

Development and Optimization of Process Parameters of Microwaved Cured Polymer Based Natural Fibre (Coir) Reinforced Composite

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ABSTRACT

Now a days the processing of natural Fibre reinforced polymer composite through microwave curing going on a fortunate steps for better properties. It has been observed that the application of NFRPC is increasing day to day. Due to their low cost and light weight that type of composite is applying at various light load capacity areas. Processing of NFRPC depends on a large no factors. Due to practical constraint 3 domen parameters were considered during experimental investigation. The value of the parameter were selected on the basis of material characteristics and experimental available in the Laboratory. Design of Experiment were used for planning the experiments. Optimum process parameter were determined for improvement ultimate tensile strength. The selection of optimum parameter was assured by mechanical testing as well as microscopic structure. Processing of composite by using optimized parameters resulted in improvement in tensile strength by 3 %. The ANOVA table was prepared and table was shown Curing Time is one of the main crucial parameter which affects the composite processing.

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KEYWORDS: Scientific research, challenges, literature review

1. INTRODUCTION

Natural Fibres, any hair like raw material directly obtainable from a vegetable, an animal or mineral source and converted into such kind of useable product. These fibres are completely renewable, environmental friendly, high specific strength, non-abrasive, low cost, and bio-degradability. Due to these characteristics, natural fibres have recently become attractive to researchers and scientists as an alternative method for fibres reinforced composites. Due to the disadvantage of the synthetic and fibre glass as reinforcement, the use of fibre reinforced composite gained the attention of the young scientists. NFCs have good potential for both interior and exterior automotive applications.

Their advantages include having low density and cost, high specific strength, and being sustainable and environmentally friendly. The resulting products from those composites can be both reused and incinerated and do not have to be land filled as glass Fibre compounds, which can help in developing cars according to the EU end-of-life directive.. Lots of work has been carried out in the production of natural fibre reinforced polymer composites, using natural fibres like coir, hemp, cotton, sisal, kenaf, bagasse, areca, abaca, bamboo etc. and their properties have been studied. Here is an attempt made on the literature survey of areca fibre reinforced polymer composites where different properties of areca fibres, its maturity level, surface treatment effect on properties of fibres.

1.1 Natural Fibres

Some of the natural and synthetic fibres that can be used for making composites are discussed below.

1.1.1 Jute

Jute is one of the most important natural Fibres now a days, and second only to cotton in the amount produced and variety of uses. Jute Fibres are extract from the plant which contained with Materials cellulose and lignin. The industrial term for jute Fibre is raw jute. The Fibres are off-white to brown, and 1–3 meters (3–10 feet) long. Jute is also called the golden Fibre for its color. The figure 1 shows the sample of jute Fibre used.



Figure 1 Jute Fibre

1.1.2 Coir

Coir or coconut fibre, is a natural fibre extracted from the husk of coconut and used in products such as floor mats, doormats, brushes and mattresses. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. Other uses of brown coir (made from ripe coconut) are in upholstery padding, sacking and horticulture. White coir, harvested from unripe coconuts, is used for making finer brushes, string, rope and fishing nets. It has the advantage of not sinking, so can be used in long lengths on deep water without the added weight dragging down boats and buoys. The figure 2 shows the coir Fibre used.



Figure 2 Coir Fibre

1.2 Synthetic Fibres

There are so many types of synthetic fibre are available in the market.

1.2.1 Glass Fibre

Glass fibre shown in Figure 4 is made of numerous extremely fine fibres of glass, commonly used as an insulating material. It is also used as a reinforcing agent for polymer products to produce strong and light sheets of Fibre-reinforced Polymer (FRP) popularly known as fibre glass. Glass fibres are not strong and rigid as carbon fibre, but are much cheaper and significantly less brittle. Figure 3 shows the a sample of glass fibre.



Figure 3 Glass Fibre

1.3 Matrices

Polypropylene (PP), widely used, is a thermoplastic polymer seen in packaging and labelling, textiles, stationery, plastic, etc

1.3.1 Polypropylene

Polypropylene (PP), is a thermoplastic polymer used in a wide variety of applications. It is produced through chain-growth polymerization from the monomer propylene. Polypropylene belongs to the group of polyolefin and is particularly crystalline. Its properties are similar to polyethylene, but it is slightly harder and more heat resistant. It is a white, mechanically rugged material and has a high chemical resistance.

Polypropylene is the second-most widely produced commodity plastic (after polyethylene) and it is often used in packaging and labelling. In 2014, the global market for polypropylene was about 65 million tones. The figure 4 shows the polypropylene polymer used.



Figure 4 Polypropylene

1.4 Materials

In the present work, homopolymerized granules of polypropylene were supplied by Seth Plastic Industries, Delhi, India and coir fibre were supplied from India mart website.

In this research article i.e. Coir Fibre was used as a raw material. The Fibre was chopped at different size like 20 mm, 30 mm and 40 mm. Table 1 shows the physical properties of coir fibre.

Table 1: Physical Properties of Coir Fibre

Sl. No	Physical Property	Value
1	Density(g/cm ³)	1.23
2	Tensile Strength(kN/mm ²)	210-220
3	Stiffness (kN/mm)	12-32
4	Elongation at break (%)	10-20
5	Moist Absorption (%)	5
6	Price of raw Fibre(Rs./kg)	30-50

1.5 Chemical Treatment

Chopped coir fibre (20 mm to 40 mm) were washed by distilled water at 85°C for 80 minutes and then dried it. For alkali treatment 10 wt.% solution of NaOH was prepared and washed fibres were soaked into solution for 4 hours at room temperature. After this, fibres were washed with distilled water and dried into hot air oven at 80°C for 2 hours.

