OPTIMIZATION OF PROCESS PARAMETERS IN DRILLING OF SISAL FIBRE EPOXY COMPOSITE BY USING HYBRID AHP AND SMART TECHNIQUES

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Abstract-Natural fibre composites have attracted global attention due to their lightweight. Sisal is fully biodegradable and highly renewable resource of energy and exceptionally durable and a low maintenance with minimal wear and tear. Design of experiment taguchi method L_{27} orthogonal array is used to study the various combination (high, medium and low) of input process parameters are speed (rpm),feed(mm) and diameter(mm).MINITAB software is used to generate the various combinations of input machine parameters. The out puts results are material removal rate (MRR), thrust force(N-m) and torque(N).Optimization of drilling process parameters of sisal fibre epoxy composite material by using combined hybrid analytical hierarchical process (AHP) and simple multi attribute rating technique(SMART).Drilling of sisal fibre epoxy material model is developed to simulate the process by using MATLAB and Established the relation between input and output variables by using auto regression external input analysis method. The model is simulated in different levels of iterations.

Keywords: Analytical hierarchy process (AHP), simple multi attributes rating technique (SMART) method and MATLAB.

I.INTRODUCTION

Multi-Criteria Decision Analysis has seen an incredible amount of use over the last several decades. Its role in different application areas has increased significantly, especially as new methods develop and as old methods improve. The analyses several common multi-criteria decision making (MCDM) methods and determines their applicability to different situations by evaluating their relative advantages and dis-advantages.In addition to applying single MCDM methods to real world decisions, the progression of technology over the past couple of decades has allowed for more complex decision analysis methods to be developed. This experimentation with combined multi-criteria decision-making methods has provided a whole new approach to decision analysis.The ultimate aim in machining operations is to produce parts with less cost and more quality. Cost and quality mainly depends on the parameters. Now a days proper selection of parameters is the study of most researchers.

Generally the machining parameters are chosen based on the knowledge, operators experience and also referring to standard handbooks. The selected machining parameters may not be the optimal solution which leads to higher cost of the product. High machining performance is obtained by the selection of optimum machining parameters. Optimization techniques help as to select the optimum combination of machining parameters.

ANALYTIC HIERARCHY PROCESS (AHP)

The analytic hierarchy process (AHP) is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. It has particular application in group decision making, and is used around the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, ship building and education. Rather than prescribing a "correct" decision, the AHP helps decision makers find one that best suits their goal and their understanding of the problem for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. Users of the AHP first decompose their decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently the decision makers systematically evaluate its various elements by comparing them to each other two at a time, with respect to their impact on an element above them in the hierarchy.

SIMPLE MULTI ATTRIBUTE RATING TECHNIQUE (SMART) SMART is one of the simplest forms of MAUT. It requires two assumptions, namely "utility independence and preferential independence" this method conveniently converts importance weights into actual numbers. Major advantages of SMART, in addition to those described in MAUT, are that it is simple to use and it actually allows for any type of weight assignment techniques (i.e., relative, absolute, etc.). It requires less effort by decision makers than MAUT. It also handles data well under each criterion. Like MAUT, a disadvantage is that the "procedure for determining work is not convenient considering the complicated framework". SMART's common applications are in environmental, construction, transportation and logistics, military, manufacturing and assembly problems. Many of the plant fibers such as coir, sisal, jute, banana, Palmyra, pineapple, talipot, hemp, etc. A good sisal plant yields about 200 leaves with each leaf having a mass composition of 4% fiber, 0.75% cuticle, 8% other dry matter and 87.25% moisture. Thus a normal leaf weighing about 600g yields about 3% by weight of fibre with each leaf containing about 1000 fibres.. The diameter of the fibre varied from 100mm to 300mm. The fibre is composed of numerous elongated fusiform fibre cells that taper towards each end According to Gram(1983), a sisal fibre in cross-section is built up of about 100 fibre cells. state that the number of cells in cross-section of a coconut fibre ranges from 260 to 584 depending on the diameter of the fibre.

