STUDY OF MACHINING PARAMETERS ON NATURAL FIBER PARTICLE REINFORCED POLYMER COMPOSITE MATERIAL

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ABSTRACT: Increased environmental awareness and consciousness throughout the world has developed an increasing interest in natural fibers and its applications in various fields. The aim of research is to make use of natural fiber abundantly available in India . An effort to utilize the advantages offered by renewable resources for the development of biocomposite materials based on biopolymers and natural fibers has been made through fabrication of Natural fiber powdered material (Sisal (Agave sisalana), Banana (Musa sepientum), and Roselle (Hibiscus sabdariffa)) reinforced polymer composite material by using bio epoxy resin. The present work focuses on the prediction of thrust force and torque of the natural fiber reinforced polymer composite materials, and the values, compared with the Artificial Neural Network.

KEYWORDS: Natural Fibers, Bio Epoxy Resin, ANN, Machining Parameters.

1 INTRODUCTION

Fiber reinforced composites are being used widely today, owing their use to superior mechanical properties like high strength to weight ratio, high stiffness to weight ratio and design flexibility [Ramakrishna, K., 2004]. Increased use of composites has meant there is demand for joining of some of the parts together. Adhesive bonding is the method used most often for joining most composites, but it has its disadvantages [Abrao, A.M.,et.a;.,].Adhesive bonding requires surface preparation of the materials before they can be joined. Heat and pressure may be required for curing purposes during adhesive bonding. Adhesives are chemicals used to join composites together [Baixauli]. Depending on the adhesive chosen, the cure time of composites might be low or very high. Due to the chemicals used, safety and health might be at risk. Bonded joints are difficult to inspect for faults or in general. Adhesive bonding needs specialized people to work on it and also requires more attention toward the process than needed for mechanical joints [Joseph, K et.al.,]. Adhesive bonding is a permanent bond which means that parts cannot be broken down and assembled again. On the other hand, mechanical joints can be assembled and disassembled as many times as wanted.

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Surface preparation is not required for creating mechanical joints.

They also offer the ability to check the quality of joints created and inspecting them from time to time. The widespread use of composites and the need for joining them has meant that there is an increasing demand for machining of composites. The characteristics of the material determine how they behave during machining [Fenner, R.].

There are various new methods for machining of composites, such as water jet machining and laser machining [Charvet, J.L]. Due to the high cost of such processes, drilling is still used widely as a major secondary machining process, due to the need for structural joining of composites materials. Machining involves the removal of any extra or unwanted material. Some of the most common machining processed are drilling, turning and milling. Machining of composites brings with it some major problems, including rapid tool wear due to the abrasiveness of composites, fiber fracture and matrix breaking [Clemons, C.M. and D.F. Caulfield]. Another known nuisance has been delamination, or the breaking of materials fibers, which crates a bad surface finish and caused stress concentrations at such regions. Earlier composites were machined like metals. But poor surface finish and faster tool wear led to the further study of composite machining [Chandramohan, D. and K. Marimuthu, 2010]. Unlike metals, composites need separate tools and working conditions. Although tools used for machining of metals can still be used for composites, care must be taken to maintain optimum levels of, feed rate, thrust force, and other factors. One of the main advantages of composites has been the fact that an entire part can be manufactured [Boeree, N.R et.al.,]. This minimizes the machining of composites. However with part integration, sometimes composites need to be joined to form a larger part, which means that a certain amount of machining needs to be done for composites too. Since the last decade, a great deal of emphasis has been focused on the development and application of natural fiber reinforced composite materials in many industries. Needless to say, this called special attention of the automotive industry for the application of many parts such as interior panels. Increased use of natural fiber composites implies that there is demand for joining of some of the parts together.

2 MATERIALS AND METHODS

The specimen used in this study is a cylindrical rod of 60x40 mm made of natural fiber reinforced composite material. The composite is made of natural fibers.

The materials used in this project are

1. Sisal & Roselle (hybrid) particle fibre reinforced composite

2. Banana & Sisal (hybrid) particle fibre reinforced composite

3. Banana & Roselle (hybrid) particle fibre reinforced composite.

2.1 Preparation of composite cylindrical rod

A mold of 60-mm length and 40-mm diameter was created using GI sheet mold. An OHP Sheet was taken and a releasing agent was applied over it and fitted with the inner side of the mold and allowed to dry. A glass beaker and a glass rod or a stirrer were taken and cleaned well with running water and subsequently with warm water. Then, calculated quantity of bio epoxy resin and hardner was added and the mixture was stirred for nearly 10-15 min. Stirring was done to create a homogeneous mixture of resin and accelerator molecules. Subsequently, calculated quantity of fibres was added and the stirring process was continued. Then, the mixture was poured into the mold and rammed mildly for uniform settlement. The mold was allowed to solidify for nearly 24 hours.

