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# Experimental Research on Natural Fiber Reinforced Polymer Composite Material Composites

**D. Logendran, T. Naresh Kumar, A. Abraham Eben Andrews**

***Abstract:*** ***In this examination, common strands like Abaca, Coir and Flax , Abaca and Coir (half breed) , Flax and Coir (cross breed) and Flax and Abaca (crossover) are manufactured with bio epoxy tar utilizing forming technique. In this paper the ideal blending of fortitude and sap is accomplished by utilizing Taguchi strategy. In this effort, flexural unbending nature and rigidity of Abaca besides Coir (half and half), Flax and Coir (hybridand Flax and Abaca (cross breed) composite at dry and wet conditions were considered. Hardness test remained directed utilizing rigidity testing machine. In this effort small scale edifice of the examples are examined by the Skim through Electron Hand-held microscope.***

***Key words:*** ***Natural strands, Bio epoxy tar, Experimental Research, Taguchi technique.***

## I. INTRODUCTION

These days, the common strands, for example, Abaca, Coir and Flax can possibly be utilized by means of a substitution for glass or other conventional fortification ingredients in aggregates [33-35]. Different focal points incorporate low thickness, high durability, tantamount explicit quality properties, decrease in apparatus wear, simplicity of partition, diminished vitality of manufacture [1-3]. Composites are materials that involve solid burden conveying physical drive in more fragile substantial. Walls gives quality and inflexibility, supporting basic burden [4-6]. The lattice, or cover (natural or in-natural) keeps up the position and direction of the fortification for example, firmness, sway opposition, adaptability, and modulus [7-9]. What's more, they are accessible in huge sums, and are inexhaustible and biodegradable [32,36]. Other attractive properties incorporate minimal effort, low thickness. Employments of these filaments fulfill both financial and natural interests. The outcomes demonstrated that the most elevated mechanical properties were seen when Flax and Abaca (half breed) strands were fused [10-12]. It is surely known currently that in cooperation the quality and firmness of fortitude amalgams rely upon fiber focus, fiber viewpoint proportions, fiber-network grip, just as powdered particles of fiber direction and scattering [37]. The present commitment reports use of untreated Abaca, Coir and Flax filaments as strengthening fillers for bio epoxy tar as framework just because [12-14]. The Flax and Abaca (cross breed) Abaca and Coir (half and half) and Flax and Coir (crossover) fiber-strengthened polymer composites were readied utilizing hand shaping technique. The impacts of filaments gratified on mechanical properties.

## II. EXPERIMENTAL

The network quantifiable utilized cutting-edge this examination remained bio epoxy sap Provided by Lab synthetic concoctions, Chennai. Flax, Coir & Abaca strands must remained utilized customarily in great superiority riggings in India [15-17].

*A. Manufacturing process*

*1) Compound Treatment*

The strands are pulverized. At that point the strands are scrubbed ordinarily in unsoiled consecutively river and dehydrated. A schooner measuring utencil is reserved and 6% NaOH is included and 80% of refined aquatic is included and an answer is ended. After satisfactory dehydrating of the filaments in ordinary concealing for 180 min, the strands are engaged and absorbed the readied NaOH arrangement [18]. Splashing is completed for various time interims relying on the quality of fiber required. In this investigation, the filaments are absorbed the answer for 180 min.

*2) Favorable circumstances of compound behavior*

Compound action by NaOH expels dampness gratified beginning the filaments along these lines expanding its quality. Additionally, synthetic treatment improves the flexural inflexibility of the strands [19-21].

**Fig. 1 Specimens For Tensile test**

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*E. Symmetrical cluster of analyses*

By assessing the exhibition of the item in a few natural conditions, there would be a reasonable information to ascertain this present reality difference. The old style trial structure technique are excessively mind boggling, tedious and difficult to utilize. An enormous number of examinations must be completed when the quantity of procedure parameters are more. To tackle this issue, taguchi technique utilizes an uncommon structure of symmetrical clusters to ponder the whole parameter space with the base number of examinations [29].

