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To,
DR. SHAIK HUSSAIN

Agent Number:

DEPARTMENT OF MECHANICAL ENGINEERING, MALLA REDDY ENGINEERING COLLEGE (AUTONOMOUS), MAISAMMAGUDA (H), GUNDLAPOCHAMPALLY VILLAGE, MEDCHAL MANDAL, MEDCHAL-MALKAJGIRI DISTRICT, HYDERABAD, TELANGANA STATE - 500100. hussainshaik@mrec.ac.in

Sr. No.	CBR No.	Reference Number /Application Type	Application Number	Title/Remarks	Amount Paid
1	5003	ORDINARY APPLICATION	202141005815	EVALUATION OF THRUST FORCE AND TORQUE IN DRILLING OF NATURAL FIBER PARTICLE REINFORCED POLYMER	1750
2		E-2/478/2021-CHE	202141005815	Form2	0
3		E-3/4920/2021-CHE	202141005815	Form3	0
4		E-5/551/2021-CHE	202141005815	Form5	0
5	5003	E-12/542/2021-CHE	202141005815	Form9	2750
Total :					4500

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<table>
<tr><td colspan="6">"FORM 1
THE PATENTS ACT 1970 (39 of 1970) and
THE PATENTS RULES, 2003
APPLICATION FOR GRANT OF PATENT
(See section 7, 54 and 135 and sub-rule (1) of rule 20</td><td colspan="3">(FOR OFFICE USE ONLY)</td></tr>
<tr><td colspan="4">Application No.</td><td colspan="5"></td></tr>
<tr><td colspan="4">Filing date:</td><td colspan="5"></td></tr>
<tr><td colspan="4">Amount of Fee paid:</td><td colspan="5"></td></tr>
<tr><td colspan="4">CBR No:</td><td colspan="5"></td></tr>
<tr><td colspan="4">Signature:</td><td colspan="5"></td></tr>
<tr><td colspan="2">1. APPLICANT'S REFERENCE / IDENTIFICATION NO. (AS ALLOTTED BY OFFICE)</td><td colspan="7"></td></tr>
<tr><td colspan="9">2. TYPE OF APPLICATION [Please tick ( ) at the appropriate category</td></tr>
<tr><td colspan="2">Ordinary (√)</td><td colspan="2">Convention (x)</td><td colspan="5">PCT-NP (x)</td></tr>
<tr><td>Divisional ()</td><td>Patent of Addition ( )</td><td colspan="2">Division ( )</td><td>Patent of addition ()</td><td>Division ( )</td><td colspan="3">Patent of Addition ( )</td></tr>
<tr><td colspan="9">3A. APPLICANT(S)</td></tr>
<tr><td colspan="2">Name in Full</td><td>Nationality</td><td>Country of Residence</td><td colspan="5">Address of the Inventor</td></tr>
<tr><td colspan="2" rowspan="6">Dr.SHAIK HUSSAIN</td><td rowspan="6">INDIAN</td><td rowspan="6">INDIA</td><td>House No.</td><td colspan="4">DEPARTMENT OF MECHANICAL ENGINEERING</td></tr>
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<tr><td>State</td><td colspan="4">TELANAGANA</td></tr>
<tr><td>Country</td><td colspan="4">INDIA</td></tr>
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<tr><td colspan="2" rowspan="6">Dr.V.SIVA RAMA KRISHNA</td><td rowspan="6">INDIAN</td><td rowspan="6">INDIA</td><td>House No.</td><td colspan="4">DEPARTMENT OF MECHANICAL ENGINEERING
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<tr><td>Pin code</td><td colspan="4">500100</td></tr>
</table>

Natural Person (√)	Other than natural Person		
	Small Entity (x)	Startup (x)	Others (x)

4. INVENTOR(S) [Please tick at the appropriate category]		
Are all the inventor(s) same as the applicant(s) named above?	**Yes (√)**	
If "No", furnish the details of the inventor(s)		

5. TITLE OF THE INVENTION
EVALUATION OF THRUST FORCE AND TORQUE IN DRILLING OF NATURAL FIBER PARTICLE REINFORCED POLYMER COMPOSITE MATERIAL USING FUZZY LOGIC

6. AUTHORISED REGISTERED PATENT AGENT	IN/PA No.	**- NA-**
	Name	

7. ADDRESS FOR SERVICE OF APPLICANT IN INDIA	Name	Dr.SHAIK HUSSAIN
	Postal Address	DEPARTMENT OF MECHANICAL ENGINEERING MALLA REDDY ENGINEERING COLLEGE (AUTONOMOUS), MAISAMMAGUDA(H), GUNDLAPOCHAMPALLY VILLAGE,MEDCHAL MANDAL,MEDCHAL-MALKAJGIRI DISTRICT,HYDERABAD, TELANGANA STATE – 500100.
	Telephone No.	--
	Mobile No.	9966874496
	Fax No.	--
	E-mail ID	hussainshaik@mrec.ac.in