2.2 Machining of composite specimens

After getting the composite cylindrical rod with required dimensions, the machining (drilling process) of composite specimens is carried out using MAXMILL CNC machining center using high speed steel (HSS) twist drill bits. All experiments were performed under dry drilling conditions. The drilling process was carried out using HSS twist drills with constant geometry Table 1. The levels of the machining parameters used in this investigation are given as Table 2. Drill tool dynamometer was used to measure thrust force and torque respectively during the drilling processes. The effects of machining parameters on thrust force, torque and delamination of composite materials were understood by large number (27) of machining experiments.

Table 1: Constant tool geometry of HSS twist drill bits used in this investigation

Drill Diameter (mm)	3,4,5
Point angle in (Degree)	118
Helix angle in (Degree)	30
Rake angle in (Degree)	30
Clearance angle (Degree)	12
Cutting edge length (mm)	3.75
Chisel edge angle (Degree)	2.2
Chisel edge length (mm)	51

2.3 Factorial design

A 33 full factorial design with a total of 27 experimental runs were carried out. The thrust force and torque were the response variables recorded for each run. The effect of the machining parameters is another important aspect to be considered. It can be observed that the cutting speeds from 20 to 60 m/min are usually employed, whereas feed rate values lower than 0.3 mm/rev are frequent. Cutting speed is not a limiting factor when drilling polymeric composites, particularly with hard metals, and therefore, the use of cutting speeds below 60 m/min may be explained by the maximum rotational speed of conventional machining tools, because drill diameters above 10 mm are rarely reported. Another reason for keeping cutting speeds below 60 m/min may reside in the fact that higher cutting speed values lead to higher cutting temperature, which in turn may cause the softening of the matrix. The use of feed rates below 0.3 mm/rev may be associated with the delamination damage caused when this parameter is increased.

Table 2: Assignment of the levels to the factors

L evel	Dr ill size,d (mm)	Velo city,N (m/min)	Feed rate,f (mm/rev)
1	3	600	0.1
2	4	900	0.2
3	5	1200	0.3

3 EXPERIMENTAL SETUP

A number of drilling experiments were carried out on a CNC machining center (Maxmill) using HSS twist drills for the machining of NFRP composites. A two-component drill tool dynamometer was used to record the thrust force and torque. Conventional high-speed steel twist drills were used as much as cemented tungsten carbide drills. Tool geometry is a relevant aspect to be considered in drilling of fibre-reinforced plastics, particularly when the quality of the machined hole is critical.

3.1 Artificial neural network

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems. ANNs, like people, learn by example. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurons. In this research work ANN has been used as a tool to predict the experimental results. In ANN, feed forward back propogation was used to predict the values. The input parameters are speed, feed and tool diameter. By means of using these parameters the output parameters such as thrust force and torque has been predicted. The network has been trained by varying the neurons and the layers. Two – third of the experimental values are used for one – third of the values are predicted based on the training.

3.2 Measures of prediction erformance

Using the results produced by the network, statistical methods have been used to investigate the prediction performance of ANN results. To judge the prediction performance of a network, several performance measures are used. Those include statistical analysis in terms of Mean Square Error [MSE] and Mean Absolute Relative Error [MARE].

$$MSE = 1/P \sum (\text{Predicted value-actual value})^2 \quad (1)$$

$$MARE = 1/P \sum (\text{Predicted value-actual value})/\text{actual value} \quad (2)$$

Where, P is the pattern number.