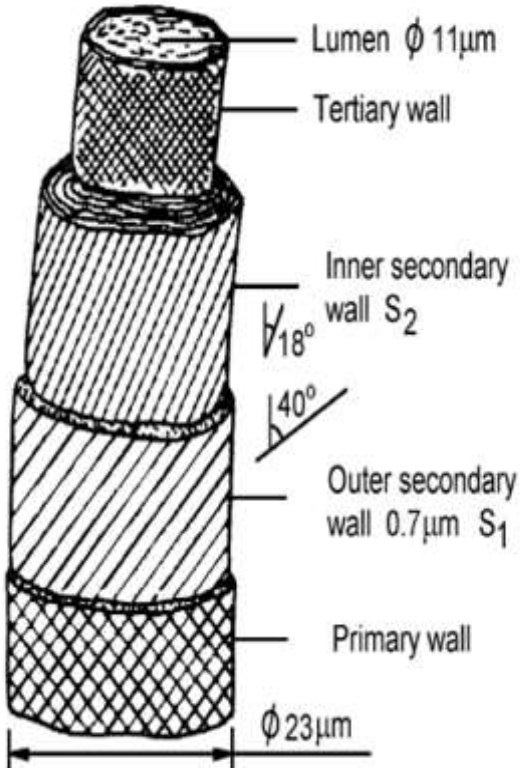
RAW MATERIAL STRUCTURE AND PROPERTIES OF SISAL FIBRE

Fibres obtained from the various parts of the plants are known as vegetable fibres. These fibres are classified into three categories depending on the part of the plant from which they are extracted.

1. Bast or Stem fibres (jute, mesta, banana etc.)

2. Leaf fibres (sisal, pineapple, screw pine etc.)

3. Fruit fibres (cotton, coir, oil palm etc.)



DESIGN OF EXPERIMENT

Classical experimental design methods are too complex and are not easy to use. A large number of experiments have to be carried out when the 86 number of process parameters increase. To solve this problem, the Taguchi method uses a special design of orthogonal arrays to study the entire parameter space with only a small number of experiments.

Three superplastic forming parameters are considered as controlling factors. They are Pressure, Temperature and Time. Each parameter has three levels – namely low, medium and high, denoted by 1, 2 and 3 respectively. According to the Taguchi method, if three parameters and 3levels for each parameters L27 orthogonal array should be employed for the experimentation. Table 1.1shows the Super plastic forming parameters and their levels considered for the experimentation.

The maximum thrust force and torque is calculated using the graphs obtained from CNC drilling machine. MRR is calculated using the formula given below:

For MRR(material removal) rate we used formula

MRR=(Π/4)D^2 fN

D=drill diameter

F=feed rate

N=rpm of drill

Orthogonal arrays are special standard experimental design that requires only a small number of experimental trials to find the main factors effects on output. Before selecting an orthogonal array, the minimum number of experiments to be conducted is to be fixed based on the formula below Taguchi=1+NV(L–1)

TABLE1.1
LEVELS OF PARAMETERS

Process parameters	Level 1	Level 2	Level 3
Speed	500	750	1000
Feed	0.03	0.06	0.09
Drill dia	4	5	5

The 27 experiments are to be conducted. Based on this orthogonal array (OA) is to be selected which has at least 27 rows i.e.,27 experimental runs. The following standard orthogonal arrays are commonly used to design experiments:

2-Level Arrays: L4, L8, L12, L16, L32
3-Level Arrays: L9, L18, L27
4-Level Arrays: L16, L32

II.PROPOSED WORK

The company's cutting force dynamometer is said to enable investigations of high speed machining processes and monitoring machining of critical tool. The dynamometer has a lightweight construction to enable speeds up to 25,000 rpm. The stationary head is mounted to the machine tool and receives data by wireless transmission, which is said to eliminate mechanical contact systems. Three measuring ranges of force can be selected and measurement can be started either manually or via the serial interface. The sensors use piezoelectric technology and provide outputs of force and moments at ±10 V. Measuring error associated with conventional units is reduced as the cutting tool is attached to the dynamometer. It can be placed in any orientation and has an internal coolant supply

TABLE 1.2
INPUT PARAMETERS FOR SISAL FIBRE EPOXY

S.NO	SPEED (rpm)	FEED (mm/min)	DRILL DIA (mm)
1	500	0.03	4
2	500	0.03	5
3	500	0.03	6
4	500	0.06	4
5	500	0.06	5
6	500	0.06	6
7	500	0.09	4
8	500	0.09	5
9	500	0.09	6
10	750	0.03	4
11	750	0.03	5
12	750	0.03	6
13	750	0.06	4
14	750	0.06	5
15	750	0.06	6
16	750	0.09	4
17	750	0.09	5
18	750	0.09	6
19	1000	0.03	4
20	1000	0.03	5
21	1000	0.03	6
22	1000	0.06	4
23	1000	0.06	5
24	1000	0.06	6
25	1000	0.09	4
26	1000	0.09	5
27	1000	0.09	6

III.RESULTS

An AHP hierarchy is a structured means of modelling the decision at hand. It consists of an overall goal, a group of options or alternatives for reaching the goal, and a group of factors or criteria that relate the alternatives to the goal.

Calculate priority vector

The nth root of product values (and total) from the previous step will be normalized to calculate the weights for each criteria

Thrust force=0.538142/0.997271

=0.539615

Torque=0.29615/10.

