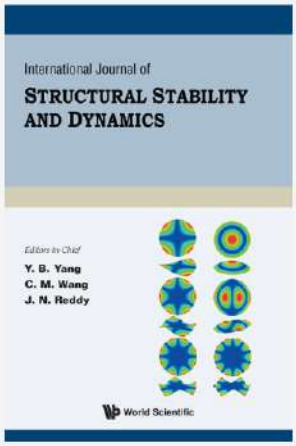


Vol. 21, No. 13

Restricted access | Research article | First published online January 7, 2021

Static and dynamic path optimization of multiple mobile robot using hybridized fuzzy logic-whale optimization algorithm

Saroj Kumar, Dayal R Parhi, [...], and Manoj K Muni +1 View all authors and affiliations

Volume 235, Issue 21 | https://doi.org/10.1177/0954406220982641

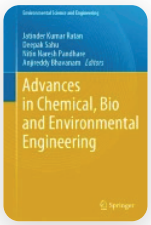
Abstract

Fuzzy logic is widely known as a value-based technique. Whale optimization algorithm (WOA), on the other hand, is a nature-inspired optimization technique. Hybridization of these two techniques is proposed for path planning and control, over multiple mobile robots in static and dynamic environments. The effectiveness of the resulting technique, known as 'Fuzzy-WOA', is tested through MATLAB simulation coupled with real time experiments. Upon testing, a good agreement is observed

Preparation and Characterization of Amine Modified Activated Carbon from Corncobs for Carbon Dioxide Capture

| Conference paper | First Online: 12 May 2022

| pp 219–228 | Cite this conference paper



Advances in Chemical, Bio and Environmental Engineering

(CHEMBIOEN 2021)

Dipa Das & Liku Swain

Part of the book series: Environmental Science and Engineering ((ESE))

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International Conference on Chemical, Bio and Environmental Engineering

Abstract

Marine Pollution Bulletin 177 (2022) 113492

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Strategic implementation of integrated bioaugmentation and biostimulation for efficient mitigation of petroleum hydrocarbon pollutants from terrestrial and aquatic environment

Ipsita Dipamitra Behera [a], Manoranjan Nayak [b,c], Asmita Mishra [a], Bhim Charan Meikap [a,d], Ramkrishna Sen [b,e,*]

[a] Department of Chemical Engineering, Indian Institute of Technology Kharagpur, West Bengal 721302, India
[b] School of Energy Science and Engineering, Indian Institute of Technology Kharagpur, West Bengal 721302, India
[c] Biorefinery and Bioenergy Research Laboratory, Amity Institute of Biotechnology, Amity University Uttar Pradesh, Noida 201313, India
[d] Department of Chemical Engineering, School of Engineering, Howard College, University of KwaZulu-Natal, Durban 4041, South Africa
[e] Department of Biotechnology, Indian Institute of Technology Kharagpur, West Bengal 721302, India

ARTICLE INFO

Keywords:
Petroleum hydrocarbon pollutants
Biodegradation
Bioaugmentation
Nutrient amendment
Bacterial consortium

ABSTRACT

Release of petroleum hydrocarbon pollutants poses a serious problem to the terrestrial as well as marine ecosystem. This study investigated and compared the potency of different biodegradation strategies for mitigating total petroleum hydrocarbon (TPH) of petroleum refinery sludge by an integrated action of bioaugmentation and biostimulation vis-à-vis separate bioaugmentation and biostimulation approaches. The implementation of a concomitant bioaugmentation-biostimulation strategy (BABSS) involving the indigenously developed bacterial consortium and poultry litter extract showed the best performance by mitigating the TPH up to 90.3 ± 3.7% in 21 days. The GC-FID analysis confirmed the efficacy of different TPH degradation strategies. The kinetic study of TPH degradation of BABSS resulted first-order with rate 0.11 day^{-1}. Thus, the BABSS proved to be more efficient in degrading TPH in an eco-friendly manner and hence, may pave the way for better management of petroleum hydrocarbon pollutants, while providing a sustainable solution to the disposal of poultry wastes.

1. Introduction

Petroleum hydrocarbon pollutants pose a serious problem to the terrestrial as well as marine ecosystem (Kapsalis et al., 2021). A massive quantity of petroleum oily sludge is liberated to both terrestrial and marine ecosystems by the petroleum refineries due to the increased requirement of petroleum products for our routine life. Marine ecosystem is the final destination of various anthropogenic pollutants among which, oil spills are universal problematic situations which severely affect the marine environment along with the human populations nearby it (Liu et al., 2016; Mishra et al., 2019). A significant quantity of petroleum hydrocarbon pollutants released to the natural habitat, including terrestrial as well as aquatic environment during processing, transportation (oil spills), and by execution of the physico-chemical process of crude oil (Dellagnezze et al., 2014; Xu et al., 2018; Jasmine and Mukherji, 2019; Sayed et al., 2021). Indefinite handling of these petroleum refinery sludge (PRS) and petroleum hydrocarbons has adverse effects on human health besides environmental issues as it is recalcitrant and persistent in nature (Basak et al., 2020). Petroleum sludge is primarily composed of aliphatic hydrocarbons, including alkanes, alkenes, and alkynes, polyaromatic hydrocarbons, and toxic heavy metals (Cerqueira et al., 2014). Along with it also contains 5–85% of total petroleum hydrocarbons (TPH) based on its different processing techniques (Jasmine and Mukherji, 2015). Petroleum hydrocarbons have been found to be mutagenic and carcinogenic and cause respiratory and health issues to human beings, as well as endanger to aquatic life and terrestrial animals (Sayed et al., 2021). The toxic effects of petroleum hydrocarbon also caused damage to the phytoplankton and algae of the marine ecosystems, which imbalance the marine food chain (Mishra et al., 2019). As sequel to these negative effects, petroleum pollutants are considered as hazardous waste (USEPA, 2004; Cerqueira et al., 2014; Mishra et al., 2021).

Considering the toxicity of petroleum hydrocarbons, it is essential for

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E-mail address: rksen@bt.iitkgp.ac.in (R. Sen).

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Received 30 November 2021; Received in revised form 2 February 2022; Accepted 22 February 2022
Available online 16 March 2022

Journal of Environmental Management 292 (2021) 112746

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Enhanced biodegradation of total petroleum hydrocarbons by implementing a novel two-step bioaugmentation strategy using indigenous bacterial consortium

Ipsita Dipamitra Behera [a,1], Manoranjan Nayak [b,c,1], Subrata Biswas [a], Bhim Charan Meikap [a,d], Ramkrishna Sen [b,e,*]

[a] Department of Chemical Engineering, Indian Institute of Technology Kharagpur, West Bengal, 721302, India
[b] School of Energy Science and Engineering, Indian Institute of Technology Kharagpur, West Bengal, 721302, India
[c] Biorefinery and Bioenergy Research Laboratory, Amity Institute of Biotechnology, Amity University Uttar Pradesh, Noida, 201313, India
[d] Department of Chemical Engineering, School of Engineering, Howard College, University of KwaZulu-Natal, Durban, 4041, South Africa
[e] Department of Biotechnology, Indian Institute of Technology Kharagpur, West Bengal, 721302, India

ARTICLE INFO

Keywords:
Petroleum refinery sludge
Bacterial consortium
Two-step bioaugmentation strategy
Total petroleum hydrocarbons
Biodegradation

ABSTRACT

In the present study, a two-step bioaugmentation strategy (TSBS) was implemented by using indigenous bacterial consortium to enhance the degradation of total petroleum hydrocarbons (TPH) from petroleum refinery sludge (PRS). A bacterial consortium was developed using four indigenous isolated strains, Dietzia sp. IRB191, Dietzia sp. IRB192, Staphylococcus sp. BSM19 and Stenotrophomonas sp. IRB19 from PRS. The optimum conditions of pH, temperature, and sludge concentration were 7, 34 °C, and 2% (w/v), respectively, for maximum TPH degradation, obtained using one variable at a time approach. Under the optimal culture conditions, the developed consortium was inoculated twice to the culturing medium, at the beginning (0^{th} day) and again on the 10th day for implementing a novel TSBS. The maximum TPH degradation of 91.5 ± 2.28% was found with TSBS, which was 1.18 times higher than that of SSBS (77.3 ± 2.6%) in 15 days of incubation. GC-FID study also confirmed that the TPH present in the PRS was effectively degraded by the bacterial consortium with TSBS. The TPH degradation by using TSBS proceeded according to the first-order kinetics with a rate constant of 0.155 d^{-1}. Hence, biodegradation using a TSBS can be considered an effective and eco-friendly process for safe disposal of petroleum refinery sludge.

1. Introduction

The growing demand of petroleum products has led to the generation of a huge amount of petroleum hydrocarbon pollutants through refineries and petrochemical industries to the environment (Koolivand et al., 2019; Varjani, 2017). Mainly, oil refineries generate petroleum sludge during the crude oil production, pre-treatment, processing, the oil-water separation system, and from the bottom of storage tanks (Gholami-Shiri et al., 2017; Jasmine and Mukherji, 2015; Varjani and Upasani, 2019). Petroleum refinery sludge (PRS) is a complex mixture of hydrocarbons, water, and toxic heavy metals. Organization for Economic Co-operation and Development (OECD) countries, United States Environmental Protection Agency (US-EPA), USA, and India have recognized and stated oily waste as hazardous material due to their mutagenic, carcinogenic, and toxic properties (USEPA, 2004). Improper disposal of these pollutants may cause mutation or death of plants as well as animals (Poddar et al., 2019). Moreover, the accumulation of these pollutants to the environment represents a hazardous to human health, aquatic life and decreases soil fertility (Basak et al., 2020; Poddar et al., 2019; Poi et al., 2018; Varjani and Upasani, 2019). Therefore, hydrocarbon rich sludge requires effective treatment and proper disposal to ensure environmental safety.

Several physicochemical methods, such as incineration (Zhou et al., 2009), froth flotation (Ramaswamy et al., 2007), solvent extraction (Taiwo and Otolorin, 2009), pyrolysis (Qin et al., 2015) and ultrasonic treatment (Sivagami et al., 2019), chemical treatment by addition of

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E-mail addresses: rksen@yahoo.com, rksen@bt.iitkgp.ac.in (R. Sen).
[1] The authors contribute equally to this paper.

https://doi.org/10.1016/j.jenvman.2021.112746
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Indian Journal of Chemical Technology
Vol. 28, November 2021, pp. 709-716

Effect of superficial gas velocity and ratio of bed volume to reactor volume of inverse fluidized bed biofilm reactor on the removal of ammonia-nitrogen from wastewater

Anup Kumar Swain*, Abanti Sahoo, Hara Mohan Jena & Satish Chandra Bhuyan
Chemical Engineering Department, National Institute of Technology, Rourkela, Odisha 769 008, India
E-mail: anup.k.swain@gmail.com

Received 25 July 2021; accepted 17 October 2021

Hydrodynamic parameters of an inverse fluidized bed biofilm reactor (IFBBR) have been studied using spherical polypropylene (PP) particles having average diameter and density of 5.63 mm and 920 kg/m^3 respectively. Gas-phase holdup (ε_g) was analyzed for various ratios of settled bed volume to reactor volume (V_b/V_r) and superficial gas velocities (U_g) with a liquid recirculation velocity (U_l) of 0.0021 m/s. The ε_g values were found to increase with V_b/V_r ratios up to a certain limit and then decrease with further increase of V_b/V_r ratios. The effect of U_g, V_b/V_r ratios, and initial concentration of ammonia-nitrogen (NH_4^+-N) on the removal of NH_4^+-N from synthetic wastewater were studied. The optimal values of V_b/V_r ratio and U_g were found to be 0.380 and 0.0085 m/s respectively for all initial NH_4^+-N concentrations. Complete removal of NH_4^+-N was achieved in 8 to 44 hours for different initial NH_4^+-N concentrations. It was also observed that with the increase in initial NH_4^+-N concentrations, the nitrification decreases.

Keywords: Ammonia-nitrogen, Biofilm reactor, Inverse fluidization, Nitrification, Wastewater treatment

The detrimental effects of NH_4^+-N present in wastewater are eutrophication; reduction of dissolved oxygen (DO) level; and toxicity to human, animal, and aquatic species[1]. Its removal from wastewater can be achieved by chemical, physical, combined chemical-physical, or biological treatment methods[2]. Among these methods, the biological treatment methods are widely used for the removal of NH_4^+-N from wastewater due to its high efficiency and low operating costs[3]. The biological method of converting NH_4^+-N to unstable nitrite-nitrogen (NO_2^--N) and then to less toxic nitrate-nitrogen (NO_3^--N) is known as nitrification. The conversion of NH_4^+-N to NO_3^--N proceed faster due to which at any instance the level of NO_2^--N in the system is usually low[4]. The basic nitrification reactions[2] can be written as:

$$NH_4^+ + 1.5\ O_2 \xrightarrow{Nitrosomonas} 2\ H^+ + H_2O + NO_2 \quad \ldots (1)$$

$$NO_2^- + 0.5\ O_2 \xrightarrow{Nitrobacter} NO_3^- \quad \ldots (2)$$

The nitrification steps are dependent on *p*H; temperature; alkalinity; DO level; concentrations of NH_4^+-N, NO_2^--N, and NO_3^--N; presence of heavy metals and toxic substances; and concentration of organic substrate[3,5]. The nitrification steps are carried out by two different growth conditions of bacteria: suspended and attached (as biofilm) growth conditions. The reactors based on attached growth condition have several advantages such as minimum wash off of the microorganisms, ease of handling, better stability, and capability to withstand shock loading[6]. These reactors require less floor area for erection and the separation of solids is easier[5]. Furthermore, the growth of the nitrifying bacteria is slow and can easily be swept away from the treatment systems. Therefore, it is essential to use such type of biofilm reactors which can hold the biomass inside the reactor for long duration and can also facilitate their growth[3].

In the fluidized bed biofilm reactors biomass can be hold for long duration as well as their growth can easily be facilitated due to which these reactors were in use for the removal of NH_4^+-N from wastewater[7-11]. Though the use of fluidized bed biofilm reactors is advantageous, the use of IFBBRs has emerged in recent times for the treatment of wastewaters generated from a wide variety of industries[12,13].

In conventional three-phase fluidized bed biofilm reactors (FBBRs), the particle density is higher than

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Analysis of iron ore pellets properties concerning raw material mineralogy for effective utilization of mining waste

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ABSTRACT

The value addition in iron ore mining waste generated from washing or beneficiation plants is a challenging task. The iron ore slimes, which contain low iron content with high gangue minerals like kaolinite, gibbsite, and quartzite, cannot be used directly for iron production. The present study focuses on utilization of iron ore slimes without beneficiation by blending with high-grade fines for making iron ore pellets. The pellets were prepared by adding slimes in different weight proportions (0, 10, 20, 30, 40, and 50%) with high-grade iron ore fines. The high-grade iron ore fines contain 64% Fe, 2.25% LOI, and Blaine number 2975 cm^2/g, whereas iron ore slimes contain 52.45% Fe, 5.60% LOI, and Blaine number 7046 cm^2/g. Pellets were produced without using bentonite as the binder. The pellet properties, such as drop number, green and dry compressive strength and moisture content of green pellet, cold compressive strength, porosity, swelling index, reduction degradation index, and reducibility index of fired pellet, have been investigated. The pellet mineralogy was analyzed using x-ray diffraction and optical microscope. The empirical correlation has been developed incorporating feed mineralogical data based on kaolinite and goethite to predict the physical and metallurgical properties of pellet.

1. Introduction

The demand and supply of iron ore and steel production are allied to each other. According to the new National Steel Policy 2017, the Ministry of Steel, Govt. of India has set up a target to produce 300 million tonnes per annum (MTPA) of crude steel making by 2030–31 [1]. For the production of 300 MTPA, around 450 MTPA of high-quality iron ore is needed in the form of calibrated ore, sinters, and pellets. High-grade iron ore resources are depleting day by day. To achieve the given target, there is a pressing need to utilize the low and lean grade iron ore resources and rejected mining waste material found from sources like washing or beneficiation plant called "iron ore slimes". During the washing and size reduction of the iron ore, around 15–25% of the mined ore is lost as slimes with a size less than 45 μm. Around 25–30 MTPA is discarded as slimes into the slimes pond, which are stockpiled at different mine heads and create a massive environmental problem in the locality of mines [2,3]. Hence, the optimal use of currently available low and lean-grade iron ore resources like slimes with particular emphasis on preserving high-grade ores has to be always encouraged. Slimes are associated with mineral phases like hematite, goethite, gibbsite, kaolinite, and quartzite. Kaolinite contributes the lion's share of alumina in the slimes. These slimes cannot be utilized directly in iron production through a blast furnace, DRI, and Corex processes due to their high silica, alumina content, and ultra-fine particle size distribution. Therefore, there have been many attempts to produce high Fe content concentrate from iron ore slimes using conventional beneficiation techniques.

Desliming with hydrocyclone followed by high-intensity magnetic separation and flotation of iron ore slimes could enrich the Fe content from 49.86% to 66.36% Fe in the concentrate with a 25% yield [4]. It has also been reported that it is possible to enrich Fe content to 66.97% from 37.86% Fe with a yield of 14.4% by the conventional beneficiation process [5]. To improve the magnetic susceptibility of goethite and hematite particles, an advanced technique, i.e., selective coating of magnetite nano-particles through dispersing in anionic reagent and then followed by low-intensity magnetic separation, was used to enhance Fe content from 59% to 65.9% [6]. In another instance, through simple classification by hydrocyclone and followed by reverse flotation, Fe content in the concentrate could be achieved 64.64% Fe from a feed of

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Review

Graphene, Graphene-Derivatives and Composites: Fundamentals, Synthesis Approaches to Applications

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Abstract: Graphene has accomplished huge notoriety and interest from the universe of science considering its exceptional mechanical physical and thermal properties. Graphene is an allotrope of carbon having one atom thick size and planar sheets thickly stuffed in a lattice structure resembling a honeycomb structure. Numerous methods to prepare graphene have been created throughout a limited span of time. Due to its fascinating properties, it has found some extensive applications to a wide variety of fields. So, we believe there is a necessity to produce a document of the outstanding methods and some of the novel applications of graphene. This article centres around the strategies to orchestrate graphene and its applications in an attempt to sum up the advancements that has taken place in the research of graphene.

Keywords: graphene; grahene-derivatives; composites; synthesis; applications

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1. Introduction

Graphene is an allotrope of carbon which has a two-dimensional structure. It is in the form of a hexagonal lattice (see Figure 1) that resembles honeycomb structure [1]. It has some unique properties that have interested the researchers since its discovery by Geim and Noveselov [2]. Due to its high versatility and relatively huge specific surface region [3], graphene is sought as a good option in sensing applications [4]. Main advantages of graphene are: (a) it is the finest and toughest material known; (b) it has carbon monolayered atoms that are both flexible and transparent in colour; (c) it is an excellent thermal and electrical conductor; (d) its main usage is in the manufacture of high-speed electronic gadgets; (e) explosives detection through chemical sensors; (f) membranes for more proficient separation of gases and is produced using sheets from which nanoscale pores have been made; (g) for manufacturing of transistors operating at high frequencies; (h) it has boosted the manufacture of low-cost display screens of cell phones replacing the indium-based electrodes in organic light emitting devices (OLED); (i) to produce lithium-ion batteries that use graphene on the anode surface and these batteries recharge faster; (j) stockpiling hydrogen for cars powered by fuel cells; (k) cheaper water desalination techniques by using graphene films with nanoscale holes to separate water from ions in brine; and (l) Graphene condoms are produced to increase the sensation and is thinner than conventional latex condoms.

The very first examinations on exfoliated graphene done by Schedin et al. [5] have showcased graphene's capability on identifying single gas particles based on estimations under Hall effect. The basic guideline behind the usage of graphene in gas sensors is the transfer of charge between the molecule adsorbed to its surface and the material [6]. The carrier concentration of graphene is changed by the absorbed particles which cause the electrical properties to change and the concentration of particles is determined. The response of the

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ORIGINAL PAPER

Development of chitosan-based hybrid membrane modified with ionic-liquid and carbon nanotubes for direct methanol fuel cell operating at moderate temperature

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Abstract

Remarkable progress has been made to develop proton exchange membrane for direct methanol fuel cell to achieve higher power density. However, the higher methanol cross-over and poor water management are the two major obstacles of fuel cell which significantly reduces its performance. In this work, we have developed a highly performance Ionic Liquid (IL) modified chitosan based composite membrane and characterized by different experimental technique. The incorporation of IL in the chitosan composite introduces cationic acid which increases the ion exchange capacity and proton conductivity. Although the hydrophilic base of IL enhances water uptake capacity of the composite, the water is strongly attached with the polymer chain via hydrogen bonding thereby reducing free water content. The incorporation of Carbon Nanotubes (CNT) and bulky pendant group of IL in the chitosan composite reduces methanol cross-over and the methanol cross-over reported for CPCN@IL-4 composite (5.58×10^{-8} cm^2sec^{-1}) is significantly lower than the commercial N117 membrane (2.74×10^{-6} cm^2sec^{-1}). The IL modified composite membrane provides higher proton conductivity and membrane selectivity which is desirable for fuel cell design. At 70 °C, the maximum proton conductivity was achieved in CPCN@IL-3 composite (21.52×10^{-4} Scm^{-1}) and the proton transport was controlled by bound water regulated Grotthus mechanism. The polarization curve obtained for CPCN@IL-3 composite at 70 °C and 2 M methanol feed in a single cell of fuel cell provides the maximum power density of 82 mW/cm^2 at a current density of 370 mA/cm^2. The modification of chitosan based composite membrane with CNT and IL significantly reduces the methanol cross-over and provides higher membrane selectivity which will attracted a possible candidate for DMFC application.