8. IN CASE OF APPLICATION CLAIMING PRIORITY OF APPLICATION FILED IN CONVENTION COUNTRY, PARTICULARS OF CONVENTION APPLICATION

Country	Application Number	Filing date	Name of the applicant	Title of the invention	IPC (as classified in the convention country)
NA	NA	NA	NA	NA	NA

9. IN CASE OF PCT NATIONAL PHASE APPLICATION, PARTICULARS OF INTERNATIONAL APPLICATION FILED UNDER PATENT CO-OPERATION TREATY (PCT)

International application number	International filing date
NA	**NA**

10. IN CASE OF DIVISIONAL APPLICATION FILED UNDER SECTION 16, PARTICULARS OF ORIGINAL (FIRST) APPLICATION

Original (first) application No.	Date of filing of original (first) application
NA	NA

11. IN CASE OF PATENT OF ADDITION FILED UNDER SECTION 54, PARTICULARS OF MAIN APPLICATION OR PATENT : NA

Main application/patent No. : **NA**	Date of filing of main application : **NA**

12. DECLARATIONS

(i) Declaration by the inventor(s)

(In case the applicant is an assignee: the inventor(s) may sign herein below or the applicant may upload the assignment or enclose the assignment with this application for patent or send the assignment by post/electronic transmission duly authenticated within the prescribed period).

We, the above named inventor(s) are the true & first inventor(s) for this Invention and declare that the applicant(s) herein are our assignee or legal representative.

NAME	SIGNATURE	DATE
Dr.SHAIK HUSSAIN		11-02-2021

Dr.V.SIVA RAMA KRISHNA		11-02-2021
Dr.R. DHARMALINGAM		11-02-2021
Mr. T. NARESH KUMAR		11-02-2021

(ii) Declaration by the applicant(s) in the convention country
(In case the applicant in India is different than the applicant in the convention country: the applicant in the convention country may sign herein below or applicant in India may upload the assignment from the applicant in the convention country or enclose the said assignment with this application for patent or send the assignment by post/electronic transmission duly authenticated within the prescribed period)

We, the applicant(s) in the convention country declare that the applicant(s) herein are our assignee or legal representative.

(a) Date
(b) Signature(s) -------NA----------
(c) Name(s) of the signatory

(iii) Declaration by the applicant(s)

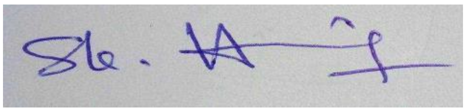
- We the applicant(s) hereby declare(s) that: -
- We are in possession of the above-mentioned invention.
- The ~~provisional~~/complete specification relating to the invention is filed with this application.
- ~~The invention as disclosed in the specification uses the biological material from India and the necessary permission from the competent authority shall be submitted by me/us before the grant of patent to me/us.~~
- There is no lawful ground of objection(s) to the grant of the Patent to me/us.
- We are the true & first inventor(s).
- We are the assignee or legal representative of true & first inventor(s).
- ~~The application or each of the applications, particulars of which are given in Paragraph-8, was the first application in convention country/countries in respect of our invention(s).~~
- ~~We claim the priority from the above mentioned application(s) filed in convention country/countries and state that no application for protection in respect of the invention had been made in a convention country before that date by me/us or by any person from which I/We derive the title.~~
- ~~Our application in India is based on international application under Patent Cooperation Treaty (PCT) as mentioned in Paragraph-9.~~
- ~~The application is divided out of my /our application particulars of which is given in Paragraph-10 and pray that this application may be treated as deemed to have been filed on DD/MM/YYYY under section 16 of the Act.~~
- ~~The said invention is an improvement in or modification of the invention particulars of which are given in Paragraph-11.~~

13. FOLLOWING ARE THE ATTACHMENTS WITH THE APPLICATION (a) Form 2

Item	Details	Fee	Remarks
Complete specification	No. of pages : 20		
No. of Claim(s)	No. of claims : 08 and No. of pages :01		
Abstract	No. of pages :01		
No. of Drawing(s)	No. of drawings :-- and No. of pages:--		

~~# In case of a complete specification, if the applicant desires to adopt the drawings filed with his provisional specification as the drawings or part of the drawings for the complete specification under rule 13(4), the number of such pages filed with the provisional specification are required to be mentioned here.~~

~~(b) Complete specification (in conformation with the international application)/as amended before the International Preliminary Examination Authority (IPEA), as applicable (2 copies).~~
~~(c) Sequence listing in electronic form~~
~~(d) Drawings (in conformation with the international application)/as amended before the International Preliminary Examination Authority (IPEA), as applicable (2 copies).~~
~~(e) Priority document(s) or a request to retrieve the priority document(s) from DAS (Digital Access Service) if the applicant had already requested the office of first filing to make the priority document(s) available to DAS.~~
~~(f) Translation of priority document/Specification/International Search Report/InternationalPreliminary Report on Patentability.~~
(g) Statement and Undertaking on Form 3
(h) Declaration of Inventorship on Form 5
(j)…………………………………………………………………………………………………..
Total fee
We hereby declare that to the best of our knowledge, information and belief the fact and matters slated herein are correct and We request that a patent may be granted to us for the said invention.