TABLE 1 Abaca and Flax (With Dampness

| S.no | Load N | ΔL Avg.(A+B)/2 | σ (N/mm²) | ε | E (N/mm²) |
|---|---|---|---|---|---|
| 1 | 98.1 | 0.00175 | 0.3122712 | 1.75E-05 | 17844.069 |
| 2 | 196.2 | 0.00365 | 0.6245424 | 3.65E-05 | 17110.7511 |
| 3 | 294.3 | 0.00545 | 0.9368136 | 5.45E-05 | 17189.2408 |
| 4 | 392.4 | 0.00675 | 1.2490848 | 6.75E-05 | 18504.9605 |
| 5 | 490.5 | 0.00865 | 1.561356 | 8.65E-05 | 18050.3588 |
| 6 | 588.6 | 0.0103 | 1.8736272 | 0.000103 | 18190.5558 |
| 7 | 686.7 | 0.012 | 2.1858985 | 0.00012 | 18215.8205 |
| 8 | 784.8 | 0.01365 | 2.4981697 | 0.000137 | 18301.6093 |
| 9 | 882.9 | 0.01505 | 2.8104409 | 0.000151 | 18674.0257 |
| 10 | 981 | 0.0175 | 3.1227121 | 0.000175 | 17844.069 |
| 11 | 1079.1 | 0.0189 | 3.4349833 | 0.000189 | 18174.5148 |
| 12 | 1177.2 | 0.02075 | 3.7472545 | 0.000208 | 18059.0578 |
| 13 | 1275.3 | 0.022 | 4.0595257 | 0.00022 | 18452.3896 |
| 14 | 1373.4 | 0.02365 | 4.3717969 | 0.000237 | 18485.3992 |
| 15 | 1471.5 | 0.0254 | 4.6840681 | 0.000254 | 18441.2131 |
| 16 | 1569.6 | 0.027 | 4.9963393 | 0.00027 | 18504.9605 |
| 17 | 1667.7 | 0.0291 | 5.3086105 | 0.000291 | 18242.6479 |
| 18 | 1765.8 | 0.0303 | 5.6208817 | 0.000303 | 18550.7648 |
| 19 | 1863.9 | 0.032 | 5.933153 | 0.00032 | 18541.103 |
| 20 | 1962 | 0.0355 | 6.2454242 | 0.000355 | 17592.7441 |
| 21 | 2060.1 | 0.03595 | 6.5576954 | 0.00036 | 18241.1554 |
| 22 | 2158.2 | 0.03725 | 6.8699666 | 0.000373 | 18442.8633 |
| 23 | 2256.3 | 0.03895 | 7.1822378 | 0.00039 | 18439.6349 |
| 24 | 2354.4 | 0.04115 | 7.494509 | 0.000412 | 18212.6585 |
| 25 | 2452.5 | 0.04225 | 7.8067802 | 0.000423 | 18477.5863 |

*B. Dampness Fascination Test Process*

Flexural examples according to ASTM gauges remained censored after the manufactured plate. The compound examples toward remain utilized on behalf of dampness ingestion trial stood paramount dried in an airborne. At that point these adapted complex examples were drenched in refined aquatic at 30 ◦C for around 120 hrs. Next to normal interims, the examples were expelled from aquatic and cleaned with channel tabloid to evacuate shallow aquatic and pondered by means of advanced parity of 0.01mg goals. The examples remained inundated in aquatic to allow the prolongation of sorption until immersion farthest point stood come to. The assessing be located thru inside 30 s, so as to keep away from the mistake because of dissipation. The test was completed by ASTM D570 to discover the puffiness of example [22-24]. Following 120 hrs, the test examples stayed over again removed from the water shower and gauged..