Keywords Methanol cross-over · Ionic liquid · Multiwall carbon nanotubes · Membrane selectivity · Polarization curve · DMFC

Extended author information available on the last page of the article

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BRIEF COMMUNICATION

A New Perspective on the Green Strategy of Close Cycle Dissociation of H_2S

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Received: 15 October 2021 / Accepted: 12 March 2022

Abstract Extremely toxic H_2S gas is produced in huge quantities across the world as a byproduct of the desulfurization of hydrocarbon fuels. This H_2S gas is further converted into sulfur in sulfur recovery units. However, the valuable hydrogen content is lost as water vapour. It emphasizes the importance of proper exploitation of this resource. A continuous two-steps cyclic process for producing H_2 and sulfur simultaneously has been derived in this study. The first well-studied photocatalytic step generates hydrogen by water splitting in the presence of sulfide (S^{2-}) and sulfite (SO_3^{2-}), the sacrificial agents. Here, these sacrificial agents are converted into thiosulfate ($S_2O_3^{2-}$). In the second step, this $S_2O_3^{2-}$ reacts with hydrogen sulfide (HS^-) to form elemental sulfur, along with generation of S^{2-} and SO_3^{2-}, which are again reused in the first step. The kinetics of the reaction involved in the second step ($HS^- + S_2O_3^{2-} + OH^- \rightarrow S + S^{2-} + SO_3^{2-} + H_2O$) were studied in the present work. The reaction was found to be non-elementary with a rate law of $k[HS^-]^{1/2}[S_2O_3^{2-}]^{3/2}$. The observed rate law is of the order of 1.5 with respect to thiosulfate and 0.5 with respect to HS^- ions. A reaction mechanism for the second step consistent with the kinetics was also proposed. The rate constant was observed to be $1.075 \times 10^{10} e^{-62280/RT}$/M/s. This new proposed close cycle may simultaneously achieve green and renewable H_2 production along with H_2S removal.

Keywords H_2S · Dissociation · Sulfur · Kinetics

Introduction

Hydrogen sulfide (H_2S) is a very poisonous and corrosive gas with a rotten egg stench [1]. H_2S is often produced by natural processes such as microbial metabolism in the absence of oxygen or volcanic eruptions. However, in current civilization, the major sources of H_2S are ascribed to human need based industries such as crude oil refineries (desulfurization), coal industries, and natural gas production. A quantity of H_2S in the air exceeding 320 ppm might cause pulmonary edema and mortality [2]. Therefore, H_2S must be properly eliminated from these industries and associated human activities. H_2S is made up of two hydrogen atoms. As a future energy carrier, H_2 may play a pivotal role [3]. The Claus process, which produces sulfur and water via a high-temperature oxidation phase followed by a low-temperature reduction step, is the standard and well-known technique for H_2S removal (Eqs. 1, 2) [4, 5].

$$2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O \quad (1)$$

$$2SO_2 + 4H_2S \rightarrow 6S \downarrow + 4H_2O \quad (2)$$

Due to the requirement of higher temperature, the energy consumption of this process is rather significant.

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ZnO/Bone-Char Hybrid Composite: Catalyst Preparation, Characterization, and Its Application

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ABSTRACT: *This study was aimed at the development of the ZnO/bone-char (ZnO/BC) hybrid composite and it was characterized by its suitability for the treatment of dye-containing wastewater. The Zn/BC composites were prepared using four different methods such as sol-gel, precipitation, hydrothermal and wet-impregnation methods. Various analyzing techniques such as X-Ray Diffraction (XRD), Fourier Transform Infra-Red (FT-IR), Brunauer-Emmett-Teller (BET) surface area, and Scanning Electron Microscopy (SEM) were performed to characterize the prepared photocatalysts. The photocatalytic activity of the ZnO/BC composite prepared from the sol-gel method was evaluated by the decolorization of brilliant green dye in an aqueous solution. The results of SEM analysis confirm the agglomeration of nano-ZnO particles and particles are evenly distributed on the surface of the bone char. Moreover, the influence of different experimental parameters like solution pH, H_2O_2 concentration, and photocatalyst dosage was studied to optimize the process efficiency. This study also shows that chicken bone waste can be used as a photocatalyst carrier for the synthesis of photocatalytic composites. It not only provides a better way to treat dye-containing wastewater but also offers an ideal solution to using chicken bone waste. From the kinetic analysis, it has been observed that the photocatalytic decolorization of BG dye with ZnO/BC photocatalyst follows pseudo-first-order kinetics.*

KEYWORDS: *Development of catalyst; Photocatalytic activity; Brilliant green dye; Environmental pollution; Wastewater treatment; Kinetics.*

INTRODUCTION

Water pollution is a global environmental issue among environmental pollutions. Industrialization and an increase in population density led to producing a large volume of wastewater, which contains a variety of refractory organic pollutants. The dye is a significant water contaminant, which has drawn the attention of

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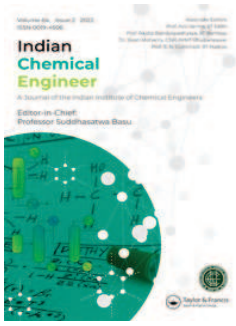

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A kinetic model and parameters estimate for the synthesis of 2-phenyloctane: a starting material of bio-degradable surfactant

Sudip Banerjee, Md Aurangzeb & Amit Kumar

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Article

Dynamics of Drop Release from the Edge of a Spinning Disc

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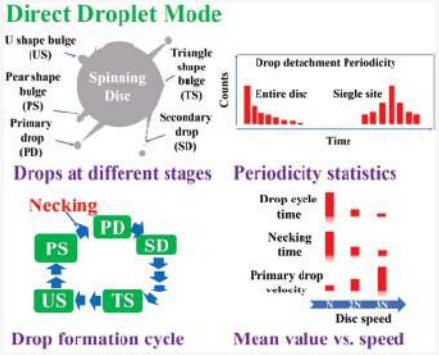
ABSTRACT: The direct formation of drops at the edge of a spinning disc is of fundamental interest. We use high-speed imaging to report here on the process of release of drops from a perfectly wetted disc at low inflow rates. A drop-detachment event begins by forming an incipient bulge on the disc edge, which grows into a series of shapes—triangle, inverted U, pear, and finally a nearly spherical bulge connected to the disc with an elongated neck. Neck pinching at the base of the bulge releases a primary drop followed by several secondary drops. The drop shape versus time plots show high variability under fixed conditions, which disappears on a single curve for time scaled with individual drop cycle time. The measurements at a different disc speed show the same scaled time evolution, pointing to a universal drop release process. The rapid stretching of the liquid thread as the bulge moves away before pinch-off follows a parabolic relationship with time but with only half the relative acceleration of a free object released from the disc edge. The mean values of cycle time and necking time follow a power-law decrease with disc speed. All of the drops generated in a single event move with the speed of the disc. There is no slip, which is not the case with the ligament mode of breakup. The intervals of quiescence between the successive release of drops from the entire disc follow the Poisson process.



1. INTRODUCTION

An incoming liquid jet spreads on a spinning disc as a thin film and emerges as fine drops. Spinning disc atomizers help produce agricultural sprays,[1] particles of controlled morphology by spray drying,[2,3] granulation of molten slags,[4−6] etc. A spinning disc can also mix two or more miscible liquid streams fed to it to facilitate chemical reactions[7,8] and synthesis of nanoparticles.[9] A recently developed contactor in our laboratory employs a spinning disc to generate drops of one liquid, which impinge on the rising film of another liquid on the cylindrical wall of a coaxially located rotating bowl.[10] The unidirectional flow on the bowl wall, driven by the centrifugal acceleration, sweeps away liquids to provide intense mixing with low back-mixing. We have synthesized sub-10 nm silver nanoparticles of narrow size distribution using a free impinging jet reactor and a spinning bowl spinning disc reactor.[11] The latter is easy to set up and operate. In this work, we focus on the process of drop formation from a spinning disc.

The flow rate and rotational speed are the two control parameters for a spinning disc. At a high flow rate, the incoming liquid leaves the disc edge as a thin sheet that disintegrates in the air to release drops. The sheet breakup mode[12] produces drops with poor control on polydispersity. At moderate flow rates, the liquid emerges as ligaments attached to the disc edge. The ligaments are of nearly fixed shape and orientation.[13−15] They release drops from the free end by the Rayleigh−Plateau instability. The drop formation in jetting mode from a capillary (away from the capillary tip by jet instability) is analogous. Peng et al.[15] have studied regime changes with flow rate and rotational speed using high-speed imaging. The improved control on drop release in ligament mode has led to studies on discs of different designs.[16−20] Guided drop formation in ligament mode is recently achieved by Wang et al.[21] using a stacked serrated disc. The authors suggest that pointed tips in their disc increase the frequency of drop formation by promoting jet formation for low-to-moderate viscosity liquids.

At low inflow rates, the drop formation occurs at the disc edge. To the best of our knowledge, there are no systematic studies on this mode of drop formation from a spinning disc. The drop formation from a capillary tube in dripping mode is analogous, for the tube end exposed to air or another immiscible liquid, stationary or coflowing. Microfluidic systems extensively use the latter to generate controlled size drops continuously. Drop formation from a hydrophobic disc is qualitatively different, as shown by the high-speed images of Wu et al.[22] and is not addressed in this study. Figure 1 schematically brings up the basic difference between direct drop and ligament modes of drop formation.

Perhaps the earliest study on drop formation from a capillary tube under gravity goes back to 1864 by Tate,[23] who argued

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ORIGINAL PAPER

Electrodeposited mixed ZnS–CdS photoelectrode for natural dye-sensitized solar cells (NDSSC)

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Abstract: Photoelectrodes and sensitizers are the vital components of future low-cost dye-sensitized solar cells which are used to meet the present energy demand. Herein, ZnS–CdS thin film photoelectrodes (WE) prepared on steel substrate by electrodeposition method are sensitized by chlorophyll extract and combined with graphite counter electrode, both being dipped in sulphide–polysulphide redox electrolytes (S^{2-}/S_n^{2-}) to form the dye-sensitized solar cells with the following configuration:photoelectrode + dye//$Na_2S(1M)$ + NaOH(1M) + S(1M)//C(Graphite).The photoelectrochemical characterizations of the dye-sensitized thin film photoelectrodes under investigation include current–voltage (I–V) characteristics in dark and light, spectral photoresponse and cells power output. Photoelectrodes are found to be n-type semiconductors. From the power output curves, the light-to-electricity conversion efficiency of dye-sensitized ZnS–CdS electrode (8 h sensitization)-based solar cells, short-circuit current density (J_{sc}) and open-circuit voltage (V_{oc}) is found to be 0.29, 0.51 mA/cm^2 and 0.34 V respectively. The PXRD results show that the fabricated mixed ZnS–CdS thin films are made up of nanocrystals of size $\sim$ 9.12 nm. Surface morphology of the films is studied, and SEM micrograms establish the polycrystalline nature of mixed ZnS–CdS thin films. The EDAX (energy diffraction analysis of X-ray) results show the presence of Zn, Cd and S in the thin films.

Keywords: PXRD; SEM image; Chalcogenides; Thin films; Liquid Junction; Mixed compound photoelectrodes

1. Introduction

Rapid urbanization, growth of population and industrial evolution result in an extraordinary increase in global energy demand. Electrical energy which is used extensively by majority of people in the world is primarily produced from fossil fuels such as coals, natural gases and crude oils. These fossil fuels being non-renewable cannot be regenerated in short duration and on burning cause environmental pollution due to emission of greenhouse gases, anthropomorphic climate change, health hazards and global warming. In order to address the dangerous effects of fossil fuels and their depletion, sustainable energy is the only option as it is replenishable, can be used over and over again, available widely free of cost and helps to reduce the adverse effects of non-renewable sources as stated above. Out of all the renewable energy sources such as solar, wind and hydropower, solar energy has been found to be the most promising candidate for production of electrical energy [1, 2]. Harvesting of solar energy became easier after the development of photovoltaic technology in which sunlight is directly converted into electricity. The technologies are mostly divided into three groups/generations. First, solar cells are manufactured by single-crystalline semiconductor wafer which are costly, second based on inorganic thin film assembly. Quantum dots and dye-sensitized solar cells are the third-generation solar cells which are economical, environmental friendly and high efficient devices [3], and more number of photons can be converted to electrical energy [4, 5]. In DSSC, wide band gap semiconductor electrodes are sensitized by dye molecules which are excited by visible light [6]. The elements of IIB–VIA and VA–VIA group of mixed chalcogenide semiconductors are significant materials for photovoltaic applications [7, 8]. A number of materials have been

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ORIGINAL RESEARCH ARTICLE

Effect of Annealing Temperature on Copper-Doped Nickel Oxide Nanomaterials for Efficient Degradation of Methylene Blue Under Solar Irradiation

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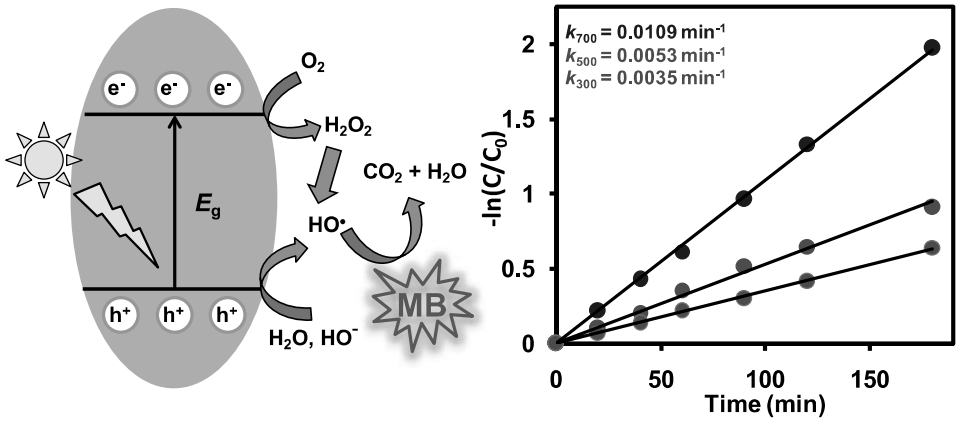
Abstract

Copper-doped nickel oxide nanomaterials (Cu-NiO_x@300, Cu-NiO_x@500 and Cu-NiO_x@700) were prepared by co-precipitation of Ni(II) and Cu(II) hydroxides followed by treatment of the solid material at different annealing temperatures (300°C, 500°C and 700°C). The samples were characterized using a combination of spectroscopic and microscopic techniques including infrared (IR), UV-visible, x-ray diffraction (XRD), field emission scanning electron microscopy (FE-SEM) and energy-dispersive x-ray (EDX) techniques. While the XRD diffractograms indicated that the crystallinity and crystallite size of Cu-NiO_x@300, Cu-NiO_x@500 and Cu-NiO_x@700 gradually increased with a decrease in specific surface area, the UV-visible study suggested a decrease in the band energy gap with increasing annealing temperature. An increase in lattice constants for the Cu-NiO_x nanomaterials in comparison with NiO suggested the successful doping of Cu into the lattice of NiO. From the FE-SEM images it was also evident that the particle size increased with increasing annealing temperature, whereas elemental mapping indicated that Ni, Cu and O atoms were well dispersed on the Cu-NiO_x matrixes. Following pseudo-first-order reaction kinetics, Cu-NiO_x@700 exhibited the most efficient photocatalytic degradation of methylene blue (MB) ($k_{700} = 0.0109\ min^{-1}$) compared with Cu-$NiO_x$@500 ($k_{500} = 0.0053\ min^{-1}$) and Cu-$NiO_x$@300 ($k_{300} = 0.0035\ min^{-1}$) under solar irradiation.

Graphical Abstract



Keywords Cu-NiO_x nanomaterials · photocatalyst · band gap · dye degradation · methylene blue

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Inorganic Chemistry Communications

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Short communication

Synthesis, characterization and molecular docking study of Nitro(4′-(2-pyridyl)-2,2′:6′,2″-terpyridyl) Palladium(II) nitrate

Debakanta Tripathy [a b c], Amlan K. Pal [b d], Soumya Lipsa Rath [e], Garry S. Hanan [b], Binod B. Panda [c], Dillip K. Chand [a]

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Cleaner Engineering and Technology
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Study on relative shrinkage of cement-based micro-concrete for durable concrete repair

Dipti Ranjan Nayak [a], Rashmi R. Pattnaik [b], Bikash Chandra Panda [a]

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Abstract

This paper presents the investigation into the crack formation in micro-concrete due to their bond strength and drying shrinkage under normal and accelerated drying conditions at the interface between the substrate and micro concrete in a concrete repair. Investigated six different cement-based micro-concretes about their grain size, compressive strength, bond strength, and relative shrinkage values due to normal and raised drying temperature. Finite element analysis and microscopic study of crack development at the interface were investigated to strengthen the analysis of the crack developments. It was observed that the bond strength and drying shrinkage of the micro concretes influence the formation of cracks at the interface due to the relative shrinkage of the substrate and the micro concrete. The micro-concrete having high bond strength as compared to low bond strength micro-concrete, exhibits low crack width even though free drying shrinkage values are high in both case. Early detection of cracks at the interface in 3 days due to the combined effect of bond strength and drying shrinkage under accelerated drying conditions can be a helpful tool for selecting the micro concretes for concrete repair.

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Soil Stabilization by Industrial Waste (GGBS and Stone Dust)

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Abstract:- In the last century, there has been a considerable increase in population and rapid industrialization. The industries emit a large amount of industrial waste. Industrial waste occupied a large area of land. It creates a land problem and also pollutes the environment. To utilize the industrial waste, an attempt is made to stabilize the expansive soil by adding ground granulated blast furnace slag and stone dust. This project work aims to evaluate the effect of addition of 0%, 5%, 10%, 15%, 20%,25%,30% GGBS and Stone dust to stabilize the expansive soil and to verify its appropriacy to be used as a construction material for road, embankment and structural fills. In this project the effects of the addition of GGBS and stone dust are investigated and are compared with that of the virgin expansive soil. The testing of expansive soil was conducted in three phases. In the first phase, the physical properties of the expansive soil samples were studied by conducting Sieve analysis, Specific gravity, Atterberg limit, Light compaction test, CBR test, and UCS test. In the second phase of the test program, expansive soil was mixed with 5%,10%,15%,20%,25%,30% of GGBS, and stone dust as a percentage of the dry weight of expansive soil. Granulated shaped blast furnace slag and stone dust were most suitable for increasing the strength of the soil and for this the following property of soil was checked. GGBS and stone dust were added from 0% to 30% by dry weight of soil. The experimental investigations indicated that generally, the engineering properties improved with the addition of GGBS and stone dust. In the standard proctor test, the maximum dry density increased and the optimum moisture content decreased with increase in GGBS and stone dust content and at maximum increase in mechanical properties was obtained at 30% of GGBS and Stone dust.

Keywords: GGBS, Stone dust, Light compaction test, UCS test, CBR test

1. INTRODUCTION

Stabilization of soil was the process of change the properties of soil by improved its engineering properties. Expansive soils exhibit major volume changed due to change in moisture content. This causes the foremost damage to the structure constructed on them. The swelling and shrinkage behavior of expansive soil was attributed to presence of montmorillonite minerals. Once they absorbed water their volume increased. A land-based structure of any type was simply as strong as its foundation. For that reason, the soil was even be a critical element influenced the success of a construction project. Soil stabilization was maximizing the suitability of soil for a given construction purpose. Soil was stabilized by chemical, mechanical, thermal, and electrical methods. Since expansive soils have changed their volume to an extent, they caused damage to engineering constructions. Although mechanical compaction, dewatering, and earth reinforcement are found to strengthen the strength of the soils, other methods like stabilization using admixtures were more efficient. The numerous admixtures available are lime, cement, fly ash, furnace slag, etc. this stabilization, nowadays, was gained importance because of its abundant availability and environmental concerns associated with its production.

1.1 SIGNIFICANCE OF THE PROJECT

Soil properties was varied a great deal and the construction of structures depended upon the bearing capacity of the soil, hence, we have to stabilized the soil, which made easier to divine the load-bearing capacity and even improve it. The gradation of the soil was additionally a really important property to stay in mind while working with soils. The soils could also be well-graded which is desirable because it has less number of voids or uniformly graded which though sounds stable but has more voids. Thus, it's better to combined different types of soils to enhance the soil strength properties. It was very expensive to replace the entire inferior soil entirely and hence, soil stabilization was that the thing to seem for in these cases. It was more economical in terms of both cost and energy to extend the bearing Capacity of the soil instead of going for a deep foundation or foundation. It was also wont to provide more stability to the soil in slopes or other such places. Sometimes soil stabilization was additionally done to prevent erosion or formation of dust, which was extremely useful especially in dry weather. Stabilization was additionally finished soil waterproofing. This prevented water from get into the soil and hence helps the soil from losing its strength. It helped in reduce the soil volume change thanks to changes in temperature or moisture content. Stabilization improved the workability and therefore the durability of the soil.