NAME	SIGNATURE	DATE
Dr.SHAIK HUSSAIN		11-02-2021
Dr.V.SIVA RAMA KRISHNA		11-02-2021
Dr.R. DHARMALINGAM		11-02-2021
Mr.T. NARESH KUMAR		11-02-2021

To,
The Controller of Patents,The Patent Office, at **CHENNAI**
Note: -
* Repeat boxes in case of more than one entry.
* To be signed by the applicant(s) or by authorized registered patent agent otherwise where mentioned.
* Tick (√) /cross (x) whichever is applicable/not applicable in declaration in paragraph-12.
* Name of the inventor and applicant should be given in full, family name in the beginning.
* Strike out the portion which is/are not applicable.

Form 2

THE PATENT ACT, 1970

(39 of 1970)

&

The Patent Rules, 2003

COMPLETE SPECIFICATION

(Section 10 and Rule 13)

Evaluation of Thrust force and Torque in Drilling of Natural Fiber Particle Reinforced Polymer Composite Material using fuzzy logic

APPLICANTS & INVENTORS

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The following specification particularly describes the invention and the manner in which it is to be performed.

TECHNICAL FIELD

The present invention relates to a fuzzy and more particularly prediction of Thrust force and Torque in Drilling of Natural Fiber Particle Reinforced Polymer Composite Material using fuzzy logic.

BACKGROUND

EP0675432A1: Fuzzy rationale in information preparing frameworks was created to conquer issues which were hard to tackle with conventional control and dynamic methods due to the uncertain, dubious, and deficient nature of accessible data. Fluffy rationale consolidates the thoughts of fluffy sets and master frameworks and utilizations them as devices to display and control complex cycles, accordingly giving a method of instructing an information processor to copy the human instinct in charge and dynamic cycles. Fluffy sets permit the outflow of any condition regarding levels of truth or participation which can fluctuate from zero (bogus or no enrollment) to one (valid or complete participation).

A fluffy rationale control motor comprises of three significant squares: a fuzzification block, a standard assessment block, and a defuzzification block. The fuzzification block takes a few outside information sources and thinks about each to a majority of predefined enrollment works (every participation work is a fluffy set) to decide the level of participation of every one of the contributions to every enrollment work. When the levels of participation of the data sources have been resolved, the standard assessment block decides the proper reaction to the contributions as per a bunch of rules. Rules are developed utilizing IF, AND, and afterward explanations. The AND activity plays out a MIN work in which a base worth is chosen.

US5179634A: According to the standard of fluffy control, a foreordained arrangement of rules are actuated when an information signal is provided to a fluffy allowance unit, and the control activity for the control object is controlled by derivation as indicated by the initiated set of rules. The arrangement of rules incorporate an enormous number of fluffy standards which are designated for various control circumstances, and such fluffy guidelines are commonly communicated as in the event that assertions.

Ordinarily, age of such fluffy guidelines were led for every particular application, and it was important to make and alter new fluffy principles for each new application. In any case, the need to make and change fluffy guidelines for each new application is profoundly lumbering to the framework administrator, and a lot of work is forced upon the administrator. Further, existing arrangements of rules were actuated distinctly for certain particular applications, and were not adequately used for making of new arrangements of rules.

It is along these lines liked to have the option to make another arrangement of rules for each new application as indicated by existing arrangements of rules. Notwithstanding, such a cycle of creation would be profoundly lumbering for the framework administrator who sets each new made fluffy principle on a derivation unit individually by methods for a man-machine interface.

SUMMARY

Materials and Methods

The specimen used in this study is a cylindrical rod of 60×40 mm made of natural fiber reinforced composite material. The composite is made of natural fibers.

The materials used in this project are:

- Abaca and Hemp (hybrid) particle fibre reinforced composite
- Mudar and Abaca (hybrid) particle fibre reinforced composite
- Mudar and Hemp (hybrid) particle fibre reinforced composite.

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 h.