TABLE 2 Abaca and Flax (Without Dampness)

| S.no | Load N | ΔL Avg.(A+B)/2 | σ (N/mm²) | ε | E (N/mm²) |
|---|---|---|---|---|---|
| 1 | 98.1 | 0.0017 | 0.31227121 | 1.7E-05 | 18368.89459 |
| 2 | 196.2 | 0.0037 | 0.62454242 | 3.7E-05 | 16879.52476 |
| 3 | 294.3 | 0.0054 | 0.93681362 | 5.4E-05 | 17348.40045 |
| 4 | 392.4 | 0.0067 | 1.24908483 | 6.7E-05 | 18643.0572 |
| 5 | 490.5 | 0.0086 | 1.56135604 | 8.6E-05 | 18155.30279 |
| 6 | 588.6 | 0.0103 | 1.87362725 | 0.0001 | 18190.55581 |
| 7 | 686.7 | 0.01195 | 2.18589846 | 0.00012 | 18292.03729 |
| 8 | 784.8 | 0.01365 | 2.49816966 | 0.00014 | 18301.60926 |
| 9 | 882.9 | 0.01505 | 2.81044087 | 0.00015 | 18674.02573 |
| 10 | 981 | 0.017 | 3.12271208 | 0.00017 | 18368.89459 |
| 11 | 1079 | 0.0189 | 3.43498329 | 0.00019 | 18174.51475 |
| 12 | 1177 | 0.0207 | 3.7472545 | 0.00021 | 18102.67873 |
| 13 | 1275 | 0.022 | 4.0595257 | 0.00022 | 18452.38956 |
| 14 | 1373 | 0.02365 | 4.37179691 | 0.00024 | 18485.39921 |
| 15 | 1472 | 0.0253 | 4.68406812 | 0.00025 | 18514.10324 |
| 16 | 1570 | 0.027 | 4.99633933 | 0.00027 | 18504.96048 |
| 17 | 1668 | 0.029 | 5.30861054 | 0.00029 | 18305.55357 |
| 18 | 1766 | 0.0303 | 5.62088174 | 0.0003 | 18550.76483 |
| 19 | 1864 | 0.032 | 5.93315295 | 0.00032 | 18541.10298 |
| 20 | 1962 | 0.0345 | 6.24542416 | 0.00035 | 18102.67873 |
| 21 | 2060 | 0.03595 | 6.55769537 | 0.00036 | 18241.15541 |
| 22 | 2158 | 0.03725 | 6.86996658 | 0.00037 | 18442.86329 |
| 23 | 2256 | 0.0389 | 7.18223778 | 0.00039 | 18463.33621 |
| 24 | 2354 | 0.04115 | 7.49450899 | 0.00041 | 18212.65855 |
| 25 | 2453 | 0.042 | 7.8067802 | 0.00042 | 18587.57191 |

*C. Tensile Test*

Eelasticity of the mixtures (with and without dampness) was estimated with a general testing apparatus as per the ASTM D638 strategy [25-27].

*D. Taguchi Quality Loss Function*

An alternate technique for estimating quality is key to Taguchi's way to deal with structure. Misfortune capacity estimates quality. The misfortune capacity builds up a monetary proportion of the client disappointment with the items execution as it strays from the objective worth. In this way, both normal execution and variety are basic proportions of value [28]. Choosing an item plan or an assembling procedure that is inhumane toward uncontrolled wellsprings of variety improves quality.

TABLE 3 Factors and levels

| No. of | Factors | Level | Level |
|---|---|---|---|
| A | F.F in | 85 | 90 |
| B | A.F in | 85 | 90 |
| C | Epoxy | 50 | 55 |
| D | A. | 10 | 15 |
| E | A. | 10 | 15 |
| F | A. T | YES | NO |

*F. Abaca And Flax (Tensile test)*

A characteristic strands cross breed polymer composite material is manufactured utilizing shaping technique.