1.2 SCOPE AND IMPORTANCE OF THE STUDY

The experimental study carried with the choice of an approximate sort of soil to realize a high degree of compaction and to show the compaction properties of expansive soil. The expansive soils are difficult to compact within the initial stage of compaction, but because the moisture content increased the compaction becomes quite easy. The study involved the usage of Ground granulated furnace Slag (GGBS) and Stone dust for the stabilization of clay soil, which is well mixed in several proportions as 5%, 10%, 15%, 20%,25%, and 30%. From the mixture, the effectiveness of the stabilizer is going to be determined by

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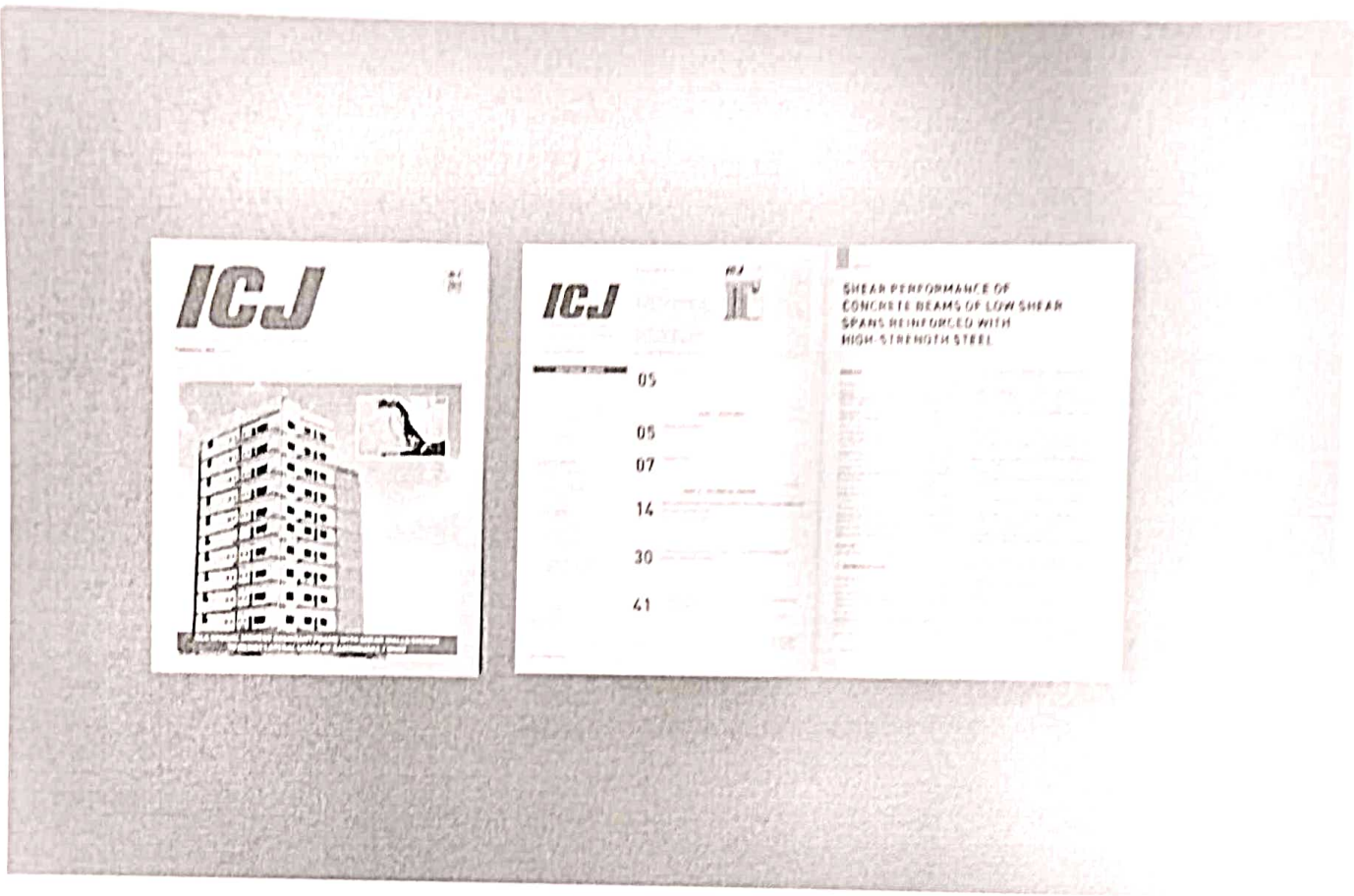

Shear performance of concrete beams of low shear spans reinforced with high-strength steel

Suraj Kumar Sahu, Dipti Ranjan Sahoo

This paper presents an experimental investigation on the shear behavior of concrete beams of low shear span-to-depth ratios with the high-strength reinforcing steel. Six beam specimens with two different grades of steel (500 and 550 MPa) as the longitudinal reinforcement and three different grades of steel (500, 550, and 600 MPa) as the transverse reinforcement were tested under monotonic loading conditions. Two different concrete grades were considered in the test specimens, whereas the shear span-to-depth (a/d) ratios were varied in the range of 1.05-1.70. The spacing of stirrups in the beam specimens was proportionately varied based on their specified yield strengths for a constant percentage of longitudinal steel. Test results showed that beams with low concrete

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A Machine Intelligence Based Model for the Classification of Odia Printed and Handwritten Images

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Abstract: Language plays an important role for the communication among all of us. It is very much essential to detect the printed and handwritten language from several images to extract crucial information from it. In this paper, a machine intelligence (MI) based model is proposed for the classification of Odia printed and handwritten language (OPHL) from the analysis of several Odia language images. The proposed approach is mainly focused on the machine learning (ML) based hybridization mechanism. This mechanism focuses on the combination of the ML based methods such as Logistic Regression (LR) and Neural Network (NN) for the classification of printed and handwritten Odia images. The proposed method is compared with the ML based methods such as Support Vector Machine (SVM), Decision Tree (DT), K-Nearest Neighbour (KNN), AdaBoost (ADB) and Random Forest (RF) methods in terms of Classification Accuracy (CA) performance metric. The proposed method is able to classify the Odia printed and handwritten images in a better way as compared to other methods. The simulation of this work is carried out using Orange 3.26.0.

Keywords: MI, ML, OPHL, SVM, DT, KNN, ADB, RF, LR, NN, CA

I. INTRODUCTION

Language is considered as an important factor for the communication among the human society. Currently, Language recognition and classification is considered as an important research perspectives. The language of entire human society mainly varies state wise of a country and country wise itself. The language can be classified as Indian, Chinese, Russian, Arabic, Spanish, etc. internationally or country wise. By considering the state wise scenario of the country India, the language can be classified as Gujarati, Odia, Tamil, Punjabi, Malayalam, Manipuri, Marathi, Urdu, Hindi, Bengali, etc. But, almost all the countries mainly focus on English language for the communication. In a particular state, the language also varies locally. The language can also be classified as printed and handwritten.

Language recognition and classification is very much essential for its wide variety of applications in the current scenario. Different techniques can be used to classify the languages which can help the blind people for their effective communication.So, it is very much essential to recognize and classify the languages properly as it is very much essential for the effective communication in the real world scenario.

Several research works have been carried out for the classification of languages [1-22]. MI plays an important role the classification of languages. Different ML [23] based methods such as SVM, DT, KNN, ADB, RF etc. can be used for such classification. In this work, we have proposed a model for the classification of Odia printed and handwritten languages from the analysis of several OPHL images. The proposed approach is focused on the combination of LR and NN MI based methods to carry out such classification.

The main contribution of this paper is described as follows.

- A MI based model is proposed for the classification of OPHL images into printed and handwritten category from the analysis of several OPHL images.
- This proposed approach is focused on the combination of LR and NN methods to carry out such classification.

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Research Article

Design and Implementation of a Floating PV Model to Analyse the Power Generation

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The floating photovoltaic (FPV) system is a revolutionary power production technology that has gotten a lot of interest because of its many benefits. Aside from generating electricity, the technology can also prevent the evaporation of water. The electrical and mechanical structures of FPV power stations must be studied to develop them. Much research on FPV technologies has already been undertaken, and these systems have been evaluated from many perspectives. Many problems, including environmental degradation and electricity generation, fertile soils, and water management, are currently limiting societal growth. Floating photovoltaic (PV) devices save a great of land and water resources and have a greater energy conversion efficiency than standard ground power systems. A performance investigation of photovoltaic (PV) installations set on a moving platform is carried out. The paper presents and discusses various design alternatives for boosting the profitability and efficiency of floating photovoltaic (FPV) systems. Especially, FPV systems that take advantage of increasing capabilities like monitoring, conditioning, and attention were included. Although researchers have agreed on the benefits of floating systems, there has been little in-depth research on the parameters of floating photovoltaic systems. The results of this research tests were performed, and these reveal that the beneficial monitoring and conditioning impacts result in a significant gain in performance. The effects of using flat reflections on improvements are also investigated. As a result, this research examines the evolution of photovoltaic systems, then investigates the power generation capacity of floating photovoltaic systems, and then examines the benefits and possibilities of floating PV systems in depth. The concept of developing an integrated air storage system using a floating building on waters is discussed.

1. Introduction

Electricity expenses have a significant impact on farmers' earnings currently. The primary reasons for agriculture's poor predicament include higher productivity expenses, limited farming sizes, competition for worldwide marketplaces, and a water shortage [1]. As a result of increased usage of water supplies and modernization initiatives implemented in recent years, the agricultural industry's power consumption is expected to rise. Water savings have resulted from the construction of more effective irrigated equipment, while energy consumption has increased due to increased filtering

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Modular unmanned aerial vehicle platform design: Multi-objective evolutionary system method ☆

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Abstract

For the air quality data collection, a great potential is offered by unmanned aerial vehicles (UAV) with spatial and temporal resolutions. The fast scientific development has enabled the class production of UAVs cost effective in which civilian applications are serviced. A modular UAV-based platform design and development are the objectives of this study. The system comprises of five modules like the UAV, the ground station, sensors, data acquisition (DA) module, and the data fusion (DF) module. With adequate flight time, UAV platform can fly on pathways which are predetermined as shown by the results of data collection missions. The high precision data and air quality are collected through the system simultaneously. In a real manner, they are integrated and visualized. The UAV system power consumption is measured on ground and flight. The consumed current reached about 30A when the UAV was in the air regardless the speed.

Introduction

The unmanned aerial vehicles growth is very fast in recent years in various fields like military and civilian domains. The sensing capabilities are powerful and the autonomy is high as the UAV is becoming smaller [1,2]. The multiple UAVs are consisted in the UAV network and the strong interests are attracted from the research communities. For many applications, the UAV networks are significant like public safety and transportation, etc. The UAV network technology is very significant as many issues are resolved by the UAV networks like Medium Access Control (MAC) and UAV coordination and cooperation [3]. The UAV networks have dynamic topologies unlike other networks with the nodes of UAVs fast changing numbers. Air quality improvement requires new techniques for the better identification and characterization of distributed pollutant sources. For the global disease burden, the identification of air pollution is as a risk factor [4,5]. The establishment of air monitoring network has been done for the air pollutants concentration monitoring in ambient air. To cover large areas, the current networks are not sufficient for the efficient control strategies implementation. The air quality data is gathered by the Internet of Things (IoT) by the worldwide consumers [6]. The massive sensors are deployed by the IoT solutions on the city infrastructure. The data is captured by

JAYA Algorithm-Optimized Load Frequency Control of a Four-Area Interconnected Power System Tuning Using PID Controller

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Abstract-This study examined the design of a Load Frequency Control (LFC) component in a four-area interconnected power system. LFC maintains the frequency of a power system within a prescribed limit. Various controllers for the LFC of a power system have been proposed. The PID controller is a classical approach to LFC. A PID controller that uses a filter in the derivative part amplifies and smooths out the high-frequency noise. The selection of the appropriate optimization method to tune controller gains plays a vital role for LFC. In this work, the PID controller was optimized using the Particle Swarm Optimization (PSO) and the JAYA optimization methods and was simulated in Matlab-Simulink. After studying and comparing the results, it was concluded that the PID controller using the JAYA algorithm provided better LFC in terms of system settling time, overshoot, undershoot, and performance index compared to other optimization methods.

Keywords-load frequency control; AGC; tie line; PIDN; PSO; JAYA

I. INTRODUCTION

An electric power system is a sequential arrangement of components to generate, transmit, distribute, and utilize power while continuously protecting it [1]. A power system has two important parameters that need to be constantly monitored and corrected: voltage and frequency. A generator generates power at some voltage and frequency, and these parameters should be controlled when there is a mismatch between active or reactive power generation and demand [2]. There are basically two methods to perform such control. When the active power demand is not equal to the active power generation, the frequency should be controlled, and when the reactive power demand is not equal to the reactive power generation, the voltage should be controlled [3]. Control of voltage and frequency can be performed in two ways, which are the primary and secondary control mechanisms. The primary control mechanism examines the aspects of generation, as generation remains constant most of the time while demand varies [5]. In the primary control mechanism, the Automatic Generation Control (AGC) has to match the demand by varying the generation. But in emergency conditions, where it is not possible to control generations, the load should be controlled, which is known as the load side management [6]. AGC can control voltage as well as frequency, i.e. load frequency control plus excitation control [7]. In AGC, there is a generator that generates active power P_g and reactive power Q_g. The generator gets input power from a turbine, and the turbine gets input power from the boiler [8]. While the steam comes from the boiler, there is a governor valve placed in the boiler to control the steam. When the active power is delivered to the bus, there is a comparator that receives and senses the frequency f_g coming from the generator [9]. The comparator has a reference frequency f_{ref}, which has to be maintained, and if there is any difference between f_g and f_{ref}, there will be an error f_e which will be operated by the generator valve. This whole closed loop is the LFC [10].

II. INTERCONNECTED SYSTEM

The operation of more than one interconnected areas is known as an interconnected system or power pool or pool operation [12]. Under normal operating conditions, each control area carries its own load and each control area adopts beneficial regulating and control strategies. These are two basic operating principles of a multi-control area system [11]. Unlike a small system, where a sudden change in load causes a large

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Controller Design for the Pitch Control of an Autonomous Underwater Vehicle

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Abstract-In recent years, the Autonomous Underwater Vehicle (AUV) has found its application in a large number of areas, especially in the ocean environment. But due to its highly non-linear nature with six degrees of freedom and the presence of hydrodynamic forces, the equations for AUV control become complex and difficult to design. Hence, in order to overcome this complexity and non-linearity, a reduced-order subsystem is derived for controlling the pitch. Linear Quadratic Regulator (LQR) and Fractional Order PID (FOPID) techniques have been applied for determining the controller for better performance of pitch control in the presence of disturbance.

Keywords-Autonomous Underwater Vehicle (AUV); IMC-PID; LQR; FOPID

I. INTRODUCTION

An AUV is an automatic submersible vehicle that can function in the absence of real time controller, without any human interference [1]. The presence of nonlinearity in the vehicle dynamics makes difficult to apply linear controller to the AUVs and the complexity in the dynamics of AUVs makes the design of its controller difficult. Due to the presence of high non-linearity, time-varying characteristics, unpredictable hydraulic coefficients, and the interference caused by sea currents and waves, the dynamics of the AUV become quite complex. The design of a controller for AUV is a challenging task as the complexity in design basically lies in finding the hydrodynamic parameters and the non-linearity in the dynamics of the vehicle [2]. In order to control the pitch of AUV many methods have been proposed. The LQR-based controller has been designed for the derived divine plane model of AUV and the performance is analyzed with Matlab/Simulink in [3, 4].

The current paper, gives a detailed study of the Particle Swarm Optimization (PSO) algorithm used to optimize the Fractional Order PID (FOPID) controller for obtaining a fast and robust response for the pitch control of an AUV [1, 5]. The parameters obtained using the PSO-based FOPID will be utilized for obtaining the response for pitch angle. The response of the PSO based FOPID controller is compared with the response of IMC-PID and LQR controllers. With the help of the response, Rise Time, Settling Time, Overshoot and Integral of Time Absolute Error (ITAE) can be computed. ITAE has been considered as the objective function [6, 7].

II. MODELING OF THE AUV

The mathematical modelling of an AUV requires the study of its kinematics and dynamics. The geometrical aspect describes the kinematics, while the dynamics of the vehicle describe and analyze the forces that cause motion [8]. To identify the location and direction of the AUV, the differential equation of the vehicle's 6-DOF (degrees of freedom) motion must be solved [9]. The positional and translational motion along x, y and z axes is represented using flow, amplitude, and heave [9] respectively, while the orientation and rotational motion are described with the help of roll, pitch, and yaw [1, 11, 12]

A. Vehicle Kinematics

A two-coordinate frame has been used to analyze a vehicle path with 6 DOFs [13]. Because it is attached to the vehicle, the moving reference frame is known as a body-fixed reference frame [13, 14]. An inertial frame is used to describe the trajectory of the body-fixed frame. With the body-fixed frame, we can characterize the vehicle's linear and angular velocities, whereas the inertial frame describes its position and orientation [1]. Six-DOF vehicle motion can be represented in a generic sense by the following vectors [14]:

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Controller Design for the Pitch Control of an Autonomous Underwater Vehicle

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Research Article

Hui Xie, Yatao Wang, Zhiliang Gao, Bibhu Prasad Ganthia*, and Chinh V Truong

Research on frequency parameter detection of frequency shifted track circuit based on nonlinear algorithm

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Abstract: The basic task of railway signal work is to ensure safe and smooth transportation, improve transportation capacity, and improve transportation conditions and quality. Since it carries important information and control technology; it must be characterized by high security and high reliability. To address the aforementioned issues, this study uses a nonlinear technique to provide high-precision real-time detection of frequency shift signal parameters, based on an investigation of the sources of spectrum leakage in the FFT transformation. It not only reduces the sampling time but also the computation time when compared to the nonlinear method. This paper presents a frequency shift track circuit parameter based on nonlinear algorithm, studies the application of frequency shift signal parameter detection based on nonlinear algorithm, and simulates it with MATLAB. The experimental results show that the errors of center frequency, low frequency, and frequency offset are distributed in the range of ±0.05 Hz, ±0.005 Hz and ±0.15 Hz, respectively, which meet the parameters of frequency shift signal. The algorithm can meet the requirement of technical indexes and shorten the sampling time, which provides a theoretical basis for the design of the real-time frequency shift signal parameter tester.

Keywords: Frequency shift signal; frequency resolution; nonlinear algorithm

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1 Introduction

Railway plays an essential role in the development of the national economy. The main function of railway signals is to ensure traffic safety and improve transportation capacity. The switch of safety signals at any moment can cause a disastrous situation and it's a matter of many lives and the government property. Since, with the rapid increase in population, the railway tracks are too busy and proper functioning of the track signals is the matter of priority. Various sensors operated with the artificial intelligence tools and data analytics has been employed in train operations to improve the efficiency of operation. Many algorithms are proposed for the allocation and optimization [1, 2]. To ensure driving safety, the relevant operation parameters of the track circuit need to be detected regularly in daily maintenance. However, the current track circuit mainly uses frequency shift signal as control information, so timely understanding the status of the frequency shift signal of track circuit can provide great convenience for line maintenance work. In the railway equipment system, the railway signal carries all kinds of information states [3]. It controls the running direction, running line, running speed, and running interval of the train and shows the running state and line of the train. Railway signal equipment is an important technical equipment to ensure the safety of train operation and improve transport efficiency [4]. It can control the safe operation of trains by sending various control information to trains, thus, it effectively ensures the smooth and orderly operation of railway transportation dispatching and command, improves the railway transportation management level on the one hand, and improves the safety level of train operation on the other hand, the safety of people's lives and property has been effectively guaranteed [5]. Since the 1980s, with the continuous emergence and development of new technologies, modern communication technology, microelectronics, computer control, and other advanced technologies have been widely used in railway signals, it integrates the process of information collection and processing with the control, which makes the modernization

Monitoring Nonlinearities and Power Smoothing in Modified Mathematical Modeled Type-III Wind Turbine System using Artificial Neural Network

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Abstract

For feasible wind power generation the speed of the rotor should be maintained balanced with respect to the production of generator power. This research introduces a sliding mode controller to manage wind speed and preserve system stability. It is useful to reduce the nonlinearities using an Artificial Neural Network based Radial Basis Function Neural Network (RBFN). The tip speed ratio technique is utilized in this paper to harvest the most power from wind energy. To optimize this Tip Speed Ratio (TSR) approach, a Proportional-Integral PI-RBFN tuned sliding mode controller was employed to obtain maximum power while minimizing active power losses. Nonlinearities in the pitch angle due to variable wind speed can be solved using this proposed technique. Hence in this paper the robustness of the modified Type-III wind turbine system is studied using MATLAB Simulink. The Simulink results are compared with the existing technique of Double Fed Induction Generator (DFIG) based modified Type-III wind turbines.

Keywords

Wind energy, Type III Wind Turbine, Wind Speed, Pitch Angle Control, RBFN, Sliding Mode Control, Power Smoothing.

1.Introduction

Wind energy, being a renewable source of energy, is now in high demand across all power sectors due to its clean and abundant nature. It could be critical in balancing power demand and increasing energy efficiency for business and residential utilities [1]. The best part about this type of energy is that it does not pollute the environment by generating toxic gases. As a result, it is employed to meet our energy needs as a useful source of energy. To attain high output, a balanced and dependable power system with complete control is essential [2]. Renewable energy sources are becoming increasingly crucial in the huge Generation, Transmission and Distribution system's balancing [3]. We now produce 15 to 20 million Megawatt of power from renewable sources, with wind being the most cost-effective [4]. This can be utilized in both independent and grid-integrated modes to balance out power needs. For complete control over power generation, transmission and distribution, a technical wind turbine system requires both mechanical and electrical components. We started with double fed induction generators, which have no control mechanism and generate losses owing to abrupt variations in wind speed because they are designed for fixed speed operation [1] [16]. Later on we developed the type-III wind turbine system which uses DFIGs with full control over speed and power generation. These are designed with Rotor side and grid side converter based with Maximum power point tracking abilities. Then type-IV PMSG based but the cost is so high, these mechanisms are less used in the world. In our country India type –III DFIGs are maximum used and play efficient power generations in both standalone and grid connected mode. But the controller to the rotor side and grid side should be more precise and faster responsive techniques should be implemented. Many researchers are using adaptive techniques like genetic algorithms, Artificial intelligence and meta-heuristic controllers for fault analysis during transients [1][2]. Fuzzy logic controllers are another example of a control approach that can be used to provide a quicker response to transients. Because the wind energy system requires a steady wind speed for reliable power generation, the wind speed should be balanced between low and high speeds. Wind flow might be unpredictable, causing harm to the system, so the controllers for the rotor and grid should be thoroughly evaluated and implemented [2] [3].