4 DISCUSSION

In this research work ANN has been used as a tool to predict the experimental results. In ANN, feed forward back propogation was used to predict the values. The input parameters are speed, feed and tool diameter. By means of using these parameters the output parameters such as thrust force and torque has been predicted. The network has been trained by varying the neurons and the layers. Two – third of the experimental values are used for one – third of the values are predicted based on the training and both the results from experimental and Artificial Neural Network are good in agreement as shown in Figure 4.1 to 4.6

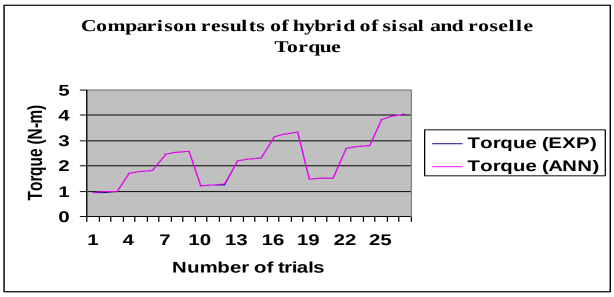

Fig 4.1. Comparision of hybrid of sisal and rosell torque

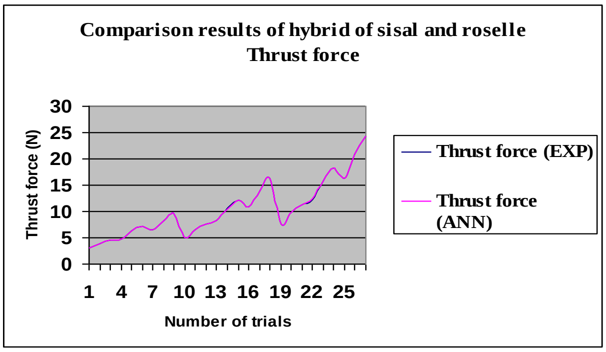

Fig 4.2. Comparision of hybrid of sisal and rosell thrust force

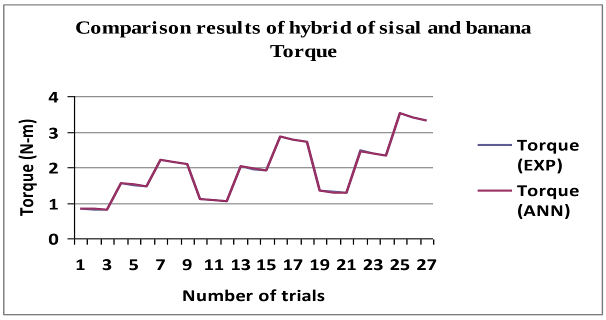

Fig 4.3. Comparision of hybrid of sisal and banana Torque

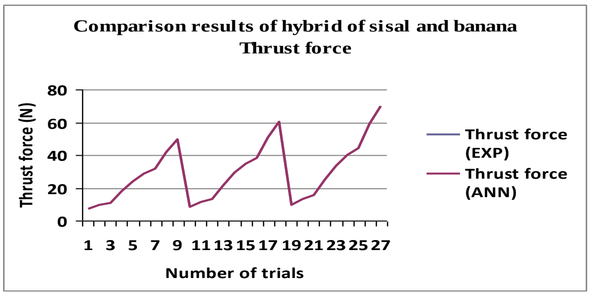

Fig 4.4. Comparision of hybrid of sisal and banana thrust force

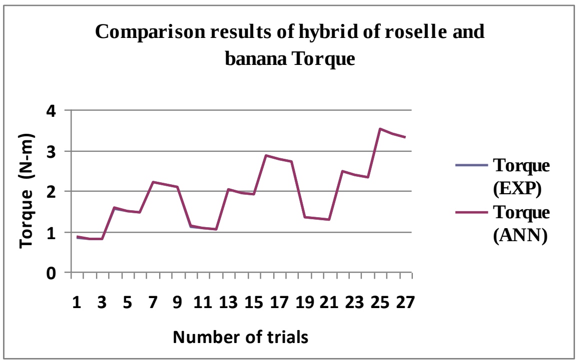

Fig 4.5. Comparision of hybrid of rosell and banana torque

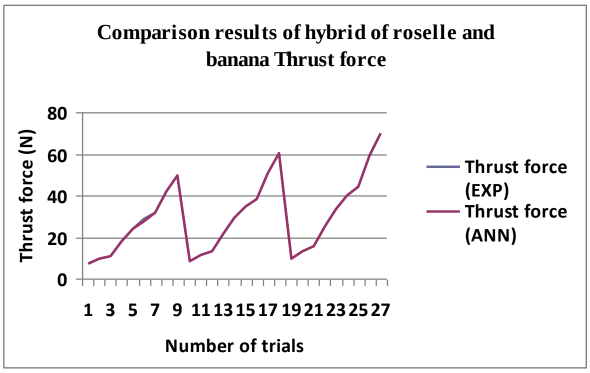

Fig 4.6. Comparision of hybrid of rosell and banana thrust force

Statistical values and of hybrid of sisal and roselle, hybrid of sisal and banana and hybrid of roselle and banana are shown in table 4.1 to 4.3 and Scatter Index of above said hybrid materials shown in figure 4.7 to 4.12 from this comparison of experimental and ANN results hybrid of sisal and banana machining properties is better than other two hybrid materials.