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TABLE 4 Factors and levels

| Trial | FACTORS | | | | | | In(KN/mm2) |
|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | |
| | 1 | 2 | 3 | 4 | 5 | 6 | |
| | F.F gms | A.F gms | Epoxy gms | A. Ratio of F.F | A. Ratio of A.F | Chemical treatment | |
| 1 | 85 | 85 | 50 | 10 | 10 | YES | 18368.89459 |
| 2 | 85 | 85 | 50 | 15 | 15 | NO | 17348.40045 |
| 3 | 85 | 90 | 55 | 10 | 10 | NO | 18643.0572 |
| 4 | 85 | 90 | 55 | 15 | 15 | YES | 16879.52476 |
| 5 | 90 | 85 | 55 | 10 | 15 | YES | 18292.03729 |
| 6 | 90 | 85 | 55 | 15 | 10 | NO | 18368.894595 |
| 7 | 90 | 90 | 50 | 10 | 15 | NO | 18102.67873 |
| 8 | 90 | 90 | 50 | 15 | 10 | YES | 18174.51475 |

To get a superior gauge of the general significance of every one of the huge factor, non-huge variables are expelled On the off chance that the F-measurements for any factor is short of what one, at that point pool the 'SS' of that factor into the mistake term.

In the event that the quantity of elements isn't around one-half or less the quantity of sections in the table, pool the variables with the littlest F – Statistic until the no of components remaining is roughly one-portion of the no of segments [30].

particularly when more factors are included. This is known as pooling.

TABLE 5 Factors and levels Factors and mean

| FACTOR | LEVEL | TOTAL | MEAN |
|---|---|---|---|
| A | 1 | 71239.877/4 | 17809.96925 |
| | 2 | 72938.12536/4 | 18234.53134 |
| B | 1 | 72378.22692/4 | 18094.55673 |
| | 2 | 71799.77544/4 | 17949.94386 |
| C | 1 | 71994.48313/4 | 17998.62078 |
| | 2 | 72183.51355/4 | 18045.87839 |
| D | 1 | 73406.66722/4 | 18351.66681 |
| | 2 | 70771.33464 | 17682.83366 |
| E | 1 | 73555.36054/4 | 18388.84014 |
| | 2 | 70622.64123/4 | 17655.66031 |
| F | 1 | 71714.97139/4 | 17928.74285 |
| | 2 | 72463.03097/4 | 18115.75774 |
| TOTAL | | 144178.0018/8 | 18022.25023 |

*Pooling Rules Applied In Taguchi Designed Experiments*

*H. Filtering Electron Microscopy*

A filtering electron microscopy (SEM) machine Model Hitachi S-3000N was utilized to examine the impact of the microstructure of composites examples with dampness and without dampness [31].