2.Literature Survey

The Lyapunov-based sliding mode control (SMC) approach has a number of advantages over previous approaches. For many practical systems, it has been recognized as one of the most effective design methodologies [1][4]. It may be used to tackle issues that are both linear and nonlinear. It may be used for both continuous-time and discrete-time systems, and it has long been regarded as a reliable control system approach due to its simple design procedure and robustness to system uncertainties and external disturbances. SMC's purpose is to transfer a system route's state to an appropriate area in a finite period of time and keep it there. After that, the problem region is labeled as a sliding surface or switching, implying that the system state variables are related. [3][5] It is completely defined by a differential equation that defines the dynamics of the system. Dynamic sliding mode describes the system's behavior as it moves across the sliding surface. Chattering, a type of high-frequency oscillation that can cause system instability and damage, is one of the most common and major undesirable phenomena that SMCs experience. SMC was used in this work to control and regulate nonlinearities in order to get the most power out of it [6][13][15]. The adaptive

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ORIGINAL CONTRIBUTION

Fault Analysis of PI and Fuzzy-Logic-Controlled DFIG-based Grid-Connected Wind Energy Conversion System

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Abstract This research is based on the design of modified version of Type-III wind turbine system using DFIG (Double-Fed Induction Generator). The control technique associated with Type-III wind turbine system is Modified Type-I Fuzzy Logic Controller. Using this advanced form of controller, four different models are designed to control the active and reactive power during the transients and unwanted faults cause voltage sags. Mechanical Drive Train-modified Type-III DFIG-based wind turbine system during various fault conditions like voltage dip conditions, swell conditions with respect to variation in wind speed is explained in MATLAB model with control action of PI controller and Fuzzy Logic Controller (FLC) with grid integration. The research highlights implementations of four types of Fuzzy structures with different modes of operations that are modeled, and comparisons were made between all the structures with PI control structure for both steady state and dynamic state. The model is assembled to the lattice of grid, and the control of the model mechanisms using PI and FLC is studied to estimate the fast response of settling time after the removal of faults. The simulation is done to find the effective controller with respect to cost and economic point of view. The model is based on transient responses to calculate the settling time with application of various fault conditions. In this paper, DFIG, i.e., Double-Fed Induction Generator, is operated through variable speed and variable pitch angle control scheme which is now mostly implemented in power generation and distribution industries. In this paper, DFIG in wind turbine model is assembled to a constant frequency and constant voltage source and tied into a grid which is modeled using MATLAB and to the corresponding generator for operation and control action on active and reactive power are highlighted. The steady state operation and transient characteristics of the whole wind energy conversion system is explained with detail study with respect to the transients due to sudden change in wind speeds.

Keywords DFIG · WECS · GSC · RSC · FLC · PAC

Introduction

The study depicts wind energy system is now the most efficient, ecofriendly and economical source of energy among renewable sources, i.e., solar power, wind and tidal. Wind energy is most abundant, available with no operational cost, and it is away from the releasing any gases which cause harm to our environment at any form. The wind energy system has the high conversion efficiency, and overall environmental harmless makes it most favorable choice as a supply of renewable strength to utilize for the source of energy for humanity [1]. Wind generators are much sensitive to the grid disturbances like faulty condition and voltage dips, etc. During fault conditions, over currents reflect to the RSC through stator and rotor. To protect the system during this condition, crowbar protection is used on the rotor windings to disable the RSC temporarily. Whenever there is a fault occurred, the high magnitude fault current is diverted by the crowbar resistance; thus, the rotor-side converter (RSC) is protected. But

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LOW VOLTAGE RIDE THROUGH CAPABILITY ENHANCEMENT USING SERIES CONNECTED FACT DEVICES IN WIND ENERGY CONVERSION SYSTEM

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Abstract

The complete assessment of the various strategies used to decorate the skills of Low Voltage Ride Through (LVRT) of Double Fed Induction Generators (DFIG) primarily based Type-III wind turbine systems (WT) explained in this research paper. In this paper, simulation results in MATLAB show that a DFIG based Type-III wind turbine system do not have the LVRT capacity due to insufficient reactive power support during disturbances using conventional PI controller. Hence using proposed Mode 4 Type-I fuzzy logic controller in associated with series connected FACTS devices can improve the LVRT capacity of DFIG based WECS, with DVR providing better VAR compensating capacity than other series connected FACTs devices. Type-III wind turbine system with DFIG based WECS has better LVRT capacity and voltage stability due to its real and reactive power control ability using proposed controller technique. Therefore, unique LVRT approaches based at the implementing additional active interface technologies had been proposed in this paper. Many techniques are developed nowadays to overcome the issue of this low voltage due to faults. This paper tries to define such active methods to short the gap by presenting a complete analysis of these LVRT strategies for DFIG based WECS in terms of overall adaptive performance, complexity of controllers, and cost effectiveness using fuzzy logic controller. Here characteristic of this paper is to highlight the methods for increasing the ability of LVRT relying on the configuration of the relationship into 3 major areas according to its grid integrations. In this paper smooth and simple series connection of FACT devices are used in WECS to study its effectiveness and benefits. The mathematical models of the whole system are simulated through MATLAB Simulink and results are discussed. In this paper all the types of wind turbine systems (Type-I and Type-II) are implemented by FACT devices with comparison to previous works and the faster FACT device is used on new proposed Type-III wind turbine system with fully control mechanisms (aerodynamic, mechanical, electrical and drive train system) are introduced to get more stability in the power system operation and control.

Keywords: DFIG, FACTs, FSIG, LVRT, Type-I FLC, Type-III WT, WECS.

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Review Article

A Comprehensive Examination of Bandgap Semiconductor Switches

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Improvements in the material characteristics of bandgap semiconductors allow the use of high-temperature, high-voltage, and fast switch rates in power devices. Another good reason for creating new Si power converter devices is that previous models perform poorly. The implementation of novel power electronic converters means high energy efficiency but a more logical use of electricity. At this moment, titanium dioxide and gallium nitride are the most prospective semiconductor materials because of their great features, established technology, and enough supply of raw components. This study is focused on providing an in-depth look at recent developments in manufacturing Si-C- and high-powered electronic components and showcasing the whole scope of the newly developing product generation.

1. Introduction

Using electronic switching devices is the most efficient way to handle electrical energy. As of today, over 40% of global energy is used to generate, store, and distribute electricity, making power electronics a critical part of the process. On power electronic converters, the power semiconductor devices' losses account for a substantial percentage of the energy loss. Si's blocking voltage capabilities as well as the operating temperature and switching frequency have been proven to be limited [1–5]. So far, the maximum commercial breakdown voltage for Si IGBTs is 6.5 kV, and the device must operate at a restricted switching temperature of 200°C.

Currently used power converters must contend with certain inevitable physical limitations, including costly cooling systems and costly passive components. As a result, we may anticipate a young generation of power converters that use wide bandgap semiconductors. Enhancing the performance of the power transformations will enable better overall utilisation of energy and improved size and durability of power converters [6–10].

According to researchers, silicon carbide (Si-C) or gallium nitride (Ga-N) are considered the most promising

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Implementation and Analysis of Mathematical Modeled Drive Train System in Type III Wind Turbines Using Computational Fluid Dynamics

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ABSTRACT

This paper is based on designing a modified rotor for a drivetrain in a Type-III wind turbine system for maximum power generation to work effectively under low and high wind speed and its variation. In this paper three drive trains are designed for the gearbox to provide regulated torque and thrust force. For time to time variation in wind speed the voltage sag and during over speed condition voltage swell problem can be solved by using this modified design. The pitch control, gear box and yaw of the wind turbine basically focused for modification. Mainly the gear box for the rotor causes sluggish motion of the rotor during low wind speed. This paper explained the design of modified rotor control for the gear box in DFIG based (Type-III) wind turbine. Also in this paper how the modified rotor system can be helpful for reactive power control highlighted with comparison with existing models. For designing MATLAB Simulink platform is taken and validated using CFD mechanical design analysis. Using these types of modified drive trains maximum power for the wind turbines is enhanced by 40–60% of its reference value.

Keywords: type III wind turbines, gear train, pitch control, gear ratio, pitch angle, yaw system, angular velocity, CFD.

INTRODUCTION

Renewable energy sources such as wind energy have grown significantly in recent years, while nonrenewable sources such as coal, petroleum, natural gas, large and medium-sized hydropower are depleting. These days energy from wind gained more attentions around world. Energy from wind using wind turbine has gained more concentration which made long blade design and also manufacturing of large horizontal-axis wind turbines has increased with a cost advantage. For the wind turbine, its unit cost will decrease with the raise of single-unit power. In the wind turbine, energy is produced by blades by means of transmitting torque. The stiffness of the blade is the major factor when designing for massive structure. The blade must also have sufficient bending stiffness to avoid blade tips from colliding with the tower under extreme wind load condition. Providing sufficient bending stiffness will increase the weight of the blade. The heaviness of blade material has a considerable influence on the operation, fatigue life and energy output of the wind turbine and also this leads to transportation problem. This invention provides modified rotor to reduce the weight of the blade and to overcome above stated problems. Since the past two decades, the milieu has witnessed a plethora of energy related issues owing to fossil fuel depletion as in case of coal and oil. Also, continuous utilization of such fuel has lead to various environmental concern.The present scenarios globally imposes the scientists and engineers to switch over to renewal energy sources (RESs) like wind and solar energy etc. [1]. In the process of extracting the electric energy out of the wind energy, there lies certain mechanical

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Nonlinear dynamic measurement method of software reliability based on data mining

Yinsheng Fu, Jullius Kumar, Bibhu Prasad Ganthia & Rahul Neware

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Abstract

Developing high-quality software is the ultimate goal of any software development organization. But the major challenge is to achieve good quality. It can usually only be measured after delivery, and reliability is the primary measure of software quality. During development, there are many attempts to assess software quality. To solve the reliability problem of evaluating software, the data mining model of BP neural network is proposed to predict the reliability of software. Firstly, data mining is carried out on the number of faults of the software, and data such as the cumulative execution time and the corresponding observed cumulative number of faults in the testing process

Open Access Article

LOAD FREQUENCY CONTROL OF MULTI AREA SYSTEM INCORPORATING DISTRIBUTED GENERATION RESOURCES USING CLOSED LOOP CASCADE OF 3DOFPID-FPID-TID CONTROLLER

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Abstract: This study emphasis on load frequency control (LFC) to retains the deviations of system frequency and tie line power at their preferred values by maintaining the steadiness between power generation and demand. It defines the importance of integrating distributed generation (DG) resources with existing power system in terms of system dynamic performance. A maiden attempt has been taken to apprehend and deliver CC-3DOFPID-FPID-TID controller with DG resources for frequency and power stabilisation of an interconnected power systems. Cascaded two loop controllers are used here as a substitute to relieve the closed loop system by means of secondary feedback planning. The suggested controller incorporates both the value of cascade (CC) and fractional order (FO) controls for restored eradication of system insecurities. In this recommended cascade –three degree of freedom proportional integral derivative-fuzzy proportional integral derivative –tilted integral derivative (CC-3DOFPID-FPID-TID) controller, slave controller action is performed by tilted integral derivative (TID) and foremost action is governed by three degree of freedom proportional integral derivative-fuzzy proportional integral derivative (3DOFPID-FPID) controller. The controlled parameters are optimized by adaptive symbiotic organism search (ASOS) algorithm for intense outcomes of difficulties in LFC. To persist in ecosystem, adaptive symbiotic relations are expectable by organism through ASOS imitators. Further the dynamic behaviours of proposed controller optimized by ASOS,

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Application of Series Connected FACTS Devices for Low Voltage Ride Through Capability Enhancement using Phasor Measurement Unit in Wind Energy Conversion System

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Abstract

The highlights of this paper are the use of Type-III wind turbine system in application of heuristic intelligent controller (PMU) with reactive power compensation and conventional FACT devices to maintain the overall stabilities of the grid system. The complete assessment of the various strategies used to decorate the skills of Low Voltage Ride Through method (LVRT) in Double Fed Induction Generators (DFIG) primarily based Type-III wind turbine systems (WT) explained in this research paper. As the world is using about 20% to 25% of renewable energy from wind using DFIG primarily based WT machine is at once connected to the grid without the digital interface of power, as a result the terminal voltage or reactive electricity output can't manage. Therefore, unique LVRT approaches based at the implementing additional active interface technologies had been proposed within this paper. Many techniques are developed nowadays to overcome the issue of this low voltage due to faults. This paper tries to define such active methods to short the gap by way of presenting a complete analysis of these LVRT strategies for DFIG based WECS in terms of overall adaptive performance, complexity of controllers, and cost effectiveness. Here characteristic of this paper is to highlight the methods for increasing the ability of LVRT relying on the configuration of the relationship into 3 major areas according to its grid integrations. In this paper smooth and simple series connections of FACT devices are used in WECS to study its effectiveness and benefits. FACTS devices are mainly run on sensor based conventional SCADA framework, adaptive techniques like state estimation algorithms and smart power equipments like PMU. In this paper PMU is used as intelligent controller to enhance the stability of the power system. This heuristic technique helps in identifying the optimal location to use the minimum number of PMUs that can make synchronization between the grid and the grid parameters using FACT devices. This model simulated in MATLAB and hardware implemented filter and validated by IEEE 14 bus system with mathematical models of the Type III wind turbine (WT) system.

Keywords

LVRT, DFIG, Type-III WT, WECS, FACT, PMU, ZIB, MMR.

1. Introduction

The objective of this paper is decreasing ozone depleting substance discharges is the vital issue which related with the development and entrance of sustainable power sources. Introduced Wind Turbines (WTs) are focused on power system stability using grid integrations to enhance the power quality during faults. However, grid integration into the wind energy system of large WTs can cause serious side effects in poor or weak grids. The inclination towards more WT integration is to build the present degree of the unbalancing just as decline the voltage over the wind generators system, which can prompt the fault clearances of the WT. As of late, many power system techniques are in everywhere throughout the world have started to grow and alter their correspondence prerequisites for wind cultivates by

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ORIGINAL ARTICLE

Positional Identification Based Whale Optimization Algorithm for Dynamic Thermal–Wind–PV Economic Emission Dispatch Problem

Samita Padhi[1] · **Bibhu Prasad Panigrahi**[1] · **Deba Prasad Dash**[2]

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Abstract
Global warming is the latest important discussion, and that is due to byproducts such as SO_x, CO_2, and NO_x, and all countries have started the initiation to minimize the emission level. For environmental concern and the welfare of society, the emissions have to be minimized. Every electrical power generation company also needs to minimize the cost of operation for better use. This paper uses different constraints to reduce both the generation cost and emissions. Because the thermally operated power plants are non-convex and non-linear in nature, the emissions produced during generation are a complex mathematical problem. To improvise the issues, we introduced renewable energy sources (RES) generation such as wind and solar power along with the thermal power plant to analyze the Dynamic Economic Emission Dispatch (DEED). From an environmental point of view, RES is used to reduce the level of environmental emissions. A position-based Whale Optimization Algorithm (PWOA) is projected as the extension of WOA to upgrade the performance by accelerating the rate of convergence and improving its capability. To verify the reliability and accuracy of the PWOA and solve the DEED problem, we utilized the IEEE-30 bus 6 thermal unit and IEEE-57 bus 7 thermal unit testing systems, considering both the conditions with and without RES generation. The outcome obtained from the simulation using PWOA shows the accuracy and efficiency of the method for the reduction of operational cost and obtained emissions.

Keywords Dynamic economic emission dispatch · Position-based whale optimization · Wind power · PV power · Hourly generation

Introduction

Thermal power plants, as we know, are the base load plants that generate the majority of the electrical power. Its primary fuel is fossil fuel, and after burning to generate heat, the emissions are released into the environment. This emission consists of SO_x, CO_2, NO_x, etc., which are very harmful to the environment. India uses thermal power plants to satisfy the major portion of its electric power demand and cause harmful emissions. For the safety of our environment, it is necessary to diminish the emission level. For sustainable development, emissions have to be minimized, but on the other hand, the growth of the population and technological advancement require more and more generation of power. Due to this, demand for base and peak load increases. Normally, thermal power plants are used for base load demand. To reduce the generating cost and emission level to a minimum value, non-conventional power sources may be used. But these types of plants depend on environmental conditions and vary from time to time.

Problems associated with DEED are considered as a multi-objective optimization issue used for minimizing the fuel cost and environmental emission level by dispatching generating power subject to different constraints within the power system. Solving these two different objectives within a single model is a difficult task. So, to reduce the complexity of two objectives, it is required to reduce them into a single objective problem. To improve the ED problem in practice, the model was modified to a dynamic system of demanding loads over a single day (a 24 h span). As development is linked to renewable sources, technology is rapidly increasing, incorporating the inclusion of RES to reduce harmful emissions, i.e., wind power sources and

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ORIGINAL CONTRIBUTION

Improvement in Fault Tolerant Capability of ST-DTC for Five-Phase Induction Motor using Neural Network

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Abstract The performance of switching table-based Direct Torque Control (ST-DTC) depends on number and type of switching states. If there are greater number of switching states and are distributed uniformly in the space, then DTC can handle not only different types of loads but also it can be operated in smoother way during high and low speed operation. When DTC is considered for fault tolerant drive, there are uneven distributions of switching states. In this context, higher level inverter can be preferable as it gives greater number of switching states which are distributed nearly uniformly in the space. The artificial neural network (ANN)-based DTC has the capability to handle such situation in better way if the training data are properly prepared. In this paper, the improvement of fault tolerant capability of ST-DTC with three-level inverter (3-LI) and ANN-based DTC for a five-phase induction motor (5PIM) with one phase open (phase 'a') are compared. The result shows that the use of ANN for fault tolerant DTC reduces the torque and current ripple by 3% and 3.36% respectively. The 5PIM 3-LI gives an opportunity to use five-level torque comparator to handle transient and steady-state load separately. Moreover, with ANN-based DTC, the torque and current ripples are further reduced.

Keywords Three-level inverter · Fault tolerant capability · Five-phase induction motor · Open phase winding · ST-DTC · ANN-based DTC

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Introduction

Generally, the induction motor is controlled through an inverter whose legs and level can be increased. Because of this, the researchers are trying to exploit the advantage of multiphase induction motor like reduction in per phase current, reduction in torque ripple and fault tolerant capability, etc., to improve the overall system reliability as compared to its three-phase counterpart [1–4]. In case of three-phase induction motor (3PIM), if one of the phases is isolated due to fault, it is difficult to apply DTC. However, with multi-phase induction motor (more than three-phase), DTC can be implemented with reduced load. When ST-DTC is implemented to a five-phase induction motor with two-level inverter (5PIM-2LI) with one phase open, there are only 16 numbers of switching states which are not uniformly distributed in space. With use of five-phase three-level inverter to a faulty five-phase induction machine with one phase open, the switching states are increased to 81 and are distributed nearly uniformly in space [5–7]. This gives added advantage for selection of five-level torque comparator to handle the transient and steady-state loading separately.

In recent time, researchers are taking more interest on fault tolerant drive of multiphase machines (more than 3-phase) to improve the system reliability [3, 8, 9]. A fault tolerant DTC of a 5PIM applying virtual vector concept by setting the dwell time of the vectors of a particular sector for two-level inverter is explained in [10–12]. Model-based predictive current control technique also used to handle the fault tolerant drive [13]. The 5PIM is also capable to run with 3-phase operation mode by V/f control [14]. A six-phase induction generator can be operated with three open phases [15]. For reduction in torque ripple and to improve the dynamic response, different intelligent techniques such

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Strategic integration of photovoltaic, battery energy storage and switchable capacitor for multi-objective optimization of low voltage electricity grid: Assessing grid benefits

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ABSTRACT

Battery energy storage system has become an inevitable element in smart distribution network due to massive deployment of community level distributed photovoltaic power generation system. The battery energy storage system not only participates in the backup power supply but also have the potential to provide numerous distributed ancillary services. In this paper, Slime mold optimization algorithm is applied to optimally allocate the photovoltaic generation units, battery energy storage systems and switchable shunt capacitor banks in distribution network while minimizing the two objective functions i.e., active power loss of distribution system and annualized capital cost of integrated equipments (photovoltaic units, battery energy storage systems and shunt capacitors) simultaneously. The proposed optimization framework is implemented on an IEEE 33 bus distribution network for different cases and compared with Non-dominated Sorting Genetic Algorithm II. The comparison of simulation results for different cases reveals the promising advantages in various technical and economic issues along with an additional benefit of investment deferral for distribution feeder up-gradation up to a significant span of years.

Introduction

Realization of techno-economic proficiency of distributed generation (DG) technologies leads to suggestive restructuring of the existing distribution network. International Energy Agency [1,2] defines DG as a source of electrical power that can directly be installed in a distribution network at the load side in order to provide power to the consumers with utmost efficiency and reliability and also to improve the performance of distribution networks. The renewable energy resources such as photovoltaic (PV), wind turbine, combined heat and power (CHP) etc., if used as DGs can reduce the generation cost [3].

Increasing burden of load demand on existing distribution systems may cause the power system to experience different issues like voltage drop, reduction of voltage stability and increase in power loss. So, in recent years, electric power sectors have witnessed many reforms to supply power at maximum reliability which instigates the use of switchable shunt capacitor (SC) banks. As DGs produce power at the load end, they generally inhibit the need of up-gradation of existing power distribution systems which has a very constructive effect on energy infrastructure-related economy. But the proper allocation of renewable sources and SCs depends on load demand which is highly stochastic in nature. Thus, the optimal allocation problem becomes a bit tough to solve in real time [4]. Sensitive analysis can be performed to identify the critical weather parameters that affect the failure rates of the PV system [5].

So far, different methods have been incorporated to decide the ideal location of DG and SC along with battery energy storage system (BESS). BESS is also flexible enough to be integrated with other smart solutions, such as dynamic thermal rating (DTR) and demand side management (DSM) to form a smart grid, which has high reliability and efficient cost consumptions [6–11].

Authors in [12] suggested the methods of sensitivity analysis and Gravitational Search Algorithm (GSA) to allocate capacitors of suitable size in a distribution network. The precision and persistence of the implemented methodology were validated and confirmed on distribution network with different topologies of fluctuating sizes and complexities. In [13], Flower Pollination Algorithm (FPA), as an optimization algorithm, was proposed to get optimal size of capacitor in distribution grid. Here, FPA also

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H_∞ Load Frequency Control Design Based on Delay Discretization Approach for Interconnected Power Systems with Time Delay

Subrat Kumar Pradhan and Dushmanta Kumar Das

***Abstract*—This paper proposes a delay discretization based H_∞ load frequency control strategy for interconnected power systems. The effect of time delay is considered in the system for the design of stabilizing controller. To improve the tolerable delay margin of the system, a two-term state feedback controller structure is used. The controller requires delayed state information as control input. In the proposed approach, the amount of delay introduced in the state of the system, i.e., artificial delay, for taking control action is assumed to be constant. The approach is based on the discretization of this delay interval. In order to define a simple Lyapunov-Krasovskii (LK) function for each of the discretized interval, a stabilization criterion is developed in such a way that a single one satisfies the requirement of all the intervals. The developed criterion is computationally simple and efficient.**

***Index Terms*—Interconnected power system, load frequency control (LFC), state feedback controller, time delay.**

I. Introduction

In a large-scale power system, multiple control areas are connected through tie-lines. For supplying reliable and sufficient power of good quality, one of the most important components of the large-scale power system is the load frequency control (LFC) [1]. In LFC, the balance between power generation and demand needs to be satisfied. For LFC, some requirements must be taken into account such as: ① the minimization of the steady state error of tie-line exchanges and frequency deviations [2]; ② the optimal transient behavior [3]; ③ the optimal power dispatch [4], [5]. For interconnected power system, area control error (ACE) signal is used as an input for automatic regulation of frequency deviation [6]. And dedicated communication channels are used for the transmission of measured data from remote terminal units (RTUs) to the control center, and ACE signal from the control center to the generation station [7], [8]. During the modeling of interconnected power systems, it is unable to avoid the time required to collect the information of load frequency deviation by regulation station, and generate and transmit ACE signal from regulation station to different power system areas. This time lag or time delay in the system model makes the system dynamics infinite dimensional (infinite number of roots of the characteristics polynomial) [9]. The design of control algorithm is always a challenging task for such systems. This time delay in ACE signal may lead to oscillation and instability in power systems [10], [11]. For a reliable interconnected power system, the controller is to be designed without neglecting the delay factor in the system. Therefore, a delay-dependent stabilization criterion should be developed so that the maximum tolerable delay margin (MTDM) of an LFC scheme can be improved [10]-[13].