Taguchi Quality Loss Function

Genichi Taguchi's impact upon North American product design and manufacturing process began in November 1982. A different method of measuring quality is central to Taguchi's approach to design. Loss function measures quality. The loss function establishes a financial measure of the user dissatisfaction with the products performance as it deviates from the target value. Thus, both average performance and variation are critical measures of quality. Selecting a product design or a manufacturing process that is insensitive to uncontrolled sources of variation improves quality. Dr.Taguchi calls these uncontrolled sources of variation Noise factors.

Orthogonal array of experiments

By evaluating the performance of the product in several environmental conditions, there would be a realistic data to calculate the real world variance. The classical experimental design method are too complex, time consuming and not easy to use. A large number of experiments have to be carried out when the number of process parameters are more. To solve this problem, taguchi method uses a special design of orthogonal arrays to study the entire parameter space with the minimum number of experiments.

Table A. Hybrid of banana and sisal factors and levels (Tensile test)

No. of Factors	Factors	Level I	Level II
A	Abaca fibre (B.F) in gms	85	90
B	Hemp fibre (S.F) in gms	85	90
C	Bio epoxy in ml	50	55
D	Mixing ratio in 25 rpm	10 min	15 min
E	Mixing ratio in 50 rpm	10 min	15 min
F	Chemical treatment	YES	NO

Here only main effects are considered

Total DOF = 6 (6 × (2-1)), So L_8 OA was selected for calculation. The 6- factors are assigned to the first 6- columns (Table 3.3). The response variable (Y) is young's modulus in (N/mm^2). Only one repetition was performed.

Table B. Hybrid of Abaca and Hemp factors

No of experiments (Trial)	FACTORS						Young's modulus in(10^3 N/mm^2)
	A	B	C	D	E	F	
	1	2	3	4	5	6	
	B.F in gms	S.F in gms	Resin in ml	Mixing ratio in 25 rpm	Mixing ratio in 50 rpm	Chemical treatment	
1	85	85	50	10	10	YES	254.915
2	85	85	50	15	15	NO	246.854
3	85	90	55	10	10	NO	254.108
4	85	90	55	15	15	YES	252.442
5	90	85	55	10	15	YES	255.666
6	90	85	55	15	10	NO	254.532
7	90	90	50	10	15	NO	260.226
8	90	90	50	15	10	YES	259.865

Table C. Hybrid of Abaca and Hemp factors, levels and mean

Factor	Level	Total	Mean
A	1	1008.314/4	252.0785
	2	1030.289/4	257.5722
B	1	1011.967/4	252.9917
	2	1026.641/4	256.6602
C	1	1021.86/4	255.4654
	2	1016.748/4	254.1875
D	1	1024.915/4	256.2287
	2	1013.693/4	253.4232
E	1	1023.42/4	255.8554
	2	1014.854/4	253.7135
F	1	1022.888/4	255.7224
	2	1015.72/4	253.9367
TOTAL		2038.608/8	254.826

Sum of Squares:

$S_T = 254.915^2 + 246.854^2 + \text{------} + 259.865^2 - (2038.608)^2 / 8 = 125.103$

$S_A = (\text{SUM OF } X_1 – \text{SUM OF } X_{2)})^2 / nr$

Where n = No. of experiments in OA

r = No. of replications

(Here, r = replications = 1)

$S_A = 60.36$

$S_B = 26.915$

$S_C = 3.266$

$S_D = 15.7416$

$S_E = 9.172$

$S_F = 6.4225$

$S_e = S_T - S_A - S_B - S_C - S_D - S_E - S_F = 3.2259$

Table D. Hybrid of Abaca and Hemp intial ANOVA (Tensile test)

Factor	DOF	S	V	F
A	1	60.36	60.36	18.711
B	1	26.915	26.915	8.3434
C	1	3.266	3.266	1.0124
D	1	15.7416	15.7416	4.8797
E	1	9.172	9.172	2.8432
F	1	6.4225	6.4225	1.9909
ERROR	1	3.2259	3.2259	
TOTAL	7	125.103		

Note:

DOF (TOTAL) = (No of trials – 1) = 8 – 1 = 7

DOF (Factor) = (No of levels – 1) = 2-1 = 1

DOF (Error) = DOF (Total) – DOF (all factors) = 7- 6 = 1

V- Variance = S / DOF

F- Statistic (F) = V (Factor) / V (Error)

Pooling rules applied in Taguchi designed experiments

To obtain a better estimate of the relative importance of each of the significant factor, non-significant factors are removed especially when more factors are involved. This is known as pooling.

1. If the F-statistics for any factor is less than one, then pool the 'SS' of that factor into the error term.

2. If the number of factors is not approximately one-half or less the number of columns in the table, pool the factors with the smallest F – Statistic until the no of factors remaining is approximately one- half of the no of columns.