SEM Micrograph Of Fibers Under Tensile Loading

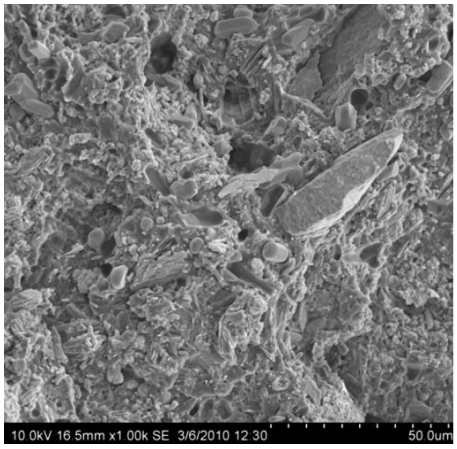


**Figure1 SEM of Abaca and Coir (hybrid) with Dampness**

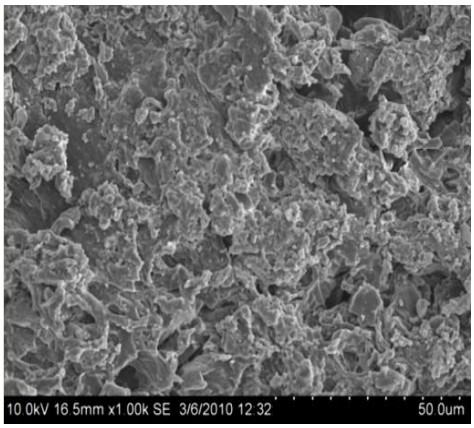


**Figure 2 SEM of Flax and Coir (hybrid) with Dampness**

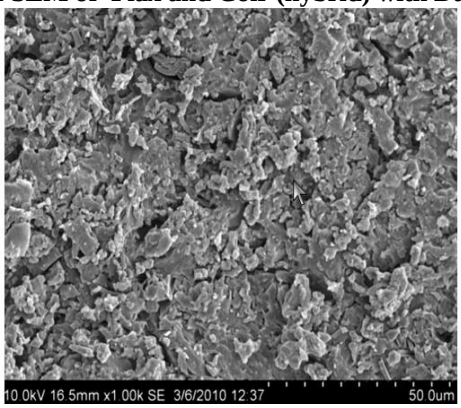


**Figure 3 SEM of Flax and Abaca (hybrid) with Dampness**

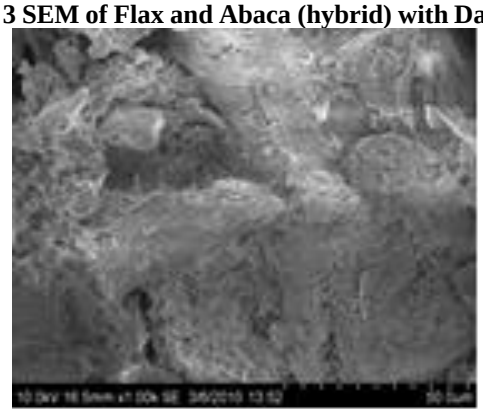

**Figure 4 SEM of Abaca and Coir (hybrid) without Dampness**



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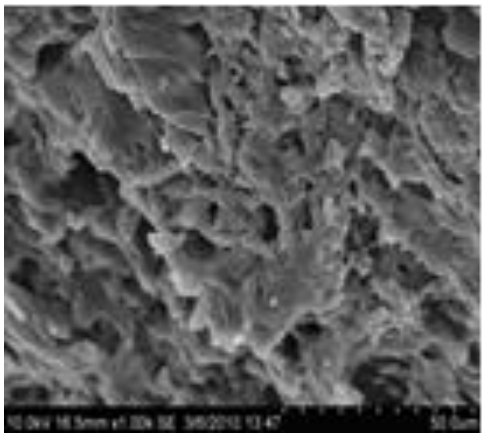

**Figure 5 SEM of Flax and Coir (hybrid) without Dampness**

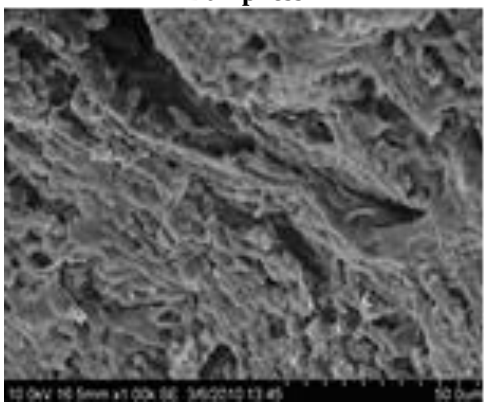

**Figure 6 SEM of Flax and Abaca (hybrid) without Dampness**

## III. RESULTS AND DISCUSSION

The half and half composites indicated relatively better execution, the micrographs taken for the cracked Abaca, Coir, Flax and crossover composites. Abaca and Coir (crossover) and Flax and Coir (half and half) fiber composites, on tractable stacking condition, demonstrated a weak like disappointment (less in % of stretching, fig 7 and 8). Curved splits and their quick spread could be watched. Less fiber haul out is watched and this could be purpose behind the decrease in the elasticity. The nature is legitimized, where more rate prolongation could be watched for the Abaca and Flax (half and half) (high in % of lengthening, Fig 9) fiber composites which display malleable nature of break because of the nearness of Abaca filaments. The half and half composites indicated nearly better execution, the micrographs taken for the broke Abaca, Coir, Flax and cross breed composites. Abaca fiber composites, on tractable stacking condition, demonstrated a weak like disappointment. Curved splits and their quick engendering could be watched. Less fiber haul out is watched and this could be explanation behind the decrease in the elasticity. The tractable break micrograph for the fiber based composites. Plastic misshapening and more fiber haul out could be watched. This nature is legitimized, where more rate lengthening could be watched for the half breed fiber composites. Half breed fiber composites show incomplete weak nature of break because of the nearness of Abaca filaments.