There has been available literature on designing suitable controllers for LFC scheme of an interconnected power system. One of the simplest controller, i.e., a proportional-integral (PI) control, is proposed in [5], [6]. To achieve better performance, some controllers such as H_∞ controller [14] and adaptive controller [4] are proposed. In [15], the effect of time-delay on LFC of microgrid is studied and a method is proposed to compute the delay margin. Various advanced control strategies are also proposed such as robust control design technique [16]-[18], H_∞ based decentralized control design [19], [20] and sliding mode control [21]. However, most of the advanced control strategies suggest nonlinear, complex state feedback and higher-order dynamic controllers. In fact, due to simple structure and effectiveness, simple state feedback and proportional-integral-derivative (PID) controllers are still preferred in industrial applications. To tune the controller gains, many methods are available such as fuzzy based tuning [22] and linear matrix inequality (LMI) based approach [10], [23]. In [12], a decentralized control strategy using two-term controller is proposed for the LFC problem. Though there are a number of control techniques available in literature to design a controller, H_∞ control technique is a very popular control technique for controller design. The H_∞ controller in a control system has some advantages such as: ① it achieves stabilization with guaranteed performance [24]; ② it increases the robustness against uncertainties [25]; and ③ it restrains interferences, unmodeled dynamics or both of them [26]. In [9]-[11], a logic of introducing an artificial delay in the state of the controller is proposed, which improves the tolerable delay margin of the closed loop system. Specifically, for LFC scheme, a two-

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RESEARCH ARTICLE-ELECTRICAL ENGINEERING

H_∞ Controller Design for Frequency Control of Delayed Power System with Actuator Saturation and Wind Source Integration

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Abstract
Inclusion of wind energy in power system network increases complexity of load frequency control (LFC). Time-delay and actuator saturation are two inevitable phenomena in LFC. This paper studies the problem on LFC design of wind-integrated power system (WIPS) considering the effects of actuator saturation and time-delay. Actuator saturation is represented by using two different methods such as polytopic method and sector bounding method. A delayed robust H_∞ load frequency controller design is proposed for WIPS with time-delay and actuator saturation. New delay-dependent H_∞ stabilization criteria with actuator saturation based on Lyapunov–Krasovskii functional are derived in linear matrix inequality framework. A two-area WIPS is considered as a case study to evaluate performance of the proposed LFC design.

Keywords Load frequency control · H_∞ Performance · Wind-integrated power system · Actuator saturation · Time-delay

1 Introduction

Modern day interconnected power system (IPS) includes renewable sources to meet the high power demand. Wind is one of the reliable renewable source, which has attracted more attention to include with IPS [1]. But, wind is usually variable because it is always affected by uncertain environmental conditions. Inclusion of large numbers of wind-driven generators into IPS creates significant variation of power generation [2]. Loads of IPS vary throughout a day which results fluctuations in power demand. IPS is disturbed by the variation of loads or wind source, and power generation does not match with load demand. So, power imbalance is established in IPS. This power imbalance causes frequency deviation in power system. The variation of load and fluctuation of renewable source may cause large frequency deviation in IPS, which makes the operation of power system unsafe, i.e. generators and other power devices deviate from their operating conditions in the entire power system network [3–5]. Thus, frequency regulation is very important for safe IPS operation. The large deviation of frequency can be maintained within tolerable limits by implementing an effective technique known as load frequency control (LFC) [6–9].

In the LFC scheme of IPS, frequency and tie-line power flows are measured and transmitted from remote terminal units (RTUs) to control centre via communication channel. The control centre computes control signal by using the information of frequency and tie-line power deviations and transmits the control signal from control centre to generating units via communication channel to regulate frequency deviation [10]. The transmission of measured and control signals through communication network in IPS always needs some time. Due to the time requirement in communication process, time-delay is appeared in LFC of IPS [11]. The existence of time-delay has an adverse effect on LFC. It deteriorates control performance or may cause instability of IPS [12,13]. The control signal generated by control centre is fed to the generating station actuator to obtain control action. But, magnitude of the input signal carried out by an actuator is limited. This limitation of actuator for input signal magnitude is known as actuator saturation [14,15]. Thus, LFC design without accounting actuator saturation phenomenon may result undesirable system response [16]. The simultaneous effect of actuator saturation and time-delay on LFC is a major issue. Therefore, design of LFC scheme for IPS should include actuator saturation and time-delay properly.

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Delay-discretization-based sliding mode H_∞ load frequency control scheme considering actuator saturation of wind-integrated power system

Subrat Kumar Pradhan[1] · **Dushmanta Kumar Das**[1]

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Abstract

This paper investigates the combined effect of actuator saturation and time-delay on load frequency control (LFC) of a wind-integrated power system (WIPS). Actuator saturation is represented in two different approaches such as polytopic and sector bounding. Delay-discretization-based sliding mode H_∞ control approach is proposed to design a novel LFC scheme. The proposed control scheme requires present as well as delayed states information as input to the controller. This requirement of control scheme is fulfilled by adopting a finite known delay. This finite known delay used in controller design is discretized into delay intervals. Lyapunov–Krasovskii functional is defined for each delay interval, and H_∞ stabilization criteria for the closed loop WIPS are derived in linear matrix inequality framework using Wirtinger-based inequality. The proposed control scheme is tested by considering a numerical example of two-area WIPS.

Keywords H_∞ sliding mode control · Linear matrix inequality · Lyapunov–Krasovskii functional · Time-delay · Actuator saturation · Load frequency control

1 Introduction

The high electric power need of present situation demands large scale of renewable source integration into interconnected power system (IPS). Wind has drawn more attention as a reliable renewable source to integrate into IPS [1–3]. Generally, wind speed is always fluctuated. Hence, electrical power of wind turbine

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Explicit model predictive controller for power control of molten salt breeder reactor core

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ABSTRACT

The molten salt breeder reactor (MSBR) uses liquid molten salt as fuel. The modeling of the control system for power control of the MSBR core is difficult due to the fuel fluidity. To solve this problem, an explicit model predictive control technique is adopted. First, the nonlinear modeling of the MSBR core is presented. Then, a linearized single-input-single-output model is established from the nonlinear MSBR core model. As the model predictive controller (MPC) has good control effect in tracking problems, an explicit MPC (EMPC) is designed for MSBR to control the power in core. The control of core power in the MSBR is studied for examples of load-following. Results of this study show that the power of MSBR core can be well-controlled by adopting EMPC.

1. Introduction

Molten salt nuclear reactor concepts are a fourth generation nuclear reactor used for electricity generation, hydrogen production, actinide burning, etc. (Nuclear Power Reactors in the World, 2019; Singh et al., 2017; Li et al., 2016; Guo et al., 2013; Abram and Ion, 2008; Haubenreich et al., 1964). Fluid molten fluoride is used as fuel, and graphite is used as moderator in a thermal or epi-thermal molten salt reactor. As liquid fuel is used in this reactor, there is no requirement for the preparation of solid fuel pellets and their encapsulation in bundles of rods. This avoids the danger of melting core and makes the reactor fuel efficient and more safe (Xie et al., 2021; Cui et al., 2021; Singh et al., 2018).

Despite these above advantages, some technical challenges arise in core power control of liquid fueled molten salt reactor in comparison to other fourth generation solid fueled reactors. Molten fuel fluidity causes decay of delayed neutron precursors in primary loop. So, effective delayed neutron fraction is reduced. Therefore, extra reactivity is required to compensate the loss of reactivity caused by the reduction of the delayed neutron fraction in molten salt nuclear reactors during steady-state operation (Zeng et al., 2020). The molten salt reactor experiment was conducted in 1965 and 1969 at Oak ridge national laboratory (ORNL), USA to demonstrate the key features of molten-salt breeder reactor (MSBR) (Kerlin et al., 1971; Rosenthal et al., 1972). The fully developed MSBR was designed in 1970s by ORNL. MSBR can convert Th-233 (fission nuclide) into U-233 efficiently, and realize effective breeding of U-233 (Rosenthal et al., 1972).

A few control methods have been applied to control MSBR core power, such as proportional-integral-derivative (PID) control method (Liu et al., 2009), internal model control based PID control method (Zeng et al., 2020; Pradhan et al., 2022), and fuzzy-PID control method (Zeng et al., 2020). The application of these control methods in core power control of MSBR has been successful. But, there are still some challenges in core power control, as the MSBR core is highly sensitive to fuel fluidity. Although traditional and hybrid PID control techniques are applied for the control of MSBR core power predominantly, the adjustment of controller parameters in PID control methods is a very difficult task (Zeng et al., 2020). Thus, the controlling of MSBR core power in an exact way is harder by adopting PID control techniques (Liu et al., 2009; Wang et al., 2017). Therefore, other control techniques should be adopted for swift and accurate control of MSBR core power.

Nowadays, the model predictive control method has been applied in various control fields because of its strong robustness and fabulous control performance (Wang et al., 2017). Recently, a model predictive controller (MPC) was designed to control the output voltage of an electrolyte fuel cell (Li et al., 2021a). An application of MPC for the reduction of energy consumption in gas compression system is presented in Giraldo et al. (2021). MPC is also used to manage the uncertainty of a remanufacturing system (Li et al., 2021b). The core power of pressurized water nuclear reactor has been controlled by using MPC (Wang et al., 2017; Eliasi et al., 2012; Wang et al., 2017). Generally, MPC creates a huge online computation (Wen et al., 2018). So, large memory space and computing power are required for the application of MPC. To avoid the

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Internal model control based proportional-integral controller with class topper optimization for power control of molten salt breeder reactor core

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ABSTRACT

Internal model control (IMC) method is based on mathematical process model to design the controller. In IMC method, the approximated object model is parallelized with the actual model. The inverse of invertible part of the approximated dynamic model and a low pass filter is considered in the proposed controller design. As an IMC approach has an intuitive design with simple structure and it does not need an accurate model of the object, to explore its application in power control, molten salt breeder reactor (MSBR) core is chosen. A proportional-integral (PI) controller based on IMC technology is designed to control core power of MSBR. The filter constant of IMC technology is optimized with Class topper optimization (CTO) algorithm which improves robustness of the control scheme. Power control of MSBR core is studied for load tracking with step disturbance. This study shows that core power is controlled by CTO based IMC-PI controller.

1. Introduction

Generation of electricity from nuclear power is a traditional electric power generation technology, which attracts worldwide attention at present due to the economic benefits of nuclear power based commercial electricity generation stations (Xie et al., 2021; Nuclear Power Reactors, 2019). Effective nuclear resources utilization, fuel consumption and radioactive waste disposal, and nuclear non-proliferation improve public trust and safety of nuclear power stations (Ashraf et al., 2021; Tripodo et al., 2021). Nuclear safety is a major issue after the accident in nuclear power plants at Three Mile Island in 1979, Chernobyl in 1986 and Fukushima in 2011. Therefore, the recent nuclear energy research focuses on the development of advanced concepts to design reactors, schemes for fuel cycle and utilization systems for nuclear resources (Kasten et al., 1966; Sides, xxxx; Wang et al., 2016).

Nuclear energy system of fourth generation selects six reactor types in 2002 for further research and development (Lake, 2002; Abram and Ion, 2008; Guo et al., 2013; Zeng et al., 2020a). One of the six types of fourth-generation reactor technology is the molten salt reactor (MSR). One type of MSR is the molten salt breeder reactor (MSBR). MSBR uses graphite and a solution of UF_4 in a solvent salt as moderator and fuel, respectively. Preparation of fuel element is not required for MSBR because the fuel used in MSBR is liquid. This avoids the danger in melting pile, makes MSBR high safe, and improves the fuel utilization efficiency (Xie et al., 2021; Cui et al., 2021). Solid fuels are used in conventional reactors where as liquid fuel is used in MSBR. Therefore, many challenges arise in theoretical modeling of MSBR and also in sustainable energy solution from MSBR. Thus, advanced and future nuclear power plants need more fundamental research on different items of MSBR along with suitable control application to get sustainable core power from MSBR (Ansarifar et al., 2016). In this present work, the control application in core power control of MSBR is studied.

There are some control applications available in recent literature for core power control of MSBR (Ansarifar et al., 2016; Zeng et al., 2020b; Liu et al., 2009). In Zeng et al. (2020a), a particle swarm optimization (PSO) based internal model control (IMC) scheme represented as PID controller is proposed for controlling core power in a nuclear reactor. In Zeng et al. (2020b), the control of a core-power for liquid molten salt-reactor is developed by using a fuzzy based PID controller. In Ansarifar et al. (2016), a sliding mode control logic is proposed for controlling power in the core of a fast nuclear reactor where an estimator of the density of neutron considering delay is discussed. The authors in Liu et al. (2009) have designed a fuzzy PID for the same purpose of power control in the reactor. In Jiang et al. (2020), fuzzy based multimodal scheme is applied for core power where the control of the switching of

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Improved Sunflower Optimization Algorithm Tuned Adaptive Type-2 Fuzzy PID Controller for Frequency Regulation of Renewable Power Integrated Hybrid Distributed Power System

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Abstract- The indeterminate characteristic of renewable sources makes present power systems very complex and introduces the frequency fluctuations. This work proposes a maiden application of an Improved Sunflower Optimization Algorithm (ISFO) technique tuned Adaptive Type-2 Fuzzy PID (AT2FPID) controller for frequency control of hybrid distributed power systems integrated with renewable sources. Initially, PID controller are considered and the dominance of ISFO over Sunflower Optimization Algorithm (SFO), Genetic Algorithm (GA) and Differential Evolution (DE) has been established. Performance comparison is carried out by assessing overshoots, undershoots and various integral errors due to Step Load Perturbations (SLPs) in each area. In the next stage, AT2FPID controller is considered and its supremacy to control the system frequency is demonstrated by comparing with Type-2 Fuzzy PID (T2FPID), Type-1 Fuzzy PID (T1FPID) and PID controllers for various cases.

Keywords- Sunflower Optimization Algorithm (SFO), Improved SFO (ISFO), Distributed Energy Sources, renewable sources, Frequency Control, Adaptive Type-2 Fuzzy PID (AT2FPID) Controller

1. Introduction

The integration of solar and wind sources to the grid, though decreases the dependency on fuel-based energy sources, introduces generation-load mismatch and hence frequency variation of 50 hertz. Load Frequency Controllers (LFC) are provided to regulate the frequency variations within the limits [1]. Various schemes have been presented in the literature for LFC [2-5]. In most cases, conventional power systems are considered but very few cases address the LFC in presence of distributed and renewable sources. This [illegible] based LFC schemes such as hPSO-PS tuned FLC [6], ICA tuned Fractional Ordered (FO) Fuzzy PID (FPID) [7] and BFOA tuned FOFPID [8]. When large uncertainties are present, the conventional fuzzy structure may not be effective and the controller structure can be modified to make it adaptive as proposed. The dual membership function-based Type-2 FPID (T2FPID) controllers, alternatively, give a better dynamic performance in this case [9]. This paper proposes an Adaptive Type-2 FPID (AT2FPID) structure to improve the performance of T2FPID [10].

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Combined fuzzy PID regulator for frequency regulation of smart grid and conventional power systems

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ABSTRACT

In continually increasing area and structure of modern power system having burden demand uncertainties, the use of knowledgeable and vigorous frequency power strategy is essential for the satisfactory functioning of the Power system. A combined fuzzy proportional-integral-derivative (CFPID) controller is suggested for frequency supervision of the power system. To optimize the controller parameters, a revised sine and cosine work adjusted improved whale optimization algorithm (SCaWOA) has been utilized. The next practical application of power-system frequency control is performed by designing a CFPID controller using the proposed SCaWOA technique for a smart grid system having unconventional sources like sun oriented, wind, photovoltaic and capacity gadgets like a battery, flywheel just as modern electric vehicles. The best advantages of the SCaWOA tuned CFPID controller over hybrid-particle-swarm-optimization and pattern-search (hPSO-PS) adjusted fuzzy proportional-integral (FPI) controller, hybrid bacterial foraging optimization algorithm-particle swarm optimization (hBFOA-PSO) adjusted proportional-integral (PI) controller, genetic algorithm (GA) tuned proportional and integral (PI) controller, BFOA adjusted PI controller, jaya algorithm (JAA) tuned PID with derivative filter (PIDN) controller and teaching learning based optimization (TLBO) tuned proportional-integral-derivative (PID) controller are demonstrated for the two-area non-reheat thermal power system. The second advantages of the SCaWOA tuned CFPID controller over artificial-bee-colony (ABC) tuned PID controller, SOSA tuned PID controller and Firefly algorithm (FA) tuned PID controller are demonstrated for two-area reheat thermal power system. It is seen that SCaWOA based CFPID controller is more effective in controlling the recurrence comparative with PID regulator.

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Low Voltage Capability of Generator for Frequency Regulation of Wind Energy System

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ABSTRACT

For the extraction of wind energy through a doubly fed induction generator (DFIG), low voltage is major particular essential controlled by the transmission structure executive. Under a structure issue condition, DFIG should remain with respect to the lattice for a particular least period and deal with open power support as a case by case basis by the Transmission framework administrator. A pleasant control plot involving gear course of action through a superconducting resistance type issue current limiter (R-SFCL) and programming plan based on the pitch reference current direction control system (RRCOCS) with transient voltage control (TVC) is proposed in this paper to address the Low voltage essential. The results got by the proposed procedure are differentiated and RRCOCS and RRCOCS-TVC.

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1. INTRODUCTION

The doubly fed induction generator (DFIG) has been broadly utilized in the breeze energy framework because of its variable working rate range, lower rating of converters, and adaptability in genuine force and receptive force control. In DFIG, the stator is straightforwardly associated with the lattice, and the force move from the stator to the network is controlled using the rotor side converter (RSC). The grid side converter (GSC) controls the voltage of the dc transport introduced between the force electronic converters. It is liable for directing the dynamic and responsive force move between the framework and the rotor of DFIG [1]. Because of the increased entrance of wind based force age in the electric utility framework, wind energy system (WES) is should have been explored for the network issue condition.

The DFIG stator direct association with the lattice is a major worry for the force makers and utility framework during matrix shortcoming [2]. The voltage level at the lattice association point gets diminished during network blames and results in a high transient stator current. This likewise detrimentally affects the rotor, since it is attractively coupled to the stator, and adds to the progression of huge current in the rotor [3-5]. The rotor end additionally increments and crosses the greatest reasonable worth under lattice shortcomings [6, 7]. The high measure of the rotor circuit current and expanded rotor emf of DFIG are liable for the RSC

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Medical Electronics

Predictive Analysis for Cancer and Diabetes Using Simplex Method Based Social Spider Optimization Algorithm

Monalisa Nayak, **Soumya Das**, Urmila Bhanja & Manas Ranjan Senapati

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Abstract

Early stage of prediction and diagnosis is the only way to solve the challenges due to medical data. Machine learning tools and techniques help in prediction and diagnosis of different types of medical data. In this paper, Simplex Method based Social Spider Optimization (SMSSO) method is used which modifies the Social Spider Optimization (SSO) method. Different types of datasets were used to validate the SMSSO-NN technique. SMSSO-NN shows 99.36%, 94%, 95.78%, and 98% accuracy in Wisconsin

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Design and Analysis of Complex Data Security Algorithm Using Cryptography and Steganography Techniques

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ABSTRACT: This paper aims to provide a security solution for 256-bits digital data using Cryptography and Steganography techniques during its transmission over the digital network. The Cryptography technique has been implemented using a newly developed data security algorithm having various operations on the data and the keys and the Steganography technique has been implemented using data cover process. In order to check the integrity of the data, the data integrity check has been done so as to ensure that the data has not been modified by the attacker during its transmission. The proposed algorithm is found to be resistant towards various types of attacks such as Brute-force attack, timing attack etc. The maximum combinational path delay of the data security unit is 10.052ns.

KEYWORDS: Cryptography, Steganography, Combinational Path Delay

I. INTRODUCTION

In order to maintain the privacy of the data, different researches are carried out so as to avoid the hacking of the information / data. The privacy can be achieved by using data security techniques. The technique may be A Cryptography Technique or Steganography Technique or the combination of both the techniques. The Cryptography technique uses the concept of encryption process to achieve data security and the the Steganography technique uses the concept of data cover / imge cover / audio cover / video cover to achieve the privacy of the information. In the Proposed algorithm, the data cover has been used to provide privacy to the 256-bits data. In the encryption algorithm, four keys are used to achieve the data security.

II. PROPOSED ALGORITHM

The proposed algorithm used for the data security is given as follows:

Step 1: The 256-bits data and four keys (K1, K2, K3, K4-256, 512, 512, 256-bits) are given to the Cryptography unit which produces 256-bits middle encrypted data.
Step 2: The output of the Cryptography unit and the 256-bits covering data is given to the Steganography unit which produces 512-bits final encrypted data.
Step 3: The output of Steganography unit is given to the reverse Steganography unit which produces 256-bits middle decrypted data.
Step 4: The output of reverse Steganography unit is given to the reverse Cryptography unit which produces 256-bit final decrypted data which is the exact replica of the original data.
Step 5: The data integrity test has been done in order to check the integrity of the data (i.e. change in the data (if any)).