Table 4.1.Statistical values of hybrid of sisal and roselle

Measures of prediction	Thrust (N)	Torque (N-m)
Mean Square Error [MSE]	0.00 3125	0.00774
Mean Absolute Relative Error [MARE]	0.00 6593	0.65935
Scatter Index	10.9	1.862

Table 4.2. Statistical values of hybrid of sisal and banana

Measures of prediction	Thrust (N)	Torque (N-m)
Mean Square Error [MSE]	0.02	0.00355 556
Mean Absolute Relative Error [MARE]	1E-03	0.09803 851
Scatter Index	56.8	1.69

Table 4.3. Statistical values of hybrid of roselle and banana

Measures of prediction	Thrust (N)	Torque (N-m)
Mean Square Error [MSE]	0.0583 33	0.003852
Mean Absolute Relative Error [MARE]	0.0022 55	0.225482
Scatter Index	55.87	1.701

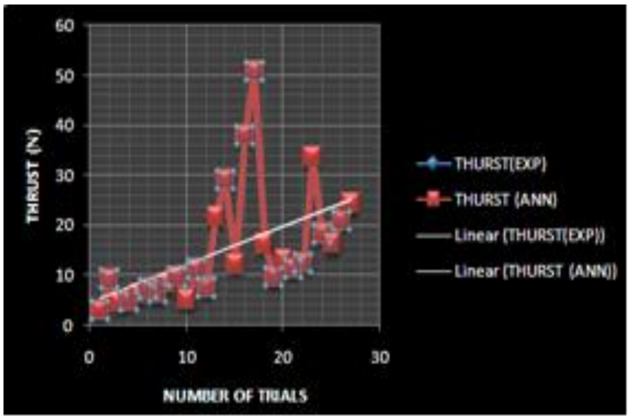

Figure 4.7 Scatter Index of hybrid of sisal and roselle thrust force using ANN

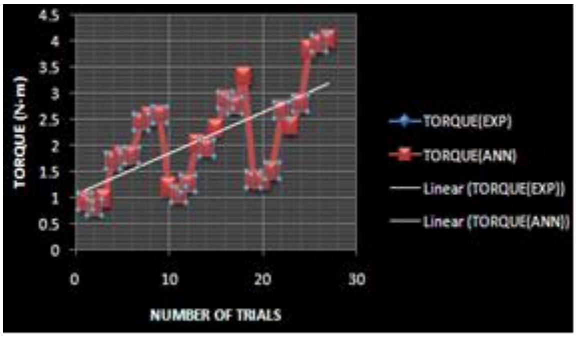

Figure 4.8 Scatter Index of hybrid of sisal and roselle torque using ANN

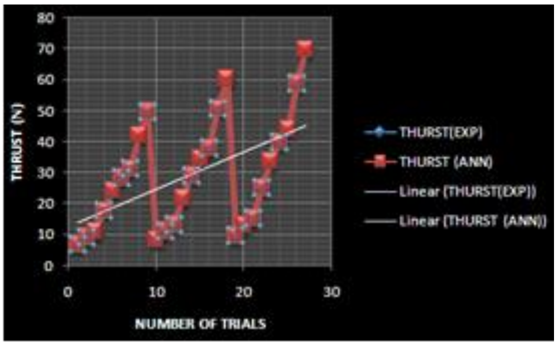

Figure 4.9 Scatter Index of hybrid of sisal and banana thrust force using ANN

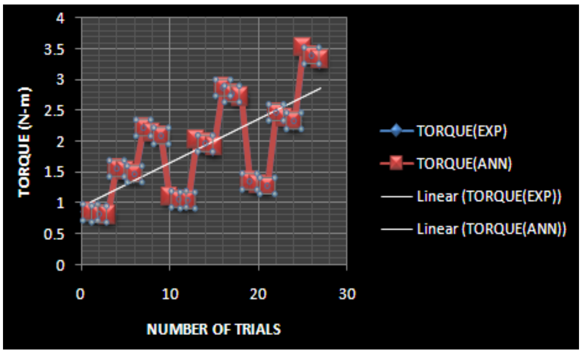

Figure 4.10 Scatter Index of hybrid of sisal and banana torque using ANN

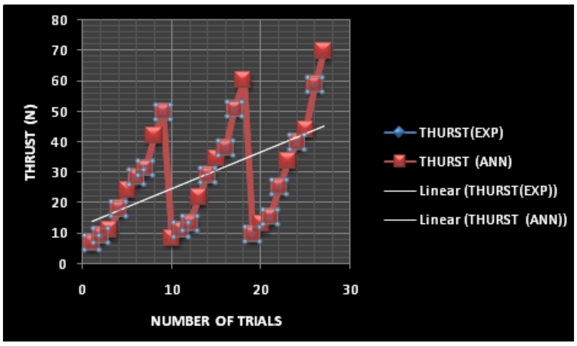

Figure 4.11 Scatter Index of hybrid of roselle and banana thrust force using ANN

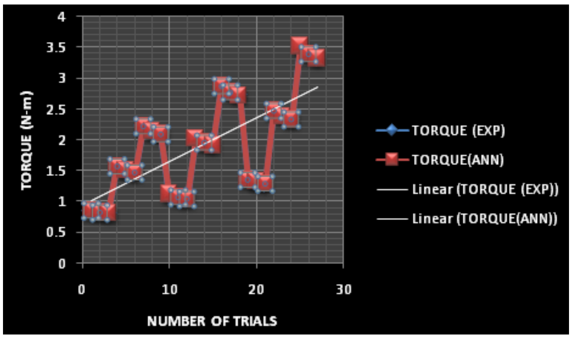

Figure 4.12 Scatter Index of hybrid of roselle and banana torque using ANN

5 CONCLUSION

In general, the thrust and torque parameters will mainly depend on the manufacturing conditions employed, such as feed, cutting speed, tool geometry, machine tool, and cutting tool rigidity. A larger thrust force occurs for larger diameter drills and higher feed rates. In other words, feed rate and drill diameter are recognized as the most significant factors affecting the thrust force. Worn-out drill may be one of the major reasons for the drastic increase in the thrust force as well as for the appearance of larger thrust forces when using multifacet drill than those when using twist drill at high cutting speed. Although tools are worn out quickly and the thrust force increases drastically as cutting speed increases, an acceptable hole entry and exit is maintained. We found that the thrust force is drastically reduced when the hole is predrilled to 0.4 mm or above. Although it is known that the thrust force increases with the increase in the feed, this study provided quantitative measurements of such relationships for the present composite materials. In general, increasing the cutting speed will decrease the thrust force. This work has shown that the cutting speed has an insignificant effect on the thrust force when drilling at low feed values. At high feed values, the thrust force decreases with an increased cutting speed.