Table E. Hybrid of banana and sisal final ANOVA (Tensile test)

Factor	DOF	S	V	S'	P%	F
C	1	3.266	3.266	26.9009	21.503	0.1082
D	1	15.7416	15.7416	14.4253	11.5307	0.5218
E	1	9.172	9.172	20.9949	16.782	0.3040
F	1	6.4225	6.4225	23.7444	18.9798	0.2128
ERROR	3	90.5009	30.1669	39.0375	31.2042	
TOTAL	7	125.103			100	

Where S' = Pure sum of squares

P = Percentage of contribution

Interpretation of ANOVA

- Factors C, D, E and F : Significant
- Factor C contributes maximum level of variation
- To decrease the young's modulus of hybrid composite, level 2 of factors C and D and level 1 of factors E and F are selected

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)	118.00
Helix angle in (Degree)	30.00
Rake angle in (Degree)	30.00
Clearance angle (Degree)	12.00
Cutting edge length (mm)	3.75
Chisel edge angle (Degree)	2.20
Chisel edge length (mm)	51.00

Table 2. Assignment of the levels to the factors

Drill Leve(mm)	size, d	Velocity, N (m/min)	Feed rate, f (mm/rev)
1	3	600	0.1
2	4	900	0.2
3	5	1200	0.3

Factorial Design

A 3^3 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.

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.

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.

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.

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) Equations 1 and 2:

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

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

where, *P* is the pattern number.

Table 3. Trained values of hybrid of Abaca and Hemp thrust force and torque using ANN

Sl. No.	Drill diameter (mm)	Speed (rpm)	Feed (mm/rev)	Thrust (EXP) (N)	Torque (EXP) (N-m)	(ANN) Thrust (N)	(ANN) Torque (N-m)
1	3	300	0.1	3	0.93	3.008	0.932
3	3	900	0.1	4.48	0.98	4.488	0.980
5	3	600	0.2	6.27	1.77	6.270	1.776
7	3	300	0.3	6.45	2.45	6.450	2.452
8	3	600	0.3	8.31	2.54	8.310	2.545
10	4	300	0.1	5.04	1.2	5.040	1.199
11	4	600	0.1	6.5	1.24	6.488	1.240
13	4	300	0.2	8.18	2.21	8.170	2.190
14	4	600	0.2	10.55	2.28	10.542	2.277
15	4	900	0.2	12.23	2.32	12.230	2.322
17	4	600	0.3	13.99	3.26	13.980	3.260
18	4	900	0.3	16.23	3.32	16.230	3.322
20	5	600	0.1	9.74	1.5	9.722	1.522
21	5	900	0.1	11.3	1.53	11.322	1.520
22	5	300	0.2	12.25	2.68	12.442	2.677
24	5	900	0.2	18.32	2.82	18.322	2.810
25	5	300	0.3	16.25	3.83	16.252	3.832
27	5	900	0.3	24.31	4.04	24.322	4.041

Tablee 4. Predicted values of hybrid of Abaca and Hemp thrust force and torque using ANN

Sl. No.	Drill diameter (mm)	Speed (rpm)	Feed (mm/rev)	Thrust (EXP) (N)	Torque (EXP) (N-m)	(ANN) Thrust (N)	(ANN) Torque (N-m)	% of Error in Thrust	% of Error in Torque
2	3	600	0.1	3.86	0.96	3.82	0.96	1.04	0.00
4	3	300	0.2	4.86	1.72	4.86	1.72	0.00	0.00
6	3	900	0.2	7.27	1.81	7.27	1.81	0.00	0.00
9	3	900	0.3	9.65	2.59	9.65	2.59	0.00	0.00
12	4	900	0.1	7.54	1.26	7.54	1.27	0.00	0.79
16	4	300	0.3	10.85	3.15	10.84	3.14	0.09	0.32
19	5	300	0.1	7.55	1.46	7.54	1.46	0.13	0.00
23	5	600	0.2	15.79	2.77	15.78	2.77	0.06	0.00
26	5	600	0.3	20.95	3.96	20.95	3.96	0.00	0.00

Table 5. Trained values of hybrid of Abaca and Mudar thrust force and torque using ANN