Performance improvement of hybrid OFDM-FSO system using modified OFDM receiver

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Abstract: Recently, free-space optical (FSO) communication systems have enlarged research and gained popularity because of its inherent advantages. The orthogonal frequency division multiplexing (OFDM) technique helps to improve the performance of the FSO communication system by using a simultaneous multi-carrier transmission scheme. The performance of the hybrid FSO-OFDM system is dependent on different parameters such as the number of sub-carriers, the nature of the laser beam, applied base band modulation, and atmospheric turbulence conditions etc. In this work, a modified OFDM receiver is proposed that improves the bit error rate (BER) significantly. This paper analyses the performance of the FSO communication system by using the proposed modified OFDM receiver over Gamma-Gamma fading channel under different weather and atmospheric turbulence conditions. Simulation results exhibit a significant improvement in the BER performance compared to the existing OFDM receivers for the FSO communication system.

Keywords: OFDM-FSO hybrid link; Gamma-Gamma distribution; modified OFDM receiver.

Reference to this paper should be made as follows: Panda, C. and Bhanja, U. (2021) 'Performance improvement of hybrid OFDM-FSO system using modified OFDM receiver', *Int. J. Systems, Control and Communications*, Vol. 12, No. 3, pp.227–242.

Biographical notes: Chinmayee Panda is working as a Research Scholar in the Department of Electronics and Telecommunication Engineering, Indira Gandhi Institute of Technology, Sarang, India. Her area of research includes optical communication, wireless communication and MIMO/OFDM. She has published a lot of reputed international and national conference and journal papers in the field of optical/wireless communications.

Urmila Bhanja received her PhD from the Department of E & ECE, Indian Institute of Technology, Kharagpur, West Bengal, India in the year 2011. Currently, she is working as an Associate Professor in the Department of Electronics and Telecommunication Engineering, Indira Gandhi Institute of Technology, Sarang, India. Her area of research includes optical communication, optical network, wireless communication, wireless network, soft computing, optimisation techniques and internet of things, etc. She has published a lot of reputed international and national conference and journal papers in the field of optical/wireless communications, networking and evolutionary computation.

Research Article

Effect of the second-order slip and heat source on dissipative MHD flow of blood through a permeable capillary in stretching motion

Bharat Keshari Swain, Manasa Manjari Biswal & G. C. Dash

Pages 5768-5779 | Received 26 Apr 2021, Accepted 01 Sep 2021, Published online: 07 Oct 2021

Cite this article https://doi.org/10.1080/01430750.2021.1979649 Check for updates

Abstract

An unsteady electrically conducting viscous fluid, flowing in permeable capillary, is subjected to magnetic field and temporal deformation with radiative and dissipative heat, representing the blood flow. Furthermore, the second-order slip at the capillary surface is considered. The use of the Runge–Kutta algorithm with

HEAT TRANSFER

ORIGINAL ARTICLE

Heat and mass transfer in MHD stagnation-point flow toward an inclined stretching sheet embedded in a porous medium

Manasa M. Biswal, Bharat K. Swain, Manjula Das, Gouranga Charan Dash

First published: 28 March 2022 | https://doi.org/10.1002/htj.22525 | Citations: 2

Abstract

The present study elucidates the magnetohydrodynamics boundary layer free convective stagnation-point flow toward an inclined nonlinearly stretching sheet embedded in a porous medium. The recent search explores the consequence of permeability of the medium, thermal as well as mass buoyancy, most importantly obliqueness, and thermal slip at the bounding surface. The solutions of the essential equations are achieved with MATLAB'S inbuilt solver bvp4c. The novelty of the present study is to account for the effect of dissipative heat, nonuniform space-dependent volumetric heat power, and a linear first-order chemical reaction of diffusive species and convective flow phenomena on an inclined plate subjected to thermal slip and space-dependent transverse magnetic field acting at a distance. The important findings are laid down as follows: The oblique-

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Research Article

Optimization of process parameter in AI7075 turning using grey relational, desirability function and metaheuristics

Dillip Kumar Mohanta, Bidyadhar Sahoo & Ardhendu Mouli Mohanty

Received 01 Oct 2022, Accepted 14 Dec 2022, Published online: 16 Jan 2023

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ABSTRACT

Even though metal may be effectively shaped by a variety of other manufacturing techniques, machining continues to play a significant role in industries. Turning is a conventional chip-forming operation that removes undesirable or surplus material from a cylindrical workpiece. The major objective of process optimization in turning operation research is focusing on the development of statistical modeling and optimization techniques for boosting production rate, lowering costs, and reducing product rejection. The current work aims to improve the CNC turning process of Al

7075 using coated carbide inserts. This investigation uses grey relational analysis, desirability function analysis, Multi-objective Genetic Algorithm (MOGA) and Multi-

Theoretical Analysis of Free Vibration of a Sandwich Beam on Pasternak Foundation with Temperature Gradient

D. K. Nayak, P. K. Jena, M. Pradhan, and P. R. Dash

Abstract A theoretical investigation is carried out for the natural frequencies of an uniform sandwich beam supported on a sinusoidally varying Pasternak foundation. It is influenced by an axial periodic load along with temperature gradient and asymmetric in nature. Hamilton's principle and generalized Galerkin's method are used to obtain Hill's equations in order to attain the objective. The influence of temperature gradient, core loss factor, foundation stiffness and the foundation parameter on the natural frequency of the beam is investigated. It is witnessed that increment in loss factor and foundation stiffness enhances the natural frequency while the reverse is experienced for increment in the temperature gradient and foundation parameter.

Keywords Natural frequency · Sandwich beam · Sinusoidally varying Pasternak foundation · Periodic axial load · Temperature gradient

Terminology

t, c, b	Refer to top layer, core layer and bottom layer, respectively.
$A_i (i = t, c, b)$	Area of cross section of ith beam
B	Beam width
c^*	$h_t + 2h_c + h_b$
$E_i (i = t, c, b)$	Elastic modulus of ith layer
G_s	Modulus of shear layer in foundation
G_c^*	Complex modulus of rigidity of core
$h_i (i = t, c, b)$	Depth of ith layer
$I_i (i = t, c, b)$	2nd moment of area about related axis
l	Span of beam
d	Depth of shear layer in foundation
m	Mass per unit span of beam

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S. K. Acharya and D. P. Mishra (eds.), *Current Advances in Mechanical Engineering*, Lecture Notes in Mechanical Engineering,
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Dynamic Stability Investigation of a Sandwich Beam Tapered along width and thickness with Temperature Gradient

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Abstract. The investigation to analyze a sandwich beam's dynamic stabilitywith asymmetric configuration, tapered along the thickness and width, and influenced by an alive axial load with temperature gradient is executed for several boundary conditions employing computational method. Use of Hamilton's principle results in the equations of motion and related boundary conditions. Hill's equations are achieved using non-dimensionalized equations of motion with the Galerkin's method. Then, the influence ofseveral parameterson the dynamic stability for different boundary conditions are attained by applying Saito-Otomi conditions. The impact of differentparameters on the regions of instabilities observed and is showcased in a sequence of graphs using the appropriate MAT LAB program.

Nomenclature

$i = 1$for top elastic layer, $i = 2$ for intermediate layer and $i = 3$ for theelastic layer at bottom.

A_i	:	The cross-section area of the beam
E_i	:	Young's Modulus of elasticity
G_2^*	:	Core's complex shear modulus orG_2 $(1+j)$
G_2/E_i	:	The ratio of the in-phase shear modulus of theviscoelastic core and the young's modulus of elasticity of the elastic layers.
$2h_i$	:	Thickness of the layers of the beam
I_i	:	Cross-sectionalmoment of inertia about an appropriate axis
l	:	Beam length
$\bar{t}$	:	Time in dimensionless form
$U_i(x,t)$	:	Displacement axially along the centre of i^{th} layer of beam
Y	:	Geometric parameter
$\bar{x}$	:	x/l
ψ_0	:	Reference temperature
α_b	:	Width taper parameter

1. Introduction

To attain superior characteristics like better stiffness and less weight, sandwich beams are extensively developedfor different engineering structures such as aerospace, helicopter blades, etc. The blades in gas or steam turbines and aerospace applications are exposed to high temperatures, so the temperature gradient's impact must be considered during the design of beams. The beams can be economical with the variation of cross-section configuration. Karand Sujata [1] evaluated the stability of a cantilever type sandwich beam under the effect of periodic load having symmetric configuration. They witnessed that the geometric and shear parameterenhances the system's stability, while the taper parameter had a

Static stability investigation of a tapered asymmetric sandwich beam supported on variable Pasternak foundation

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Abstract The investigation to analyse a sandwich beam's static stability with asymmetric configuration, tapered along the thickness, placing on a Pasternak foundation having linearly varying stiffness and influenced by an alive axial load is executed for several boundary conditions employing computational method. Use of Hamilton's principle results in the equations of motion and related boundary conditions. Hill's equations are achieved from the non-dimensionalized equations of motion with the use of Galerkin's method. Then, the effects of various parameters on the static stability for different boundary conditions are obtained and are showcased in a sequence of graphs using the appropriate MATLAB program.

Keywords: Static stability; Taper parameter; Core loss factor; Pasternak foundation.

1. Introduction

To achieve superior characteristics like greater stiffness-to-weight ratio, sandwich beams are extensively developed for different engineering structures such as aerospace, helicopter blades, etc. The beams on different foundations are also important and impact of foundations must be considered during the design of beams. The beams can be economical with the variation of cross-section configuration. Kar and Sujata [1] investigated the stability of a non-uniform configuration beam subjected to temperature gradient. The same authors [2] evaluated the stability of a cantilever type sandwich beam under the effect of periodic load having symmetric configuration. They witnessed that the geometric and shear parameter enhances the system's stability, while the taper parameter had a detrimental effect on stability. They realized that the beam's taper profile, thermal gradient, and elastic foundation stiffness affected the stability. Asnani and Nakra [3] established the equations of motion for a multi-layered sandwich beam and acquired the vibration damping features of beams with 15 layers and simply supported at the ends for cases such as constant weight, constant size, and flexural rigidity. Ray and Kar [4] inspected a sandwich beam with 3-layers and symmetric configuration for several boundary conditions. They detected that the core's loss factor, along with the shear parameter, improved the beam's stability. Chand et al. [5] examined the stability of a rotational beam with a parabolic-tapered profile and variable temperature grade. The dynamic along with static stability of a tapered sandwich beam lying on a Pasternak foundation in temperature environment is investigated by Pradhan et al.[6]. Pradhan et al. [7] examined a tapered symmetric sandwich beam's stability condition, which is on a variable Pasternak foundation. Pradhan et al. [8] examined a tapered sandwich beam's stability condition, which is on a variable Pasternak foundation. Chand et al. [9] examined the stability of a rotational beam with a parabolic-tapered profile and variable temperature grade.Pradhan and Dash [10] inspected the stability of a non-uniform sandwich beam and viscoelastic support with variable temperature gradient.

The literature assessment informs that selective study has been performed for the stability of non-uniform beams with various conditions. Nevertheless, no research has been implemented before to analyse the static stability investigation of an asymmetric sandwich beam tapered along thickness placing on variable Pasternak foundation. This research work investigates the above-suggested configuration.

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Parametric Stability Analysis of a Spring Attached, Pre-Twisted, Rotating Sandwich Beam with Tip Mass and Viscoelastic Support

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This paper inspects the influence of a spring attachment provided on the top elastic layer on the stability of a pre-twisted, rotating sandwich beam having viscoelastic supports at the root under the impact of a periodically varying axial load. The spring is deployed on the beam to achieve more strength to weight ratio without compromising the stability. The beam is exponentially tapered, and a tip mass is at the free end to represent the rotating members in various types of machinery as closely as possible. The ruling equations and inter-related boundary conditions are attained by applying Hamilton's principle. To obtain the solution, a matrix equation was developed through the assumed-mode variational method. The resulting matrix equation was converted to a coupled Hill's equation of parametric vibration through the modal matrix corresponding to the free vibration problem. Finally, static and dynamic stability graphs were obtained for several system parameters such as position and length of the attached spring on the top elastic layer, the mass of the spring attachment, stiffness of the spring attachment, angle of pre-twist, tip mass, taper parameter, temperature gradient parameter, setting angle, viscoelastic spring stiffness, etc. to analyze their impact on the system's stability. Saito and Otomi conditions were used to obtain dynamic stability plots. Greater stability is achieved due to the spring attachment on the top of the top elastic layer.

Keywords: Pre-twisted sandwich beam; viscoelastic supports; tip mass; spring attachment; spring mass; spring stiffness.

Notations

A_{i0} $(i = 1, 2, 3)$	Cross-sectional area for ith layer at the root $(x = 0)$
A_i $(i = 1, 2, 3)$	Cross-sectional area at any x for the ith layer
B	Width of the beam
$c = h_{10} + 2h_{20} + h_{30}$	Gap between the mid-planes of the top and bottom elastic layers

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Article

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Analysis of parametric instability of a spring-attached pre-twisted beam with viscoelastic end support

Dipesh K Nayak, Madhusmita Pradhan, Prabir K Jena and Pusparaj Dash

Abstract

This study investigated the parametric instability of a single elastic beam with spring attachment on the top and viscoelastic springs as end supports. The beam considered is pre-twisted with a pin connection at both ends that supports the beam. The analytical solution of the problem is expressed in the matrix form achieved from the implementation of Hamilton's principle and General Galerkin's method, from which both static and dynamic stability of the beam can be investigated. The results of various influential dimensionless parameters such as stiffness, mass, length, position of the spring attachment, and stiffness of the viscoelastic springs on both the stabilities are studied. This analysis concluded that the spring attachment on the system leads to substantial contribution in improving the stability. The viscoelastic springs also contribute in upsurging the beam's stability. Three different profiles of the beam have been considered, and for each profile, three different types of springs have been examined. The results revealed that the beam with parabolic profile and stiffness of the spring attachment with parabolic variation is most effective towards strength-to-weight ratio.

Keywords

Spring attachment; parametric instability; pre-twist; tapered beam; viscoelastic springs

Introduction

Beams with elastic restraints are a subject of interest for researchers, and in the past, many significant theoretical explorations have been carried out for the stability analysis of such beams. With the inclusion of pre-twist, the beams become more related to actual problems. Abbas[1] designed a Timoshenko beam model with elastic end supports to evaluate the natural frequencies using the finite element approach. Auciello[2] analysed the frequencies of a tapered cantilever beam with a tip mass and flexible constraints. Cortinez and Laura[3] studied the vibration and buckling of a rotationally restrained non-uniform beam with an attached mass. Hibbeler[4] used conventional methods to solve problems of vibration of elastically restrained uniform beams. Irie et al.[5] used the transfer matrix approach to analyse the stability and vibration of a non-uniform Timoshenko beam under the impact of a tangential follower load. They illustrated the influence of support stiffness on the eigenvalues of vibration. Kar[6] investigated the role of elastic end support and taper on the stability of a linear-tapered, damped cantilever beam subjected to a follower load. Kar and Sujata[7] analysed the impact of temperature and elastic support on a non-uniform cantilever beam's dynamic stability. They revealed that the stiffening of the end support stabilized the system. Kar and Sujata[8] determined the parametric instability of a uniform cantilever beam with elastic support at the fixed end. Lau[9] considered a tapered beam with a mass attached at the free end and analysed its eigen-frequencies for different beam dimensions and end mass. Lee[10] determined the eigen-frequencies of a beam with a rotational spring at one end and a mass attached at the other end. Liao and Huang[11] considered a rotating pre-twisted cantilever beam subjected to a periodic load using a finite-element approach to determine the parametric stability. Liu[12] illustrated approximate expressions for the natural frequency of a cantilever beam with different combinations of end flexibilities. The successive integration of equilibrium differential equations and the associated boundary conditions were studied by Nassar and Horton[13] to achieve the deflection of a beam with rotational restraint. Nayak et al.[14] analysed the

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Original Paper | Published: 07 October 2021

Parametric Stability Investigation of a Spring-Attached and Viscoelastic-Supported Pre-twisted Sandwich Beam

Dipesh Kumar Nayak & Pusparaj Dash

Journal of Vibration Engineering & Technologies **9**, 1399–1412 (2021)

Abstract

Purpose

This paper analyzes the stability of a spring-attached sandwich beam with pinned–pinned support and viscoelastic springs at both the ends subjected to an axial compressive periodic load. The beam is asymmetric and pre-twisted. This system is an entirely new system that will provide the highest strength to weight ratio among all other systems in use.

Methods

The analysis has been done employing Hamilton's principle. A set of Hill's equations have been derived from which the eigenvectors and natural frequencies are obtained. Finally, both static and dynamic stability analysis have been developed by Saito–Otomi conditions.

2021

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Current Advances in Mechanical Engineering pp 579–588

Probability Plot Result Comparison with Recurrent Neural Network Approach for Path Navigation of a Humanoid in Complex Terrain

Manoj Kumar Muni, Dayal R. Parhi, Priyadarshi Biplab Kumar, Prasant Ranjan Dhal, Saroj Kumar, Chinmaya Sahu & Abhishek Kumar Kashyap

Conference paper | First Online: 19 March 2021

626 Accesses | 1 Citations

Part of the Lecture Notes in Mechanical Engineering book series (LNME)

Abstract

This research work utilizes the concept of recurrent strategy of neurons, which performs sequential tasks where the output and input data are dependent with each other. The major advantage of using recurrent neural network (RNN) for humanoid motion planning lies in spending the previous used long sequence information through memory. RNNs

MKS

Current Advances in Mechanical Engineering pp 997–1006

Safe Navigation of Humanoid Robot in Cluttered Terrain Using Ant Lion Optimizer Tuned RA Approach

Abhishek Kumar Kashyap, Dayal R. Parhi, Saroj Kumar, Anish Pandey, Manoj Kumar Muni & Prasanta Ranjan Dhal

Conference paper | First Online: 19 March 2021

598 Accesses | 1 Citations

Part of the Lecture Notes in Mechanical Engineering book series (LNME)

Abstract

Automation in the industry using robots is attracting many researchers because it increases the efficiency and quality of outputs. This article proposes the ant lion optimizer (ALO) tuned regression analysis (RA) approach to guide the humanoid robot in cluttered terrain. This approach optimizes the travel length and the computational time by taking an optimum turning angle to avoid

Current Advances in Mechanical Engineering, pp 989–996

Navigational Control and Path Optimization of Mobile Robot Using Updated Sine–Cosine Algorithm in Obscure Environment

Saroj Kumar, Dayal R. Parhi, Abhishek Kumar Kashyap, Manoj Kumar Muni & Prasant Ranjan Dhal

Conference paper | First Online: 19 March 2021

605 Accesses | 4 Citations

Part of the Lecture Notes in Mechanical Engineering book series (LNME)

Abstract

The metaheuristic optimization technique, updated sine–cosine algorithm (USCA), is basically based on the mathematical explanation of sine and cosine functions. It is applied on navigational control of mobile robot to optimize the path. The application of USCA is validated with V-Rep simulation and laboratory experiments with Khepera-III robot in an unknown environment. Robot effectively achieved

Benchmark of Unsupervised Machine Learning Algorithms for Condition Monitoring

Krishna Chandra Patra, Rabi Narayan Sethi, and Dhiren Kumar Behera

Abstract Predictive maintenance and condition-based monitoring technique used to monitor the health of bearings, pumps, turbine rotors, gearboxes, etc. It uses the idea of data mining, statistical analysis, and machine learning technique to accurately predict early fault of mechanical components and calculate the remaining useful life. The paper is about condition-based health monitoring of heavy engineering equipment and their predictive maintenance. Data is gathered from the bearing of our experimental setup using unsupervised learning on type of failure and remaining useful life should be determined to predict the maintenance of a machine. In this paper, we consider a data collected from the bearing and fit different unsupervised learning algorithm, gaussian mixture model and clustering technique to check its performance, accuracy, and sturdiness. In conclusion, we have proposed a methodology to benchmark different algorithm techniques and select the best one.

Keywords Predictive maintenance · Machine learning · Deep learning · Unsupervised learning · Fuzzy C-means (FCM) clustering · Gaussian mixture model

1 Introduction

Historically maintenance of machine equipment based on trial and error or experience basis. In recent decades, predictive maintenance gains a significant prominence in the field of fault detection [1]. This is due to the advancement of the internet of things (IoT) gadgets, connected devices, and advancement in computer to handle big data sets. To minimize maintenance cost, different methodologies and algorithms proposed. One of the approaches is known as watchdog agent, the project consists of related machine learning techniques [2, 3], related techniques SIMAP [4], OSA-CBM distributed embedded condition monitoring system [5] and collective predictive maintenance frameworks [6]. Advancement of technologies like Internet of Things

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Fabrication and Characterisation of Aluminium Matrix Composite (Al 2024) Reinforced with Zircon Sand and Flyash

Laxmikant Swain, Rabinarayan Sethi, A. K. Chaubey, and Silani Sahoo

Abstract Composites are becoming popular in advance engineering. Monolithic metals are replaced by metal matrix composites due to its low cost and improved properties like better strength, good wear resistance, hardness, etc. Aluminum Metal Matrix Composites (AMMCs) are used widely in aerospace, automobile, and marine industries. Among the Aluminum Alloys, Al-2024 as a copper-based aluminum alloy shows poor strength as well as poor wear resistance. In the present investigation, Al-2024 is reinforced with Zircon Sand and Fly Ash fabricated with the Liquid metallurgy route. Al-2024 is reinforced with reinforcements in different weight fractions like 0.25, 0.50, and 1 wt.%. The microstructural analysis is carried out with the help of FESEM. XRD analysis investigates the phase and structure of both matrix and dispersive phases. Wear test is conducted on Multiple Tribotester. It is found that with the increase in weight fraction of Ceramic Reinforcement, there is an increase in wear resistance. Reinforced AMMCs with 1 wt.% of Zircon Sand and Fly Ash in equal proportion have shown better results.