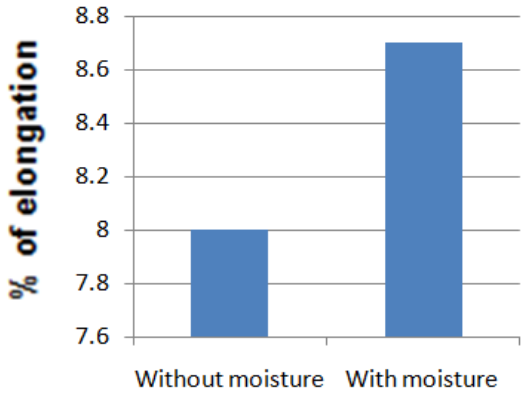


**Figure 7. Comparison of Abaca and Coir (hybrid) In with &without dampness**

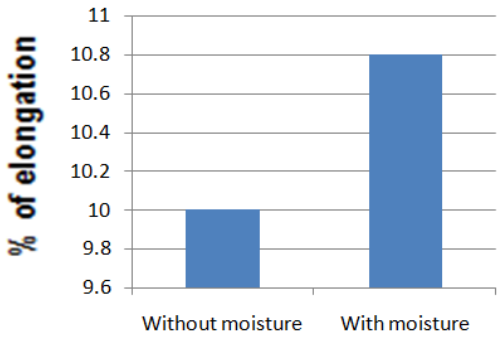


**Figure 8. Comparison of Flax and Coir (hybrid) In with &without dampness**

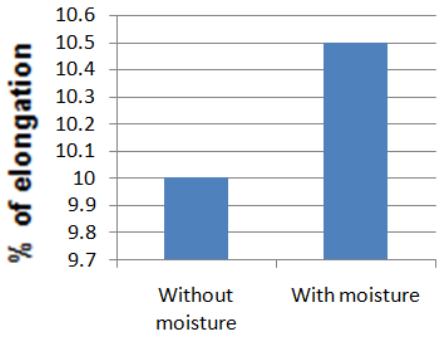


**Figure 9. Comparison of Abaca and Flax (hybrid) In with &without dampness**

## IV. CONCLUSION

In the wake of deciding the material properties of regular fiber fortified epoxy composite utilizing six distinctive device materials and geometrics by utilizing tractable test and hardness test can be drawn: The half breed composites indicated similarly better execution, the micrographs taken for the broke Abaca, Coir, Flax and mixture composites.

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Abaca fiber composites, on elastic stacking condition, demonstrated a weak like disappointment. Curved splits and their quick spread could be watched. Less fiber haul out is watched and this could be purpose behind the decrease in the rigidity. The tractable break micrograph for the fiber based composites. Plastic misshapening and more fiber haul out could be watched. This nature is supported, where more rate stretching could be watched for the half and half fiber composites. Half and half fiber composites show halfway fragile nature of break because of the nearness of Abaca strands. At last this paper presumed that a standout amongst the best materials is Abaca and Flax (half breed) can be utilized for both interior obsession and outer obsession for break bone on human body contrasted with different materials.