Sl. No.	Drill diameter (mm)	Speed (rpm)	Feed (mm/rev)	Thrust (EXP) (N)	Torque (EXP) (N-m)	(ANN) Thrust (N)	(ANN) Torque (N-m)
1	3	300	0.1	6.93	0.85	6.868	0.844
3	3	900	0.1	10.98	0.8	10.990	0.799
5	3	600	0.2	24.05	1.5	24.052	1.522
7	3	300	0.3	31.43	2.22	31.442	2.220
8	3	600	0.3	42.02	2.14	42.001	2.140
10	4	300	0.1	8.38	1.1	8.421	1.100
11	4	600	0.1	11.2	1.06	11.214	1.062
13	4	300	0.2	21.75	2.02	21.744	2.022
14	4	600	0.2	29.07	1.95	29.061	1.966
15	4	900	0.2	34.45	1.91	34.442	1.910
17	4	600	0.3	50.8	2.77	50.773	2.770
18	4	900	0.3	60.2	2.72	60.114	2.720
20	5	600	0.1	12.98	1.3	12.972	1.292
21	5	900	0.1	15.38	1.28	15.377	1.277
22	5	300	0.2	25.2	2.47	25.220	2.460
24	5	900	0.2	39.92	2.33	39.912	2.332
25	5	300	0.3	44.02	3.52	44.022	3.511
27	5	900	0.3	69.74	3.32	69.722	3.322

Table 6. Predicted values of hybrid of Abaca and Mudar thrust force and torque using ANN

Sl. No.	Drill diameter (mm)	Speed (rpm)	Feed (mm/rev)	Thrust (EXP) (N)	Torque (EXP) (N-m)	(ANN) Thrust (N)	(ANN) Torque (N-m)	% of Error in Thrust	% of Error in Torque
2	3	600	0.1	9.27	0.82	9.34	0.82	0.76	0.00
4	3	300	0.2	17.99	1.56	17.88	1.55	0.61	0.64
6	3	900	0.2	28.5	1.47	28.42	1.47	0.28	0.00
9	3	900	0.3	49.79	2.09	49.7	2.08	0.18	0.48
12	4	900	0.1	13.27	1.04	13.27	1.044	0.00	0.38
16	4	300	0.3	38	2.87	38	2.87	0.00	0.00
19	5	300	0.1	9.71	1.35	9.72	1.35	0.10	0.00
23	5	600	0.2	33.68	2.38	33.67	2.37	0.03	0.42
26	5	600	0.3	58.85	3.39	58.85	3.39	0.00	0.00

Table 7. **Trained values of hybrid of Hemp and Mudar thrust force and torque using ANN**

Sl. No.	Drill diameter (mm)	Speed (rpm)	Feed (mm/rev)	Thrust (EXP) (N)	Torque (EXP) (N-m)	(ANN) Thrust (N)	(ANN) Torque (N-m)
1	3	300	0.1	6.93	0.85	6.922	0.851
3	3	900	0.1	10.98	0.8	10.966	0.810
5	3	600	0.2	24.05	1.5	24.011	1.499
7	3	300	0.3	31.43	2.22	31.432	2.220
8	3	600	0.3	42.02	2.14	42.021	2.140
10	4	300	0.1	8.38	1.1	8.382	1.122
11	4	600	0.1	11.2	1.06	11.200	1.066
13	4	300	0.2	21.75	2.02	21.744	2.022
14	4	600	0.2	29.07	1.95	29.070	1.954
15	4	900	0.2	34.45	1.91	34.442	1.910
17	4	600	0.3	50.8	2.77	50.778	2.770
18	4	900	0.3	60.2	2.72	60.110	2.722
20	5	600	0.1	12.98	1.3	12.99	1.322
21	5	900	0.1	15.38	1.28	15.380	1.288
22	5	300	0.2	25.2	2.47	25.200	2.470
24	5	900	0.2	39.92	2.33	39.900	2.332
25	5	300	0.3	44.02	3.52	44.011	3.522
27	5	900	0.3	69.74	3.32	69.744	3.322

Table 8. **Predicted values of hybrid of Hemp and Mudar thrust force and torque using ANN**

Sl. No.	Drill diameter (mm)	Speed (rpm)	Feed (mm/rev)	Thrust (EXP) (N)	Torque (EXP) (N-m)	(ANN) Thrust (N)	(ANN) Torque (N-m)	% of Error in Thrust	% of Error in Torque
2	3	600	0.1	9.27	0.82	9.26	0.82	0.11	0.00
4	3	300	0.2	17.99	1.56	17.82	1.57	0.94	0.64
6	3	900	0.2	28.5	1.47	27.37	1.46	3.96	0.68
9	3	900	0.3	49.79	2.09	49.79	2.09	0.00	0.00
12	4	900	0.1	13.27	1.04	13.27	1.04	0.00	0.00
16	4	300	0.3	38	2.87	38	2.87	0.00	0.00
19	5	300	0.1	9.71	1.35	9.69	1.35	0.21	0.00
23	5	600	0.2	33.68	2.38	33.67	2.38	0.03	0.00
26	5	600	0.3	58.85	3.39	58.85	3.39	0.00	0.00

Table 9. Statistical values of hybrid of Abaca and Hemp

Measures of prediction	Thrust (N)	Torque (N-m)
Mean Square Error (MSE)	0.003125	0.00774
Mean Absolute Relative Error (MARE)	0.006593	0.65935
Scatter Index	10.9280	1.86200