Keywords Al-2024 · Zircon sand · Fly ash · Micro hardness · Wear · Coefficient of friction

1 Introduction

Metal Matrix Composites (MMCs) are composed of two or more materials. MMCs are the multi-phase system that consists of a dispersive phase embedded in the matrix phase. These dispersive phases can help the matrix phase in improving its properties. Aluminum Metal Matrix Composites (AMMCs) are commonly available in Automotive, Marine, Aerospace, electronic packaging applications [1]. Aluminum is

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Chapter

An Interactive Injection Mold Design with CAE and Moldflow Analysis for Plastic Components

By Sudhanshu Bhushan Panda, Antaryami Mishra

Book Data Science in Engineering and Management (https://www.taylorfrancis.com/books/mono/10.1201/9781003216278/data-science-engineering-management?refId=025531f6-6fe1-4b1c-bb7e-a0123f494e0e&context=ubx)

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ABSTRACT

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A Critical Study on Computation of Cutting Forces in Metal Cutting

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Abstract. Tool behavior in metal cutting is inevitable since they are typically required to produce components with high precision. This would have a profound impact on efficiency and costs of machining. The cutting forces involved at chip tool interface and the surface finish of the machined surfaces are the two major facets to gauge the performance of tool. The prediction by a statistical model, and the experimental values recorded using various sensors especially dynamometers are different approaches to critically analyze the cutting forces. Many researchers use to extensively practice these methodologies for their research activity. The aim of current research is to critically analyze & summarize approaches i.e., experimental/predictive available for gauging the cutting forces with user suggestion.

1. INTRODUCTION

On the demand for high-precision parts from rising sectors, such as the electrical, automobile, aeronautical, medical, and industry, the Computer Numeric Control (CNC) machining industry is projected to rise to over $100 Billion by the year 2025. Asia Pacific economies including Japan, China, and India may be looked to as possible leading signs of progress in the usage of CNC machining equipment [1-3]. The relentless increase in manufacturing is taking forth changes in this machining method. It is important for industries concerned with machining to develop and refine these processes through enriching awareness regarding cutting forces, especially while selecting suitable fixtures and tools [4]. Extensively practiced empirical models including Kienzle's formula use recorded values from experimental trials, FEM (Finite Element Modeling) and other statistical predictive models to gauge the cutting forces [5]. Apart from turning its application in milling has appeared useful for deciding suitable parameters (optimal) for machining of the components with high precision through exhaustively understanding the performance of tool, as well as, machinability of the selected workpiece material [6-9]. Furthermore, there are several issues, i.e., tool condition, overload and chatter vibration encountered while machining which can be remedied by understanding the involved cutting forces and suitable selection of cutting tool (Coated/ Un-Coated) including its optimization in geometry [10, 11]. Several researchers explored that improved machined component's surface roughness and economics in machining (Optimized Tool wear & Enhanced Tool life) are dependent on various tool coatings which needs to be suitably selected [12].

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Motion control of multiple humanoids using a hybridized prim's algorithm-fuzzy controller

Manoj Kumar Muni, Dayal R. Parhi, Priyadarshi Biplab Kumar & Saroj Kumar

Soft Computing **25**, 1159–1180 (2021)

Abstract

Prim's algorithm has demonstrated a very effective and selective method of solving the minimum spanning tree optimization problems. It is a greedy algorithm that starts from an empty spanning tree and reaches its goal by picking the minimum weight edges which alternately optimizes the path in less possible time. In this paper, the capability of prim's algorithm in designing the behavioural controller of a humanoid robot has been shown. Here, a new hybrid PA–Fuzzy motion planning approach has been proposed that uses the concept of minimizing the distance between the robot and obstacles as well as robot and target. An optimal turning angle is generated by the hybrid controller

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Design and fabrication of a solar portable refrigerator

Sabyasachi Aich, Jayashree Nayak

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Abstract

In many remote places of India electricity is unavailable and storage of medicines, vaccines, food materials is a challenge. A solar portable refrigerator is designed, fabricated and tested in an attempt to mitigate this problem. The developed refrigerator is an eco friendly one. The uninterrupted operation of the refrigerator is ensured by the use of solar panel and one UPS. This refrigerator has been successfully operated both in AC and DC power supply environment. The system is compact and portable. The results have shown reliable operation throughout the year with varying solar irradiation. The lowest obtainable temperature inside the refrigerator cabinet is 6 °C with a COP of 5.89.

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Keywords

Solar energy; Portable refrigerator; Uninterruptible power supply

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Bandita Sahu ✉ & Prasant Ranjan Dhal

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Abstract

Green supply chain management (GSCM) has become one of the most promising tools in reducing environmental hazards of many industries. Selection of indicators and its implementation needs good decision making. The expanded consideration given to the subject of GSCM warrants the composition of this paper. The idea of GSCM is to incorporate ecological speculation into the gracefully chain the board. This study encompasses the survey of factors affecting GSCM

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Manoj Kumar Muni ✉, Dayal R. Parhi, Priyadarshi Biplab Kumar, Chinmaya Sahu, Prasant Ranjan Dhal & Saroj Kumar

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Abstract

This paper focuses on navigation of a humanoid robot cluttered with obstacles, avoiding collisions in static environment using Prim's algorithm. Prim's algorithm is a minimum spanning tree (MST) method with greedy approach which uses the concept of sets. It generates the MST by selecting least weights from the weighted graph and randomly forms disjoint sets with picking one least weight edge from the ones remaining for creating node incident to form the tree. Similar approach

Current Advances in Mechanical Engineering pp 579–588

Probability Plot Result Comparison with Recurrent Neural Network Approach for Path Navigation of a Humanoid in Complex Terrain

Manoj Kumar Muni, Dayal R. Parhi, Priyadarshi Biplab Kumar, Prasant Ranjan Dhal, Saroj Kumar, Chinmaya Sahu & Abhishek Kumar Kashyap

Conference paper | First Online: 19 March 2021

626 Accesses | 1 Citations

Part of the Lecture Notes in Mechanical Engineering book series (LNME)

Abstract

This research work utilizes the concept of recurrent strategy of neurons, which performs sequential tasks where the output and input data are dependent with each other. The major advantage of using recurrent neural network (RNN) for humanoid motion planning lies in spending the previous used long sequence information through memory. RNNs

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Big Rip Scenario in Brans-Dicke Theory

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Abstract: In this work, we present a Big Rip scenario within the framework of the generalized Brans-Dicke (GBD) theory. In the GBD theory, we consider an evolving BD parameter along with a self-interacting potential. An anisotropic background is considered to have a more general view of the cosmic expansion. The GBD theory with a cosmological constant is presented as an effective cosmic fluid within general relativity which favours a phantom field dominated phase. The model parameters are constrained so that the model provides reasonable estimates of the Hubble parameter and other recent observational aspects at the present epoch. The dynamical aspects of the BD parameter and the BD scalar field have been analysed. It is found that the present model witnesses a finite time doomsday at a time of $t_{BR} \simeq 16.14$ Gyr, and for this scenario, the model requires a large negative value of the Brans-Dicke parameter.

Keywords: cosmological constant; generalised Brans-Dicke theory; Big Rip

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1. Introduction

Late-time cosmic acceleration is one of the most bizarre and unsolved problems in modern cosmology. In scalar field cosmological models, the late-time cosmic acceleration issue is predominantly attributed to an exotic dark energy (DE) form that corresponds to a cosmic fluid having low energy density, as well as negative pressure. This is usually understood through a quantity dubbed as the equation of state (EoS) parameter $\omega_D = \frac{p}{\rho}$, where p represents the DE pressure and ρ symbolises the dark energy density. The dark energy with a negative pressure corresponds to a negative EoS parameter. Despite several attempts made by astronomers and cosmologists, the experimental determination of ω_D remains challenging. Its precise estimation at the present epoch along with the knowledge of its development over a long period may unravel the mystery of the dark energy whose nature and origin remains speculative so far. In the ΛCDM model, the cosmological constant Λ with $\omega_D = 1$ plays the role of dark energy. However, in canonical scalar field models, quintessence fields or phantom fields shoulder the burden for the late-time cosmic speed-up, while the EoS parameter for the quintessence field lies in the range $-\frac{2}{3} \leq \omega_D \leq -\frac{1}{3}$ [1–3], which for the phantom fields, becomes $\omega_D < -1$ [4]. However, the EoS parameter as constrained from recent observational data favours a phantom phase in the Universe with $\omega_D < -1$ [5], while constraints from the CMB data in the nine-year WMAP survey suggest that $\omega_D = -1.073^{+0.090}_{-0.089}$ [6], a combination of the CMB data with Supernova data, predicts $\omega_D = -1.084 \pm 0.063$ [7]. Other constraints on the EoS parameter include $\omega_D = -1.035^{+0.055}_{-0.059}$ from Supernova cosmology project [8], $\omega_D = -1.03 \pm 0.03$ from recent Planck 2018 results [9] and from Pantheon data $\omega_D = -1.006 \pm 0.04$ [10].

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Tunable room temperature ferromagnetism in fullerene thin film induced by 1 MeV proton microbeam irradiation

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ABSTRACT

We report tunable ferromagnetic properties of thin films of fullerene upon 1 MeV proton microbeam ion irradiation, by varying the ion fluence. Focused microbeam scanning of 1 MeV proton ions have been performed on the fullerene thin films. Consequently, a stable and significant ferromagnetic ordering at room temperature has been observed in the fullerene thin films. The proton microbeam irradiation induces a maximum magnetic ordering in fullerene with optimum dosage and subsequently higher fluence irradiations yield, diminishing effect upon the observed ferromagnetic ordering due to the higher degree of damages. The X-ray diffraction and Raman analysis confirm the damage due to proton microbeam irradiation. The reduction in the saturation magnetic moment induced, is very sharp as a result of exposure to the larger ion fluence. The approximate distance between defects has been simulated computationally, and its relation with observed ferromagnetism has been established. The irradiation has been performed at moderate ion flux (low microbeam current) to avoid the possible annealing effects of the ion irradiation.

1. Introduction

Ion irradiation over materials instigates significant and variable impact upon the properties of the materials viz; conductivity, phase transformation, surface energy, magnetization etc., depending upon the charge state, energy, ion flux, ion fluence & the angle of the impinging ion and the type of target sample [1,2]. The findings of weak ferromagnetism in transition metal free carbon related materials, have been of immense interest in the recent past [3–7]. One of the initial reports of weak ferromagnetism in a fullerene-based derivative of the charge-transfer salt, Tetrakis Dimethyl Amino Ethylene with Curie temperature around 16 K, was reported by Allemand et al. [8]. The ferromagnetism was observed at very low temperature and was explained on the basis of the correlated presence of unpaired π electrons in the sample. The carbon rich extraterrestrial meteorite, (found in Diablo Canyan), has also been reported to have weak ferromagnetism, where part of its weak ferromagnetic ordering is attributed to the proximity effects, related to the magnetic impurities in the sample [9]. The onset of room temperature ferromagnetism due to the optimized ion irradiation in the metal free carbon related materials, has invited extensive interest of the scientific community in the last two decades [10–15]. Esquinazi et al. provided the first solid evidence of tunable ferromagnetic ordering in Highly Oriented Pyrolytic Graphite (HOPG), using 2.25 MeV proton beam irradiation [10]. The magnetism in carbon related materials viz; HOPG and carbon nanotubes etc., has largely been pinned on the magnetic correlations of the type of defects (vacancy/interstitial), presence of dangling bonds/adatom due to chemisorption, physisorption or hydrogenation and unique edge states etc. [6,7, 16–19].

It has been reported, that the lighter ions (e.g., H^+& He^+) are effective in creating defects in controlled manner and thus they induce almost similar magnetic response in graphite samples [20,44. The proton and carbon ions are more versatile choice amongst lighter ions, as they can help in the realignment of under-coordinated bonds and these ions also have the additional advantage in ensconcing chemisorption and hydrogenation. Thus, the chemical nature of irradiating ions plays a very significant role in defect-based ferromagnetism. Further, it has been reported that the irradiation of the HOPG samples with the

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transition metal elements viz; Fe^{+} ions, has failed to yield the desired result of inducing ferromagnetic ordering, as compared to that by the lighter ions [21]. The reason of this failure could be attributed to the fact, that the iron is much heavier than the proton or carbon atoms and creates 2–3 orders of extra damages in the materials with similar energy range even with very mild ion fluence.

The Buckminster fullerene material (another carbon allotrope, apart from HOPG and diamond) has also proved to be a fascinating material of interest since its discovery, due to its conspicuous properties, biocompatible nature and applications in possible electronic devices, in drug delivery, in cosmetics and as a gas sensor etc. [22–26]. The carbon allotrope in the form of fullerene (C_{60}) has a mixture of sp^2-sp^3 hybridization, with various Raman active modes and with each carbon atom covalently bonded with each neighboring carbon atom (multiple hexagon and pentagons formation), forming a closed football like structure. Fullerene samples can be readily functionalized, which further tailors its properties for various possible applications. One of the earliest reports of stable room temperature ferro- /ferri- magnetism in photo-polymerized fullerene (C_{60}), was reported as a consequence of exposure to photons of appropriate energy in oxygen atmosphere [27]. Wood et al. figured out, that the fullerene displays ferromagnetic properties under special sample environments (optimum high temperature and pressure) [28]. Although fullerene cage structure may not remain viable to above mentioned environments, and this may lead to the graphitization and functionalization of the fullerene [28]. Makarova et al. further reported, that the induced ferromagnetism can be controlled by laser exposure and electron beam irradiation and that the oxygen plays a contrasting role to the onset of ferromagnetic ordering in photo-polymerized and pressure polymerized fullerene derivatives [, [29,30]].

As the energetic stream of lighter ions, have proved to be useful in curating ferromagnetic ordering in carbon related materials, it is worthwhile to explore its effect on the fullerene thin films [10]. The ion beam irradiation upon fullerene, results in changing a variety of its properties. The observation of 7 MeV $^{12}C^{2+}$ion irradiation upon fullerene thin film reveals that the conductivity of the sample increases as a function of ion fluence [31]. This experiment also establishes the role played by the variable ion fluences, in tuning the conductivity of the fullerene samples. Bajwa et al. have also explored the effect on the conductivity of fullerene thin film using swift heavy ion irradiation of 110 MeV Ni ions and they have revealed, that the samples irradiated with lower ion fluences, exhibit lower conductivity as compared to that in the case of samples irradiated with higher ion fluences [32].

The observation of ferromagnetism in fullerene samples by ion irradiation, have been reported by various research groups [,][33,34]. Kumar et al. have performed a comparative magnetization study of swift heavy ion irradiation (92 MeV Si^{+}) and low energy (250 keV Ar^{+}) ion irradiation upon fullerene thin films [33]. In the above work, the co-authors have reported weak ferromagnetic ordering in both the cases and they have highlighted the decisive role of the electronic energy loss and the nuclear energy loss related damages, in the observed magnetic ordering in the fullerene samples [33]. Matthew et al. observed significant ferromagnetic ordering in fullerene films by 2 MeV proton irradiation at 5 K only [34]. Lee et al. irradiated pelletized fullerene samples with broad proton beam [energy 0.5–2 MeV] of optimized ion fluence and demonstrated a room temperature ferromagnetic ordering of 0.173 A-m^2/kg. Further, they have revealed, a magnetic field induced abrupt first order phase transition from ferromagnetism to diamagnetism [35]. These previous studies of the onset of ferromagnetic response in fullerene by ion irradiation, have revealed that the observed ferromagnetism has either been very feeble at room temperature or the corresponding Curie temperature has been significantly lower as compared to the room temperature or the observed magnetization undergoes phase transition with respect to higher magnetic field. Even the defects produced by neutrons in HOPG flakes, have been found to induce very low ferromagnetic behavior and strong paramagnetic behavior at low temperature (1.8 K) [36]. The onset of ion beam induced room temperature ferromagnetism in carbon allotropes is in itself intriguing, apart from various possible futuristic applications. In the present work, we have found that 1 MeV proton microbeam enhances, the ferromagnetic ordering in the fullerene thin films significantly, even at room temperature. The observed ferromagnetism vanishes, if the samples are further irradiated to larger ion-fluences. The details of the observed room temperature ordering will be discussed in the subsequent sections.

2. Experimental

The fullerene thin films have been grown on SiO_2/Si substrate, through vacuum thermal evaporation utilizing a state-of-the-art deposition system equipped with multiple effusion cells. The deposition chamber has base pressure of 1.2×10^{-5} Pa, which rises up to 4.0×10^{-5} Pa during the evaporation. The doubly sublimed, purified fullerene (C_{60}) procured from Lumtec, has been utilized for the thin film deposition. The material is evaporated from one of the effusion cells at 460–470 °C to maintain the targeted deposition rate of 1 Å/s, with the help of an *in-situ* crystal thickness monitor. During deposition, the substrate temperature has been maintained at room temperature i.e. 25 °C. The film thickness to be grown is targeted at 1 μm. The typical size of the substrates has been kept about ~ 3 mm × 6 mm, compatible with both the Vibration Sample Magnetometer (VSM) samples holders and the microbeam irradiation chamber. The samples were irradiated with 1 MeV proton microbeam utilizing patterned microbeam scanning in the desired areas. The micro-beam line (Oxford Microbeam) attached to the 90° beam line of the 1.7 MeV Tandetron particle Accelerator (High Voltage Engineering, Europa, BV), was utilized at IIT Kanpur. The system provides focused microbeam ($Z \leq 6$) with spot size ranging from 1 − 20 μm. The focusing of the microbeam is achieved by electromagnetic quadrupole triplet based charged particle optics, working in Converging-Diverging-Converging (CDC combination). There are two high quality slits (objective and collimating) to control the beam spot and current at the sample. The micro-beam line also has the capability of ion scanning in desired shapes and sizes with the help of National Instrument (NI) 6259 PCI (Peripheral Component Interface) card and ION-SCAN software. The modulated X- and Y- output signals from the NI 6259 PCI card, are then amplified by a scan amplifier to maneuver ions ($Z \leq 6$). The signal from the scan amplifier is fed into an electromagnetic scanner, which maneuvers the focused microbeam ions on the target, in the desired shape and sizes. The samples were scanned with microbeam in a predefined area of (3.8 mm × 1.6 mm), chosen as per limitations of the sample size and scan amplifier constraints. The thickness of the deposited samples, has been assessed utilizing a surface Profilometer (DekTak 3, Brucker), to be about 1 μm.

The samples have been mounted in the microbeam chamber for the microbeam scanning, with chamber pressure maintained at about 2×10^{-4} Pa. As the CDC combination of quadrupole electromagnetic lenses, focuses the proton microbeam very sharply (very high beam current density), the micro-beam target current has been maintained between 20 and 22 nA to avoid possible annealing effects. A variable exposure of 1 MeV proton microbeam has been performed in the fluence range from 5.88 pC/μm^2 to 88.2 pC/μm^2. The Vibration Sample Magnetometer (VSM; Model EV-X DMS VSM, ADE Magnetics) has been utilized for the magnetic measurements at room temperature, at Advanced Center for Material Sciences, IIT Kanpur. The maximum applied magnetic field during the VSM measurement is ± 1.7 Tesla. The samples have been mounted on a non-magnetic quartz sample holder for VSM measurements. The VSM measurement has been repeated several times on sequentially irradiated samples to assess the effect of microbeam irradiation. The samples have been handled cautiously, utilizing Teflon tweezers in order to avoid exposure to any foreign contaminants viz; iron, cobalt etc. The samples have always been transported using covered vacuum desiccators from the accelerator laboratory to the VSM Laboratory for avoiding photopolymerization and moisture related

damages to the samples, if any.

The room temperature Glancing Incidence (angle of incidence 0.8°) X-ray diffraction (GIXRD), has been performed on some of the fullerene samples before and after irradiation on the GIXRD system (D8 Discover, Brucker), having rotating anode with 4.5 kW, Cu K_α source at UGC DAE CSR Kalpakkam node of Indore. A scintillation detector was used for GIXRD measurements. The effect of ion irradiation upon thin fullerene film has also been analyzed by Raman analysis (Renishaw InVIa Raman Microscope excited by Argon Ion laser of wavelength 514 nm).

3. Results and discussion

3.1. Magnetization studies of un-irradiated and microbeam irradiated fullerene samples

The effect of 1 MeV proton microbeam scanning of appropriate fluence upon the thin films of fullerene, has been presented in Fig. 1. It shows the magnetization response to the applied field of both un-irradiated and irradiated fullerene samples. The un-irradiated sample shows, a very strong diamagnetic nature with negative slope, as expected. The sample shows, very promising response to the ion beam scanning with a fluence of 29.4 pC/μm^2, resulting in an appreciable ferromagnetic kink. This ferromagnetic kink is a manifestation of microbeam irradiation, in otherwise a strong diamagnetic fullerene sample. It is noteworthy, that the whole region of the sample has not been irradiated and only about 34% of the sample area, is exposed to the 1 MeV proton microbeam. There is a bulk SiO_2/Si substrate, underneath the thin fullerene film samples, and the overall sample has a strong diamagnetic nature. Further, this diamagnetic portion is subtracted using the slope of diamagnetic curves to explore the effect of ion beam irradiation. Five sets of similar sized samples have been utilized for ion beam irradiation by varying the irradiation fluence from 5.88 pC/μm^2 to 88.2 pC/μm^2, in the quest of exploring the optimized fluence for inducing maximum magnetic ordering in the sample. The VSM measurements performed on these samples, have been presented in Fig. 2, after the removal of the diamagnetic background.