=997271

MRR=0.162978/0.997271

=0.163424

Table5.5:Weights calculations

When calculated correctly. The weights of each criteria must sum to one.

CHECKING THE CONSISTENCY:

TABLE 1.3
OUTPUT RESULTS OF DRILLING OF SISAL FIBRE EPOXY COMPOSITE

S.NO	MRR (mm^3/min)	TORQUE (N-m)	THRUST FORCE (N)
1	188.49	0.5	16
2	294.52	0.56	15.5
3	424.11	0.85	18.2
4	376.99	0.43	12
5	589.04	0.42	15.7
6	848.23	0.45	19
7	565.48	0.44	13.5
8	883.57	0.43	21
9	1272.34	0.54	5.5
10	282.74	0.42	18
11	441.78	0.39	18.3
12	636.17	0.4	28
13	565.48	0.45	19
14	883.57	0.44	16.8
15	1272.34	0.38	23
16	848.23	0.36	17.5
17	1325.35	0.42	23
18	1908.51	0.54	28
19	376.99	0.7	17
20	589.04	0.62	26
21	848.23	0.7	23
22	753.98	0.78	17
23	1178.09	0.9	21
24	1696.46	0.8	15
25	1130.97	0.82	13.5
26	1767.14	0.92	15.5
27	2544.69	0.9	18.5

Consistency ratio=$\frac{CI}{RI} * 100$

CI=(Lambda max-n)/(n-1)

N=3

lambda max=3.009202713

CI=0.004601357

Where:

λ_{max}=sum*priority vector

n=number of comparison matrices

Ri=0.58

CI=0.004601357/0.58

CI=0.007933373

TABLE5.1 PAIRE WISE COMPARISON MATRIX

S.NO	THRUST FORCE (N)	TORQUE (N-m)	MRR (mm^3/min)
THRUST FORCE (N)	1	2	3
TORQUE (N-m)	½	1	2
MRR (mm^3/min)	1/3	1/2	1

Table5.2 Calculate the nth root of product row wise to

S.NO.	THRUST FORCE (N)	TORQUE (N-m)	MRR (mm^3/min)	nth root of product
THRUST FORCE (N)	1	2	3	0.538142
TORQUE (N-m)	1/2	1	2	0.296151
MRR (mm^3/min)	1/3	1/2	1	0.162978
Sum	1.833333	3.5	6	0.997271

The value of Consistency Ratio is smaller or equal to 10%, the inconsistency is acceptable. If the Consistency Ratio is greater than 10%, we need to revise the subjective judgment. CR value is less than 0.1 so it is acceptable and it reflects an informed judgment which could be attributed to the analysts knowledge of the problem.

Graphs:

Thrust force and torque were calculated from the graphs obtained during the machining. The software used for this purpose is dynamometer. The graphs shows the variation of thrust force and torque w.r.t.The maximum values of thrust force and torque taken for evaluation purpose.

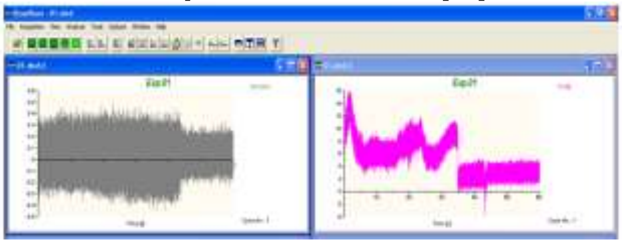


Figure 6.1:Torque(Nm) vs time(s) at 500rpm speed,0.03mm/rev feed and diameter 4mm

Decision alternatives (measures) for each strategic objective were listed using brainstorming by each member of the committee. After identifying all potential measures, a numeric score between 0 and 100 were assigned for indicating how well each decision alternative satisfies each criterion using SMART, where a score of 100 indicates extremely high satisfaction and 0 indicates virtually no satisfaction. Finally the total "score" Xi for each decision alternative

.IV. Conclusion

In this study, drilling of sisal fibre epoxy polymer is carried out with the input drilling parameters considered as spindle speed, feed rate and drill diameter, and the response obtained is hole torque and thrust force. The drilling parameters are optimized with respect to multiple performances in order to achieve a good quality of holes in drilling of sisal fibre epoxy polymer. Optimization of the parameters was carried out using Taguchi method. It was identified that a spindle speed of 1000 rpm, drill diameter of 5mm and a feed rate of 0.6 mm/rev is the optimal combination of drilling parameters.

OPTIMUM VALUE=93.6551
THE INDEX=A23
TORQUE=100.000
THRUST FORCE=85
THE MRR=90

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The heading of the Acknowledgment section and the References section must not be numbered.Causal Productions wishes to acknowledge Michael Shell and other contributors .

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