Table 10. Statistical values of hybrid of Abaca and Mudar

Measures of prediction	Thrust (N)	Torque (N-m)
Mean Square Error (MSE)	0.020	0.00355556
Mean Absolute Relative Error (MARE)	0.00233251	0.09803851
Scatter Index	56.820	1.69000000

Table 11. Statistical values of hybrid of Hemp and Mudar

Measures of prediction	Thrust (N)	Torque (N-m)
Mean Square Error (MSE)	0.058333	0.003852
Mean Absolute Relative Error (MARE)	0.002255	0.225482
Scatter index	55.87000	1.701000

The hybrid composite material finds a lots of application. This material can be used in the automobile sector as replacement of plastic fibres which is already existing. 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 overcome this problem the hybrid composite material used in this project can be replaced with plastic fibres. This hybrid composite material has less carbon composition and it is a degradable one.In this project a rear view mirror, visor in two wheeler, billion seat cover, indicator cover, cover L-side, writing pen, name plate has been fabricated and it can be replaced with the existing above said fabricated with plastic fibres. While comparing both (Hybrid) composite materials has greater impact strength than the plastic fibre. The properties of natural fibers depend mainly on the nature of the plant, locality in which it is grown, age of the plant and the extraction method used. Hemp/Mudar/Abaca fibers are abundantly found in the south India region, especially in Tamil Nadu. Traditionally, these fibrous materials are being used by the local people for making low cost articles such as socks, boots, mats, ropes, bags. There is no literature available on the application of Hemp/Mudar/Abaca hybrid fibers as reinforcing material in the polymer composites.

Fuzzy rule modeling

The fuzzy logic is used to evaluate the behavior of any system that has no analytical or numerical functions. It has high capability of understanding the more complex systems. The first stage of fuzzy is to develop the membership functions for algorithm development. In this work, the fuzzy rule was employed using the MATLAB software. The membership functions were developed by taking the appropriate range of the selected value of the factors. A triangular membership function was adopted in which three values: low, medium and high, were taken for the input and output parameters. The membership functions of the output responses are presented in Figures.