It can be clearly seen in this figure, that at the lower fluence of 5.88 pC/μm^2, the observed saturation magnetic moment is 1.16×10^{-7} A-m^2, which is significantly higher than that for the un-irradiated sample. The maximum magnetization has been achieved at the fluence of 29.4 pC/μm^2. The observed coercivity in this sample is about 20 mT (militesla). The observed magnetization further decreases significantly, after increasing the ion fluence from 29.4 pC/μm^2 to 39.1 pC/μm^2. This larger fluence brought almost no change in the magnetization, as compared to

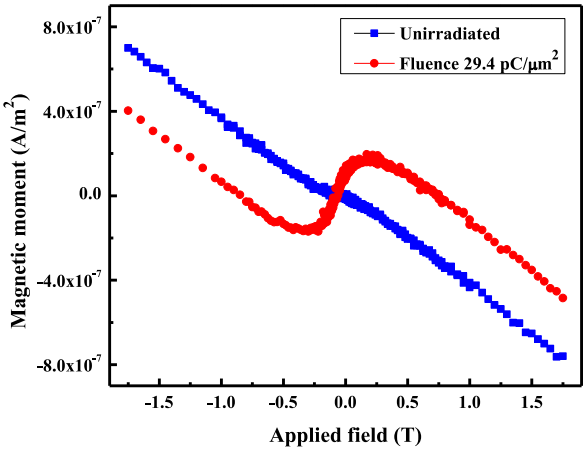

Fig. 1. Magnetic moment vs field measurement for unirradiated (C_{60}) and 1 MeV proton microbeam irradiated fullerene sample with fluence of about 29.4 pC/μm^2, showing a significant magnetization response of proton microbeam irradiation.

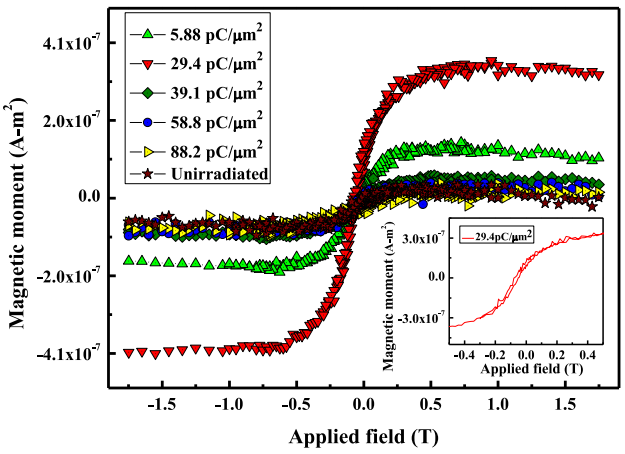

Fig. 2. Magnetic moment of un-irradiated (C_{60}) specimen and irradiated specimens with ion fluence irradiation range of 5.88–88.2 pC/μm^2, after subtracting the diamagnetic contribution (inset showing the hysteresis in the sample irradiated with ion fluence of 29.4 pC/μm^2).

the un-irradiated sample data. The saturation magnetization further decreases monotonically, for the fluences of 58.8 pC/μm^2 and 88.2 pC/μm^2. This shows that the observed maximum ferromagnetic ordering in the fullerene thin film, favors an optimum ion fluence window.

The saturation magnetic moment data vs the total charge irradiated in the microbeam scanning, has been shown in Fig. 3. The saturation magnetic moment has been derived from the data reported in Fig. 2. We can observe that the saturation magnetization is maximum for the total charge irradiation of 183.5 μC, corresponding to the ion fluence of 29.4 pC/μm^2. Fig. 3 also enunciates, that there is a threshold window of total charge irradiation, during which, the observed saturation magnetization is maximum. Fig. 3 also unravels the information, that below and above the threshold ion fluence window, the observed magnetization is much lower and that at the higher total charge irradiation, diminishes gradually. However more data points would be required to reveal the peak of the optimum fluence.

3.2. Structural analysis of unirradiated and irradiated fullerene sample

The GIXRD data for the unirradiated and the irradiated samples (where the induced magnetization was maximum), are shown in Fig. 4 (a). This figure describes, that the unirradiated sample has all the characteristic peaks of fullerene, with the highest intensity peaks (0 0 2) and (1 1 2). The observed peaks matches well with JCPDS (card no. 00–047–0787) data for fullerene. The GIXRD data for the unirradiated

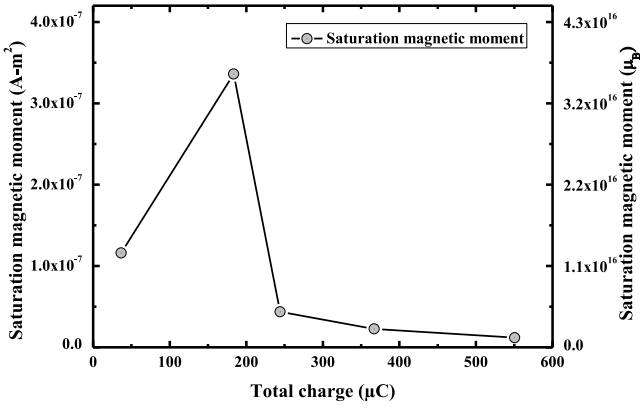

Fig. 3. Dependence of the saturation magnetic moment (in A-m^2 and Bohr magneton (μ_B) unit) vs the total irradiated charge (μC), depicting a threshold fluence window for maximum magnetization.

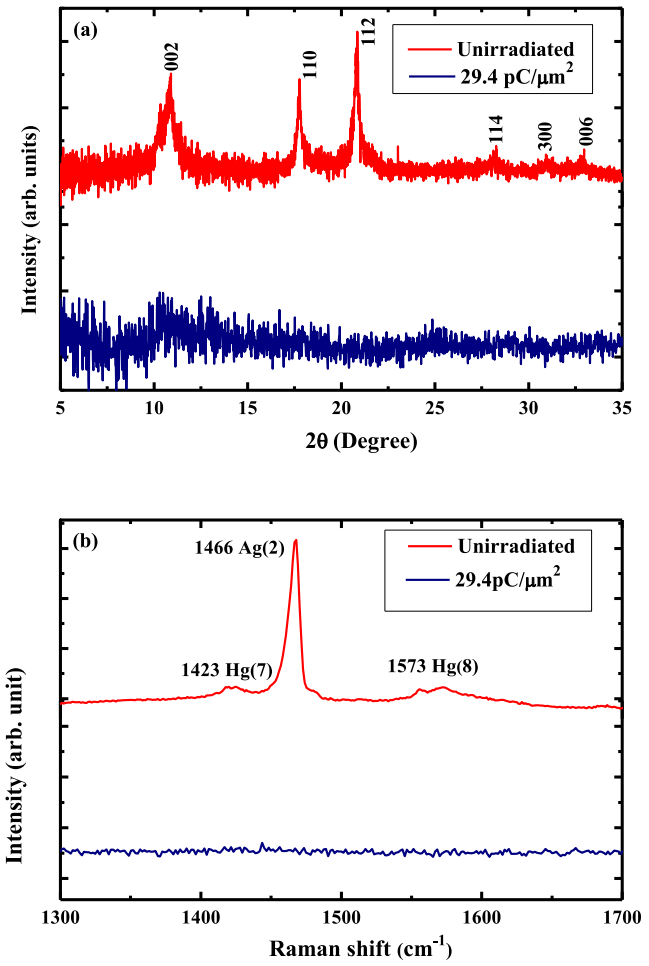

Fig. 4. (a) GIXRD data and (b) Raman data exhibiting significant damage in the irradiated sample with fluence 29.4 pC/μm^2 as compared to the unirradiated sample.

sample (fluence 29.4 pC/μm^2) shows remarkable decrease in the intensity of characteristic fullerene peaks, which is indicative of excessive ion beam induced damage. The data analysis of the observed peaks, indicate that the crystallite size for unirradiated sample is about 7 nm and that for irradiated sample (29.4 pC/μm^2) is about 31 nm. The irradiated samples clearly show the signatures of significant damage to the fullerene structure even with mild fluences, with significant decrease in the intensity of the noteworthy peaks and only one peak (0 0 2) barely survives the ion fluence of 29.4 pC/μm^2. Thus there is a significant damage due to ion beam irradiation in the fullerene thin film, which is also reflected in the Raman data of the same samples as shown in Fig. 4 (b). Fig. 4(b) shows the characteristic Raman modes of the unirradiated thin film fullerene and the 1 MeV proton microbeam irradiated samples (29.4 pC/μm^2). The unirradiated sample reveals the presence of Hg (7) mode at 1423 cm^{-1}, Ag (2) mode at 1466 cm^{-1} and Hg (8) mode at 1573 cm^{-1}. The Raman modes disappear completely post 1 MeV proton microbeam irradiation, indicating significant damage to the cage structure.

3.3. Simulation of the ion beam induced damages in fullerene sample and discussion

In collision between an energetic proton and atoms in a solid, energy from the projectile is dissipated to the atoms (to the nucleus or electrons depending the energy of the projectile). Once the recoiling atoms of the target material acquire enough energy to leave their position within the atomic network, various defects at the atomic scale may appear. While many defects such as vacancy-interstitial pair may disappear within seconds of the ion beam impact, some may remain in the system and form a more complicated defect structure. The onset of ferromagnetic ordering, as a consequence of ion irradiation upon various samples under various circumstances (change of ion, energy etc.) has been attributed to the creation of vacancies, unpaired electrons of dangling bonds and chemisorbed atoms etc. [7,11]. Therefore, the understanding of the ion beam induced damage assessment, in the present case becomes very crucial in order to gain an insight into the observed ferromagnetic ordering. We have performed the Stopping Range of Ions in Matter (SRIM) simulation for 1 MeV proton in fullerene [37–39]. We have calculated the range of the 1 MeV proton in carbon C_{60} target using SRIM, which was found to be about 16.87 μm and our specimen film is 1 μm thick. Therefore, the protons transmitted through the film, settle into the bulk silicon substrate [37]. The total energy loss of the proton microbeam in C_{60} film, has been calculated to be about 52 keV as per SRIM data analysis [37]. Esquinazi et al. [10] and Lehtinen et al. [11] have shown, that the proton beam created vacancies plays a major role in ion induced magnetic ordering in HOPG samples and the claims are supported by density functional theory as well.

1 MeV proton ions create roughly 14 vacancies per ion in the fullerene thin films as per SRIM analysis. The distance between defects estimated from the vacancy density as a function of the total charge irradiated, has been shown in Fig. 5, which exhibits that the distance between defects (considering uniform distribution) decreases as the total irradiated charge increases. This indicates that the sample sequentially leads towards amorphization. The distance between defects, is around 3.4 nm, corresponding to the ion fluence of 29.4 pC/μm^2 (Fluence of maximum/significant ferromagnetic ordering). Correlating the data from Figs. 3 and 5, it can be observed, that the measured ferromagnetism in fullerene samples vary as per distance between defects. It can be noted that the induced magnetic response is similar in the lower and the higher side of the fluence. In the former case, the distance between defects, is very large and these random sparse defects do not contribute significantly to the onset of magnetic ordering. On the other hand, in the latter case i.e. in highest fluence irradiated samples, defects come so close that they completely amorphize the sample, which again negates any possible correlation between defects leading to the poor magnetization. The higher ion-fluence irradiation would create more defects in the fullerene structure e.g., collapse of cages, fragmentation, presence of dangling bonds and point defects. As ion-fluence is increased

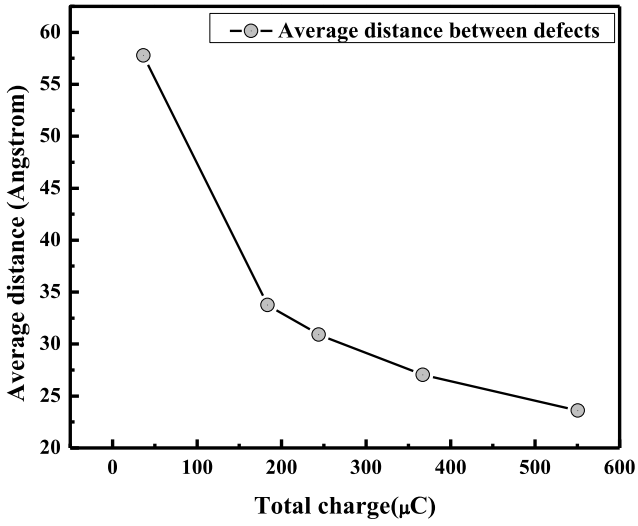

Fig. 5. Average distance between defects as a function of total charge irradiated, showing sharp decrease in the distance between defects as the total irradiated charge increases.

further, the structure of the fullerene maybe destroyed completely. If the level of damage increases beyond a certain limit as shown in Fig. 5, magnetic ordering of the sample decreases due to the complete amorphization/un-correlation of defects in the sample. The maximum saturation of magnetic moment corresponds to 183.55 μC of total charge irradiation with the fluence of 29.4 pC/μm^2. The maximum magnetic moment induced by 1 MeV proton microbeam is of order of $\sim 10^{-7}$ A-m^2, at room temperature as shown in the Fig. 3.

The proton irradiation leads to the hydrogenation/chemisorptions in carbon allotropes as well as vacancy creation. The hydrogen chemisorptions and the carbon vacancy are equivalent in terms of one orbital model and induce similar magnetic moment. The density of state calculations for chemisorbed impurity (resulting in localized π electron near zero-point energy) in hexagonal graphene reveals a strong localized density of state near zero point energy. The density of state for such quasi-localized state due hydrogen chemisorptions is stronger than that for vacancy defect in graphene layers [7]. The localization length of quasi-localized π electrons as a consequence of defects in graphene is around 3–10 nm [40]. Assuming this to be applicable to the hexagonal rings of fullerene, the π electron interaction can extend to nearest neighbor fullerenes, which may result in exchange interaction leading to the observation of net room temperature ferromagnetic ordering. Thus, the observed ferromagnetism in the sample can be related as a correlated exchange response between defects placed at moderate and optimum distances (3.4 nm) as observed from Fig. 5 for the optimum fluence/maximum magnetization.

Kumar et al. have reported the onset of magnetic ordering in fullerene samples, by 92 MeV Si^+ions and the same by 250 keV Ar^+ions irradiation with variable fluences [33]. The observed magnetic moment ($\sim 10^{-8}$ A-m^2) was one order lower than that found in the present experiment ($\sim 10^{-7}$ A-m^2). The reason of not getting appreciable ferromagnetic ordering by Kumar et al. at lower energy of 250 keV Ar^+ ions, could lie in the fact that at low ion energy, the lateral straggling effects are significant as compared to that by higher energy ions. The higher atomic number ions create more vacancy per incident ions as compared to lower atomic number (Z) ions. It has been calculated from SRIM simulations that, 1 MeV protons will create 14 vacancies/ion, while 92 MeV Si^+ion creates 2632 vacancies/ion in fullerene samples [37–39]. This difference could be the reason for better controlled defect generating capability of proton ions and other lower atomic number (Z) ions, in fullerene, as compared to that by heavier ions in MeV range. S. Mathew et al. have also reported the magnetization in fullerene at low temperature (5 K) using 2 MeV proton beam [34] and their broad beam irradiation could not lead to room temperature magnetic ordering the thin fullerene film. Lee et al. have observed a remarkable field induced transition from ferromagnetic ordering to diamagnetic ordering in broad proton beam irradiated pelletized fullerene samples in the energy range 0.5 MeV−2 MeV with variable ion fluence [35]. The sample which showed a significant response to ion beam irradiation was with broad proton beam energy of 0.5 MeV and ion fluence of 1×10^{13} H^+/cm^2. It was further demonstrated that the observed ferromagnetism in fullerene pellets retains its induced ferromagnetic order in low magnetic fields only, and as the magnetic field is increased, there is an abrupt first order phase change from ferromagnetism to diamagnetism. Lee et al. have attributed the observed magnetization of 0.173 A-m^2/kg, to the spin $S = 1$ contribution from defects related to the carbon vacancies and the hydrogen chemisorptions [35]. Though the observed magnetic ordering is smaller, but the nature of magnetic field-based phase switching is very interesting phenomenon. The microbeam utilized in the present experimentation, has an advantage of focused beam and desired pattern irradiation, thereby it produces a tunable, induced ferromagnetic ordering in the desired region. The observed ferromagnetic contribution from the irradiated thin fullerene volume (for 29.4 pC/μm^2 ion fluence) in our experiments comes out to be about 32.2 A-m^2/kg under optimal irradiation, which is very higher than that reported by Lee et al., for fullerene pellets (0.173 A-m^2/kg). The main feature of the present result, lies in the fact that the observed magnetic ordering is significant even at room temperature in fullerene thin film and shows no signs of field-based phase switching.

The effect of energy variation upon inducing magnetic ordering in samples, has not been explored in details, but possible inferences could be drawn from the work of others. A noteworthy example, is the comparison of work of Xia et al. [13] and Shukla et al. [15]. Xia et al. have reported an order of magnitude lesser magnetic ordering ($\sim 10^{-8}$ A-m^2) using 70 keV carbon ion irradiation on HOPG as compared to 1 MeV carbon microbeam irradiation on HOPG reported by Shukla et al. ($\sim 10^{-7}$ A-m^2). Here the reason for this difference could be pinned on the fact that the keV- ranged carbon ions create, a significant amount of damage near the surface as compared to 1 MeV $^{12}C^+$carbon ions in HOPG, due to the significant nuclear energy loss near the surface for keV- ranged ions, and electronic energy loss for MeV- ranged ions. One of the first reports of ion beam induced magnetic ordering in HOPG by 2.25 MeV proton ion irradiation, yielded the magnetic moments of the order $\sim 10^{-9}$ A-m^2 [10]. Very high energy ions have another disadvantage of self-annealing of defects along the ion track due to heating effects of the ion beam. This is very crucial aspect and cannot be ignored while performing experiments at higher ion fluxes. Thus, by these comparisons, it is clear in the case of HOPG that the intermediate energy values of ions, turns out to be more useful in creating ferromagnetic ordering. The average magnetic moment induced in the sample, has been estimated in terms of the equivalent Bohr magneton (μ_B) per incident ion. The maximum magnetic moment induced is 31.6 μ_B/ion. Similar experiments by 70 keV and 1 MeV carbon ion irradiation upon HOPG produced the magnetic moment of about 41 μ_B/ion and 60 μ_B/ion, respectively [13,15].

The samples have been irradiated at normal incidence to increase the chances of channeling in the crystalline Si substrate, precisely to rule out relatively larger damage in Si and avoiding any possible effect of damage to the Si substrate in the observed ferromagnetic ordering. Usually to avoid channeling effects (to maximize the damage), the Si/SiC substrates are kept at off normal (by 7°) orientations [41,42,]. The Silicon atom ($Z = 14$) is heavier than carbon atom in Fullerene ($Z = 6$) and as per SRIM calculations, 1 MeV proton ions would create lesser damage in Si than in Fullerene (The displacement energy for Si being larger than that for Carbon in fullerene). The damage in the silicon substrate is also limited due to higher order of channeling in normal irradiations. Thus, taking these precautions, it is inferred that the effect is primarily due to thin fullerene films only.

One more crucial aspect to consider while tailoring the defect density, is the heating effects of the ions beam upon the sample, as mentioned earlier. Since the *in-situ* annealing of the defects along the ion beam path might have detrimental effect on the magnetic correlations of the defects, the microbeam irradiation was performed, maintaining lower ion beam current in the range 20–22 nA throughout the experiment. An estimation of the temperature rise, due to ion beam irradiation solving the heat conduction equations, considering the possible dissipation through radiation and conduction in the sample, can be easily made. The calculations reveal, that the parameters of the microbeam (1 MeV, 20 nA) in the present experiment, would create an equilibrium temperature of about 326 K near the end of the ion range, which is insignificant for the annealing of defects. This temperature is much smaller than the possible annealing temperature in Stoner-Waals type of defects in Fullerene [43]. Therefore, the self-annealing of defects and their transformation into other forms in the present work, does not arise, as the ion fluences were administered with lower beam currents resulting in mild temperature rise.

4. Conclusions

In conclusion, 1 MeV proton microbeam ion irradiation is capable of inducing a stable and significant room temperature ferromagnetism in fullerene with optimum dose of 29.4 pC/μm^2. The results also reveal that

the observed ferromagnetic ordering, is maximum within a threshold window of fluence and the total charges irradiated. The observed magnetic ordering is negligible below and beyond the threshold window of fluence and total charge. We have found the induced magnetic moments to be of the order of 31.6 μ_B/ion for 1 MeV proton microbeam irradiation in Fullerene thin film. The advantage of utilizing the intermediate energy (1 MeV) of proton microbeam resulted in room temperature ferromagnetic ordering in the fullerene thin film. The optimum energy for creating best possible magnetization in fullerene, can be sought in future analysis, as this is also a suitable and important parameter in the quest for maximum magnetization in Fullerene. The advantage of microbeam resulted in the controlled irradiation of the sample area. The observed magnetization at optimized ion-fluence, grants us a unique recipe for creating ferromagnetic ordering in desired zones only. Thus, the present experiment could lead the way in creating a desired magnetic pattern on the thin films of fullerene, which can find applications in the preparation of light weight magnet, memory devices and many other future applications etc. at the room temperature.

CRediT authorship contribution statement

Ram Kumar: Conceptualization, Methodology, Investigation, Data curation, Validation, Formal analysis, Writing – original draft, Writing – review & editing. **Krishna Mohan:** Validation. **Amala Augusthy:** Validation. **Sandeep Bari:** Investigation. **Anukul P. Parhi:** Resources. **Aditya H. Kelkar:** Investigation, Writing – review & editing. **Sujay Chakravarty:** Investigation. **Neeraj Shukla:** Conceptualization, Resources, Investigation, Formal analysis, Writing – original draft, Writing – review & editing, Supervision, Project administration.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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PAPER

Stability analysis of two-fluid dark energy models

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References

Article and author information

Abstract

In this paper, we have studied the stability of the cosmological models with dark energy and

Wormhole solutions in $f(R)$ Gravity

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In this work, we have studied the traversable wormholes geometry in $f(R)$ theory gravity, where R be the Ricci scalar. The wormhole solution for some assumed $f(R)$ functions have been presented. The assumption of $f(R)$ is based on the fact that its behaviour changed with an assumed parameter α rather than the deceleration parameter. Three models are presented based on the physically motivated shape function and their behaviours are studied.

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S. K. Tripathy, B. Mishra, Maxim Khlopov, and Saibal Ray

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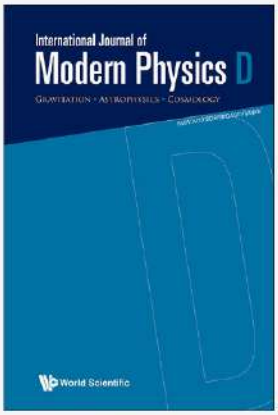
Abstract



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Dynamical system analysis for accelerating models in non-metricity $f(Q)$ gravity

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Abstract