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PREDICTING OF PROCESS PARAMETER FOR MAKING COMPOSITE NATURAL FIBER BY ANOVA ANALYSIS

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ABSTRACT

Full factorial trial designs are created at three levels for optimization of the compounding and the injection molding processes. Composites with hemp and flax fibers are considered for these investigations. The selected parameters in compounding are impact velocity, filler content, erodent temperature, impingement angle, stand of distance and Erodent Size. The effects are evaluated by statistical analysis of the resulting mechanical and microstructure properties. The conclusions of this analysis are verified by trials on composites with flax, pulp and glass fibers. However the expected strength increase is shown to be strongly limited by the manufacturing processes, which have large influence on the microstructure of the composites.

KEYWORDS: Composite Nature Fiber, Process parameter, ANOVA Analysis.

1. INTRODUCTION

Different manufacturing techniques as well as different constituents result in composite materials with diverse properties. Thus the properties of NFC can be tailored for various types of applications by a proper selection of fibers, matrix, additives and manufacturing method. The fast economic growth in some developing countries that we have seen lately will hopefully continue and spread. Conventional high performance composites contain long, mostly continuous filaments such as glass or carbon fibers. Although there have been attempts to develop natural fiber fabrics for technical applications [1], the main part of the NFC out on the market contain short fibers. In some types of synthetic short fiber composites (SMC, BMC, GMT) the fiber length remains the same throughout the processing stages. But for some processes, like compounding and injection molding, the fiber length is process-dependent i.e. the initial fiber length will not be preserved in the final product. Since fiber length is one of the most important parameters in terms of mechanical performance of short fiber composites. It is a material response to the external stimulus and can be mechanical or chemical in nature. Similarly, surface fatigue is another wear process that takes place when tiny wear particles are dislodged from a surface by fracture on repeated rolling or sliding on the surface. Owing to a repeated loading action subsurface cracks grow from pre-existing defects, join hands with other vicinal cracks and finally come to the surface removing a small chunk of material [3]. In the erosion wear mode, a progressive loss of material occurs from a solid surface due to mechanical interaction between that surface and a fluid, a multi-component fluid, or impinging liquid or solid particles [4].

2. OBJECTIVE OF WORK

The work presented here is not an attempt to solve these problems but this effort is to understanding in accordance with the environmental sustainability goal. It is also in accordance with one of my most important life. The literature survey presented above reveals the following knowledge gap in the research reported so far:

- Though much work has been reported on various wear characteristics of metals, alloys and homogeneous materials, comparatively less work has been reported on the erosive wear performance of polymer and its composites.
- Though much work has been done on a wide variety of synthetic fiber reinforced polymer composites, very less has been reported on the reinforcing potential of glass fiber in spite of its several advantages over others.
- Design of experiment with epoxy based composites are fabricated with short flax and hemp fiber as a reinforcing material.
- Evaluations of erosion wear characterization of all the fabricated composites.
- Statistical analysis based on Taguchi experimental design for parametric appraisal of erosion wear process for the composites under study.

3. MATERIALS

The extraction of fiber from it will add to the revenue of the cultivator, and the same can be used to prepare products, which will improve the economy of the villagers especially. Currently, the extracted fibres were used for making bags, purse, etc. In order to improve the application of flax and hemp fiber an attempt was made to reinforce it in an epoxy matrix to form a composite.

Table 1 Typical properties of flax and hemp fibers

Material	Density (g/cm^3)	Tensile Strength (MPa)	Young's Modulus (GPa)	% Elongation at break
Flax and hemp fiber	1.35	400-600	16-20	5.9

Flax Hemp

Fig. 1 Short flax and hemp fiber

The fibres from the pseud stem of the flax and hemp plants are extracted manually and mechanically. The extracted white portion of the stem is passed into the machine several times and dried in the sun light for a day or two. Further, the peel is clamped between the wood planks and hand-pulled through, removing the resinous material. The extracted fibres are again sun-dried which whiten the fiber. The natural fibres are made by different set of parameter and then its erodent wear measured.

4. RESULT ANALYSIS

The results of erosion experiments carried out according to the predetermined design on glass fiber-epoxy composites are presented in fig 2. This table provides the experimental erosion rate along with the ANOVA ratio for each all test run. Each value of the erosion rate is the average of three replications.