## REFERENCES


1. R.Prasannasrinivas and Chandramohan.D., "Analysis of Natural Fiber Reinforced Composite Material for the Helmet Outer shell", International Journal of current Research, Vol.4,No.3,137-141,2012.
2. B.Murali and Chandramohan.D., "Fabrication of Industrial Safety Helmet by using Hybrid Composite Materials", Journal of Middle East Applied Science and Technology, 15,584-587,2014.
3. Murali, B., Chandra Mohan, D. Chemical treatment on hemp/polymer composites, Journal of Chemical and Pharmaceutical Research,6(9), pp. 419-423.
4. Pandyaraj, V., Ravi Kumar, L., Chandramohan, D. Experimental investigation of mechanical properties of GFRP reinforced with coir and flax, International Journal of Mechanical Engineering and Technology,9, pp. 1034-1042,2018.
5. Murali, B., Chandra Mohan, D., Nagoor Vali, S.K., Muthukumarasamy, S., Mohan, A. Mechanical behavior of chemically treated jute/polymer composites, Carbon - Science and Technology,6(1), pp. 330-335.
6. K Gurusami, K et.al.,(2019): A Comparative Study on Surface Strengthening Characterization and Residual Stresses of Dental Alloys using Laser Shock Peening, International Journal of Ambient Energy, DOI: 10.1080/01430750.2019.1614987.
7. Sathish, T., Chandramohan, D. Experimental study and model development for on-line drill wear monitoring system using lab view, International Journal of Recent Technology and Engineering,7(6), 281-286,2019.
8. Sathish, T and Chandramohan, D, Teaching methods and methodologies used in laboratories, International Journal of Recent Technology and Engineering Volume 7, Issue 6, March 2019, Pages 291-293.
9. Chandramohan, D et al. Mechanical, Moisture Absorption, and Abrasion Resistance Properties of Bamboo–Jute–Glass Fiber Composites. Journal of Bio- and Tribo-Corrosion (2019) 5:66.
10. DOI: https://doi.org/10.1007/s40735-019-0259-z
11. Chandramohan, D., Bharanichandar, J., Karthikeyan, P., Vijayan, R., Murali, B. ,Progress of biomaterials in the field of orthopaedics, American Journal of Applied Sciences, 11 (4),623-630,2014.
12. Chandramohan, D.and Marimuthu, K., Natural fibre particle reinforced composite material for bone implant, European Journal of Scientific Research, Vol.54, No.3,384-406,2011.
13. Chandramohan, D, et.al., "Applications of CT/CAD/RPT in the Futurestic Development of Orthopaedics and Fabrication of Plate and Screw Material from Natural Fibre Particle Reinforced Composites for Humerus Bone Fixation – A Future Drift", Malaysian Journal of Educational Technology, Vol.10,No.12,73-81,2010.
14. Chandramohan, D and John Presin Kumar A. Fibre reinforced composites: A promising material for artificial limp. Data-Enabled Discovery and Applications. 1-9. 2017.
15. DOI: https://doi.org/10.1007/s41688-017-0010-1
16. Chandramohan, D., Bharanichandar, J, Impact test on natural fiber reinforced polymer composite materials, Carbon - Science and Technology,5(3), pp. 314-320,2013.
17. Chandramohan, D., Murali, B., Machining of composites - A review, Academic Journal of Manufacturing Engineering,12(3), 67-71,2014.
18. Chandramohan.D., "Analysis On Natural Fiber Bone Plates", European Journal of Experimental Biology, 4(2):323-332,2014.
19. Chandramohan, D., Rajesh, S,Study of machining parameters on natural fiber particle reinforced polymer composite material, Academic Journal of Manufacturing Engineering12(3),72-77,2014.
20. D Chandramohan, K Marimuthu, Bio composite materials based on bio polymers and natural fibers-contribution as bone implants, International Journal Of Advanced Medical Sciences And Applied Research, Vol No. 1, Issue No. 1, 009 – 012,2011.
21. Chandramohan, D., Marimuthu, K. Applications of natural fiber composites for replacement of orthopaedic alloys, Proceedings of the International Conference on Nanoscience, Engineering and Technology, 6167942, pp. 137-145,2011.
22. Chandramohan, D., Rajesh, S., Increasing combusting resistance for Hybrid composites, International Journal of Applied Engineering Research,9(20), 6979-6985,2014.