1.6 Manufacturing of composite

The following steps were followed for making natural fibre reinforces composite.

- Step 1.** Domestic microwave was used as the primary source for making composite. Polymer composites come in the category of mixed microwave absorbing materials as absorption of microwave energy is dependent on the dielectric properties of the matrix as well as reinforcements.
- Step 2.** The treated fibre were chopped into 3 categories like 25 mm, 20 mm, and 15 mm.
- Step 3.** Bone china was taken as mold material for getting desired shape and size.
- Step 4.** The another properties like power and time was taken the process parameter.
- Step 5.** Power range 720 W, 640 W and 560 W and Time slot 16 min, 18 min, 20 min.
- Step 6.** After completed the production process composite was taken and was being ready for mechanical testing.

Taguchi design of the experiment is a simple optimization technique which is used for reducing the no of conducting experimnts.In this experiment procedure ,the three factors were selected with their level which is shown in the table no 2. Depending on different process parameters, the composite was prepared. Nine specimen with unique dimension was ready for tensile test.Tensile test specimens are fabricated as per ASTM standard and a test specimen is shown in fig 2.

Table 2: Level and parameters of Experiments

Symbol	Parameter	Level 1	Level 2	Level 3
A	Power (Watt)	720	640	560
B	Operational time (min)	16	18	20
C	Fibre size (mm)	25	20	15



Figure: 5 Sample of NFRPC

In the present experimental work, an L9 Orthogonal Array with 3 rows and 3 column was used. This array can handle three level process parameters. Nine experiments were conducted to study the process parameters using the L9 OA.OA and the corresponding values of process parameters are listed in Table 3.

Table 3: Values of parameters, UTS and S/N ratio

S No	Power A	Opr. Time B	Fibre size C	Result in UTS	S/N RATIO
1	720	16	25	28.2	29.01
2	720	18	20	29.1	29.27
3	720	20	15	30.3	29.63
4	640	16	20	30.4	29.66
5	640	18	15	30	29.54
6	640	20	25	28.9	29.22
7	560	16	15	28.1	29.97
8	560	18	25	28.4	29.07
9	560	20	20	29.4	29.37

From S/N ratio, Noise factors are those uncontrollable factors which affect the process result (Output), whereas final response is known as the signal. The variation of the index is known as S/N ratio. Variations are usually three types i, e “lower is better”, “higher is better” and “Normal is better”. In the Present study depending upon the criteria Ultimate tensile strength (UTS), Ultimate tensile strength (UTS) consider as “higher is better”. In order to evaluate the influence of each selected factor on the response, S/N ratios for each control factor was calculated.

$$\frac{S}{N} = -10 \log_{10} \left(\sum_{i=0}^n \frac{1}{y_i^2} \right), \text{ Higher is better} \dots\dots 1$$

Table: 4 Response Value

Level	Power A	Opr.Time B	Fibre size C
1	29.14	29.21	29.38
2	29.47	29.30	29.43
3	29.30	29.40	29.10
Delta	0.34	0.19	0.34
Rank	2	3	1

1.7 Tensile strength

Ultimate tensile strength (UTS) was calculated experimentally, Taguchi technique was applied for analysis with support of ANOVA and mode of fracture was studied. On the basis of data analyzed, plots for S/N ratio are shown in fig 4.it is much cleared that third level of Power (640 w), the second level of Operational Time (20 min) and third level of Fibre Size (20 mm) gives higher tensile strength.

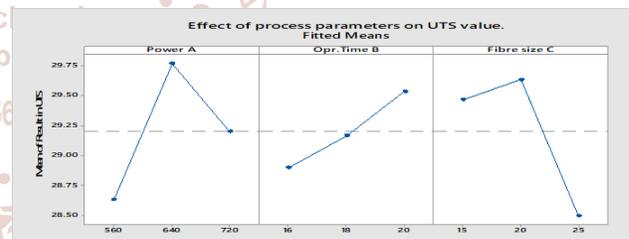


Figure 6 Effect of Process Parameters on UTS Value

1.8 ANOVA

Analysis of variance (ANOVA) was used to investigate the effects of various design parameters on microwave curing characteristics. The analysis was carried out at 95% confidence level.ANOVA result for Ultimate tensile strength (UTS) is given in table 5, shows that Fibre Size has the most significant effect with 35.78%, while Power and Operational Time having least effect.

Table 5: ANOVA Table

Source	DOF	SS	MS	F- Ratio	P- Value	% of contribution
Power	2	1.9267	0.9633	1.28	0.438	30.68
Opr. Time	2	0.6067	0.3033	0.40	0.712	9.66
Fibre size	2	2.2467	1.1233	1.50	0.400	35.78
Error	2	1.5000	0.7500			23.88
Total	8	6.2800				

1.9 Conclusions

In this study to investigate the effect of Microwave processes on different process parameters was observed. Power, Fibre size, Operational Time were the variable parameters.

Following conclusion was drawn from the experiments and analysis of results.

1. In this experimental work, the selection of the process parameters for microwave curing with better quality has been presented.
2. Surface level is better by this process.
3. It is also observed from experimental work that mechanical properties depend on the fibre strength.
4. Taguchi technique is method power pull tool to discover the effect of microwave process parameters on mechanical quality.
5. ANOVA (Analysis of variance) depicts that operational time having a significant parameter that affects the UTS followed by power and fibre size.
6. Ductile fracture mode observed with fine dimples for tensile test samples.

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