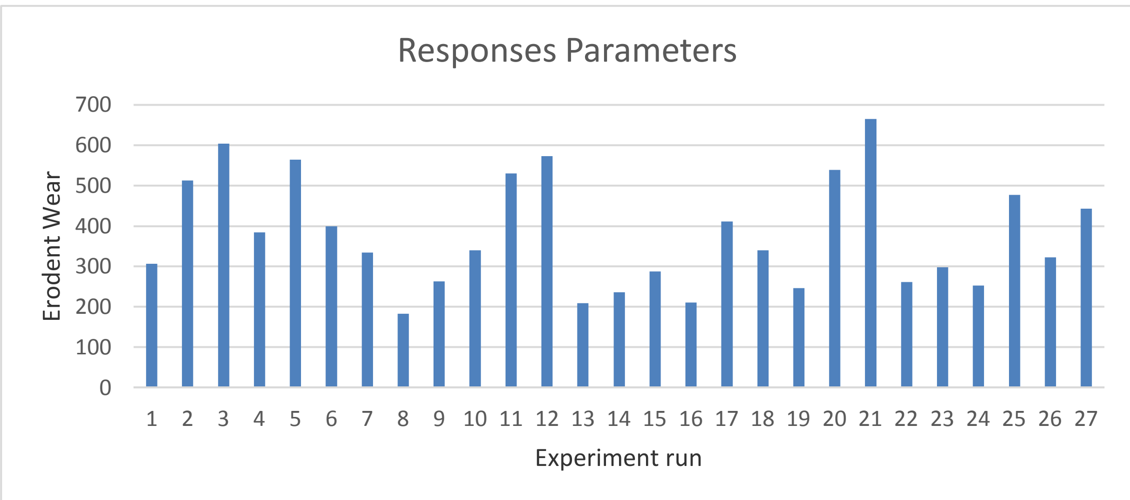

Fig 2 Responses Parameter of Experiment

The results of erosion experiments carried out according to the predetermined design on flax and hemp fiber-epoxy composites are presented in Fig 2. This table provides the experimental erosion rate along with the signal-to-noise ratio for each individual test run. Each value of the erosion rate is the average of three replications. The overall mean of the S/N ratios is found to be -51.8247 db for flax and hemp fiber based composites. Figs 3 illustrate the effect of control factors on erosion rate of glass fiber epoxy composites. Analysis of the results leads to the conclusion that factor combination ofA1 (Impact velocity: 30 m/sec), B2 (Filler content: 15 wt%), C1(Erodent temperature: 40°C), D3 (Impingement angle: 90°), E2 (Stand-off distance: 70mm) and F2 (Erodent size: 450μm) gives minimum erosion rate for flax and hemp fiber-epoxy composites.

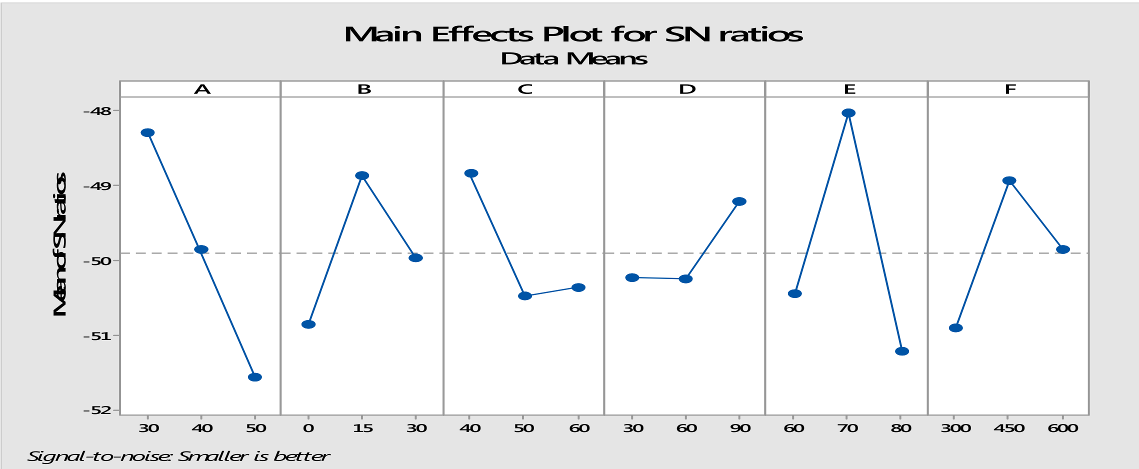

Fig. 3 Effect of control factors on erosion wear rate of flax and hemp fiber-epoxy composites

The S/N ratio response is given in the Table 2, from which it can be determined that among all the factors, impact velocity of erodent is the most significant factor followed by stand-off distance, fiber loading, erodent size while erodent temperature, impingement angle has the least or negligible significance on wear rate of flax and hemp fiber-epoxy composites. It can be seen from table 2 and 3 that for similar test conditions, flax and hemp fiber-epoxy composites exhibit much lower wear rates than those by glass fiber-epoxy composites.

Table: 2 Analysis of variance for SN ratio (flax and hemp fiber epoxy composites)

Source	DF	Seq SS	Adj MS	Adj MS	F	P
A	2	48.214	48.214	24.107	1.41	0.416
B	2	18.123	9.062	9.062	0.53	0.654
C	2	15.201	7.601	7.601	0.44	0.693

D	2	6.349	3.174	3.174	0.19	0.844
E	2	49.759	24.880	24.880	1.45	0.408
F	2	17.705	8.853	8.853	0.52	0.659
A*B	4	12.681	3.170	3.170	0.18	0.927
A*C	4	12.254	3.063	3.063	0.18	0.931
B*C	4	19.212	4.803	4.803	0.28	0.871
Residual Error	2	34.27	17.139	17.139		
Total	**26**	**233.777**				

Table 3 Response table for erosion wear rate of flax and hemp fiber–epoxy composites

Stage	A	B	C	D	E	F
1	-48.28	-50.86	-48.84	-50.24	-50.45	-50.91
2	-49.85	-48.86	-50.48	-50.24	-48.03	-48.93
3	-51.56	-49.97	-50.37	-49.21	-51.21	-49.85
Delta	3.27	2.00	1.65	1.03	3.19	1.98
Rank	1	3	5	6	2	4

5. CONCLUSIONS

Successful fabrication of epoxy matrix composites reinforced with synthetic fiber as well as natural fiber is possible by simple hand-lay-up technique. This study reveals that both the fibers possess good filler characteristics as it improves the erosion wear resistance of the polymeric resin. Erosion wear characteristics of these composites can be gainfully analyzed using a design-of-experiment approach based on Taguchi method. The analysis of experimental results shows that factors like glass fiber content, erodent temperature, stand-off distance, impingement angle, erodent size and impact velocity in sequence are the significance factor on wear rate of glass fiber-epoxy composites whereas impact velocity, stand-off distance, fiber loading, erodent size, erodent temperature, impingement angle in sequence are the significance factor on wear rate of flax and hemp fiber-epoxy composites.

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