23. Chandramohan, D. and Marimuthu, K., "Contribution of Biomaterials to Orthopaedics as Bone Implants – A Review", International Journal of Materials Science, Vol.5, No.3,445-463,2010.
24. Chandramohan.D., and A.Senthilathiban. Effects of chemical treatment on jute fiber reinforced composites, International Journal of Applied Chemistry, 10 (1),153-162,2014.
25. S.Dinesh kumar and K. Purushothaman (2018): Enhancement of thermal conductivity in a plate heat exchanger by using nano particles CNT, Al2O3,surfactant with De-ionised water as coolant, International Journal of Ambient Energy, DOI:10.1080/01430750.2018.1562979.
26. Chandramohan, D., Bharanichandar, J. Natural fiber reinforced polymer composites for automobile accessories, American Journal of Environmental Sciences,9(6), 494-504,2014.
27. Sathish,T., Periyasamy,P., Chandramohan,D., Nagabhooshanam, N., Modelling K-nearest neighbour technique for the parameter prediction of cryogenic treated tool in surface roughness minimization, International Journal of Mechanical and Production Engineering Research and Development, Volume 2018, Issue Special Issue, 2018, Article number IJMPERDSPL201883, Pages 705-710.
28. S. Dinesh Kumar, K. Purushothaman, D. Chandramohan et al., ANN-AGCS for the prediction of temperature distribution and required energy in hot forging process using finite element analysis, Materials Today: Proceedings, DOI:https://doi.org/10.1016/j.matpr.2019.05.426.
29. Sathish, T., Chandramohan, D. Design and analysis of wind box segment in travelling grate stoker boiler using CFD, International Journal of Recent Technology and Engineering,7(6), 287-290,2019.
30. Sathish,T., Periyasamy,P., Chandramohan,D., Nagabhooshanam, N., Modelling of cost based optimization system E-O-L disassembly in reverse logistics, International Journal of Mechanical and Production Engineering Research and Development, Volume 2018, Issue Special Issue, 2018, Article number IJMPERDSPL201883, Pages 711-716.
31. Chandramohan, D and John Presin Kumar A. Experimental data on the properties of natural fiber particle reinforced polymer composite material, Data in Brief,13, pp. 460-468,2017.
32. Raja Ganesan Prabhakaran Vasantha-Srinivasan, Sengodan Karthi, Muthiah Chellappandian, Athirstam Ponsankar, Annamalai Thanigaivel, Sengottayan Senthil-Nathan, Devarajan Chandramohan, Aspergillus flavus (Link) toxins reduces the fitness of dengue vector Aedes aegypti (Linn.) and their non-target toxicity against aquatic predator, Microbial pathogenesis,128,281-287,2019.
33. DOI:https://doi.org/10.1016/j.micpath.2019.01.014.
34. J Bharamichandar, D Chandramohan, B Murali, Natural fibre reinforced polymer composite in synthetic bone grafting-a new approach, J Mid East Appl Sci Technol,16,588-596, 2014.
35. Karthick, S. TDP: A Novel Secure and Energy Aware Routing Protocol for Wireless Sensor Networks, In International Journal of Intelligent Engineering and Systems, Vol. 11, No. 2, pp. 76-84. 2018.
36. Sathish, T., Muthukumar, K., Palani Kumar, B. A study on making of compact manual paper recycling plant for domestic purpose, International Journal of Mechanical and Production Engineering Research and Development, Vol. 8, No. Special Issue 7, pp. 1515-1535, 2018.
37. Sathish, T., Jayaprakash, J. Multi period disassembly-to-order of end-of-life product based on scheduling to maximise the profit in reverse logistic operation, International Journal of Logistics Systems and Management, Vol. 26, No. 3, pp. 402-419, 2017.
38. Sathish, T., Muthulakshmanan, A. Modelling of Manhattan K-nearest neighbor for exhaust emission analysis of CNG-diesel engine, Journal of Applied Fluid Mechanics, Vol. 11, No. Special issue, pp. 39-44, 2018.
39. Sathish, T., Vijayakumar, M.D., Krishnan Ayyangar, A. Design and Fabrication of Industrial Components Using 3D Printing, Materials Today: Proceedings, Vol. 5, No. 6, pp. 14489-14498, 2018.

40. Sathish, T. BCCS Approach for the Parametric Optimization in Machining of Nimonic-263 alloy using RSM, Materials Today: Proceedings, Vol. 5, No. 6, pp. 14416-14422, 2018.

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