It can be observed that thrust force and torque increase with the drill diameter and feed rate. By examining these results, it can be concluded that the torque slightly increases as the cutting speed increases. However, we found that the increase in torque was much smaller than that in thrust force, with the increasing cutting speed. The average torque appearing when using a multifacet drill was larger than that using the twist drill at low drilling speed, and the average torque when using a multifacet drill was smaller than that when using twist drill at high drilling speed. It was noticed that the average torque decreased as the drilled length increased for twist drill. The results indicate that the torque increases as the feed increases. This increase is owing to the increasing cross-sectional area of the undeformed chip. The results also indicate that the torque increases with the increase in the fibre volume fraction. Increasing fibre volume fraction increases the static strength, and thus, the resistance of the composite to mechanical drilling increases. This leads to the increase in the required thrust force and torque. The result also indicates that the torque decreases when increasing the cutting speed. The hybrid composite materials find lots of application. This material can be used in the automobile sector as replacement of plastic fibres which already exists. The plastic fibre, which has a high carbon composition, causes a problem for environment and moreover it is not a degradable one. Therefore these plastic fibres are not eco friendly. In order to over come this problem the hybrid composite materials used in this project can be replaced with plastic fibres. This hybrid composite material has less carbon composition and it is a degradable one. The material properties also allow aiming at applications which are today dominated by glass fibre reinforced plastics. Nevertheless, there a restrictions with respect to extreme environmental conditions. An essential branch of applications is to be seen e.g. in covering elements with structural tasks in automobile accessories.

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