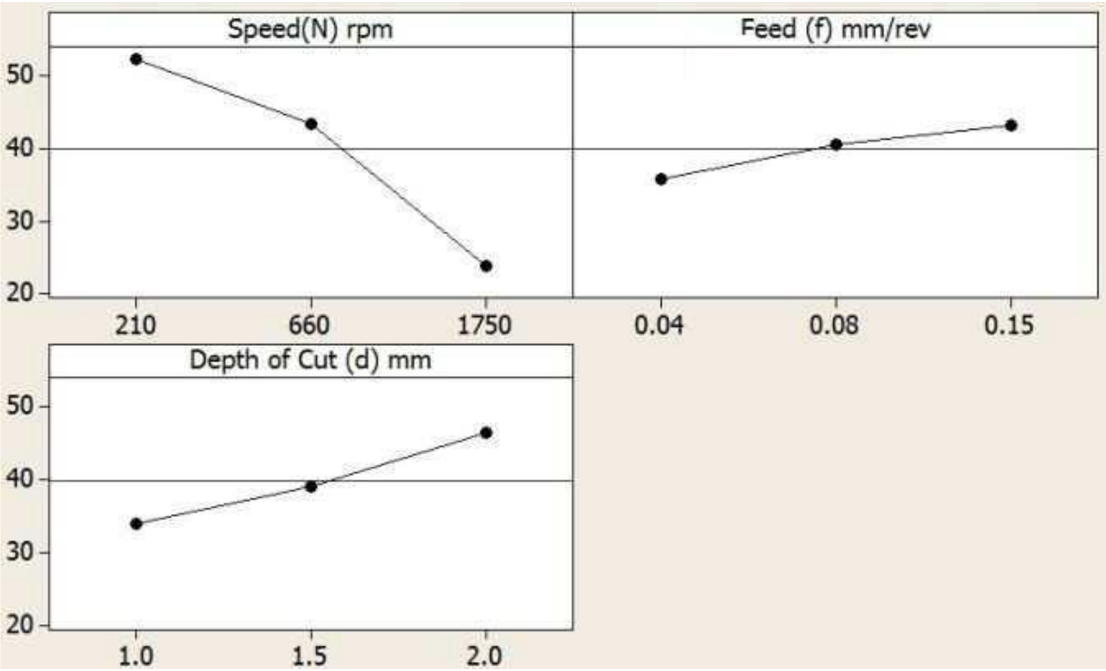

Figure 1. Plots of the main effects for thrust force

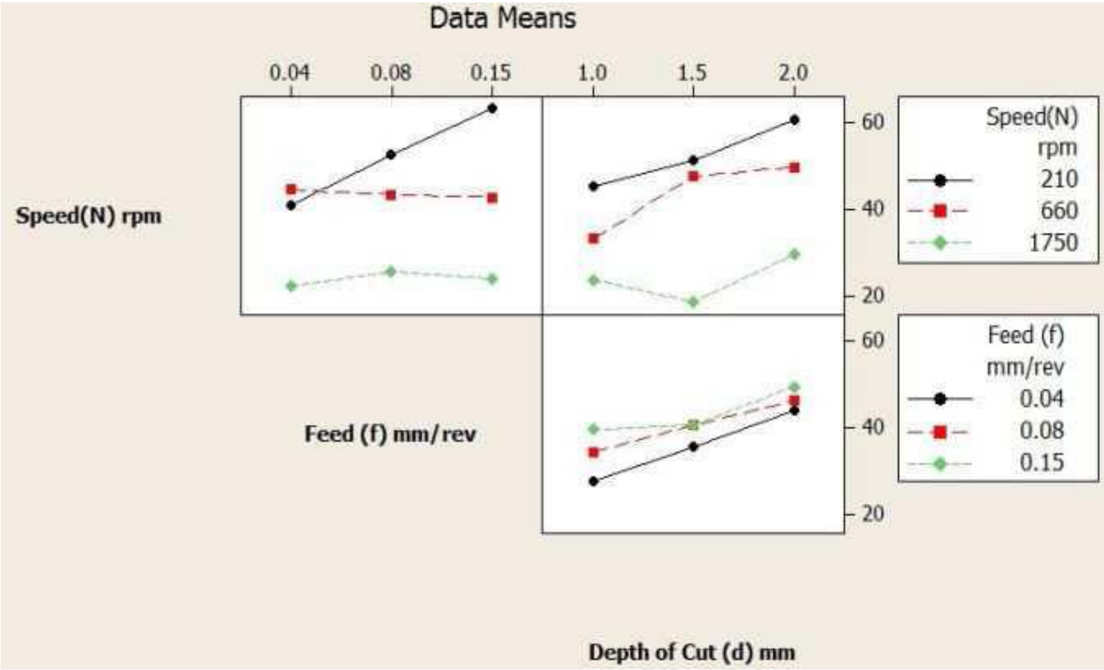

Figure 2. Plots of the interactions for thrust force

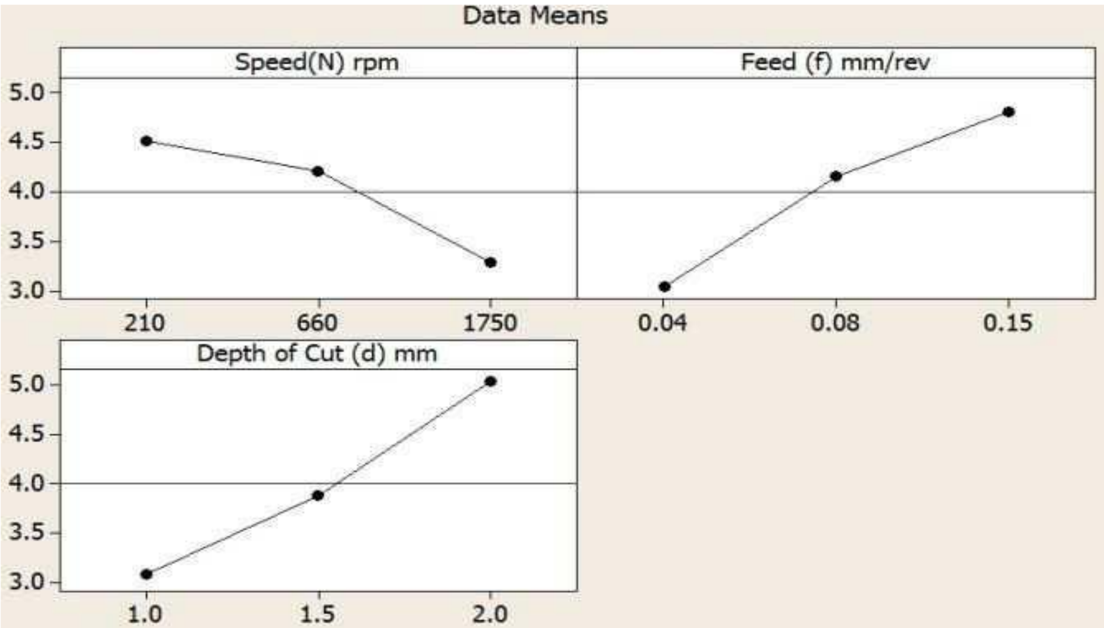

Figure 3. Plots of the main effects for torque

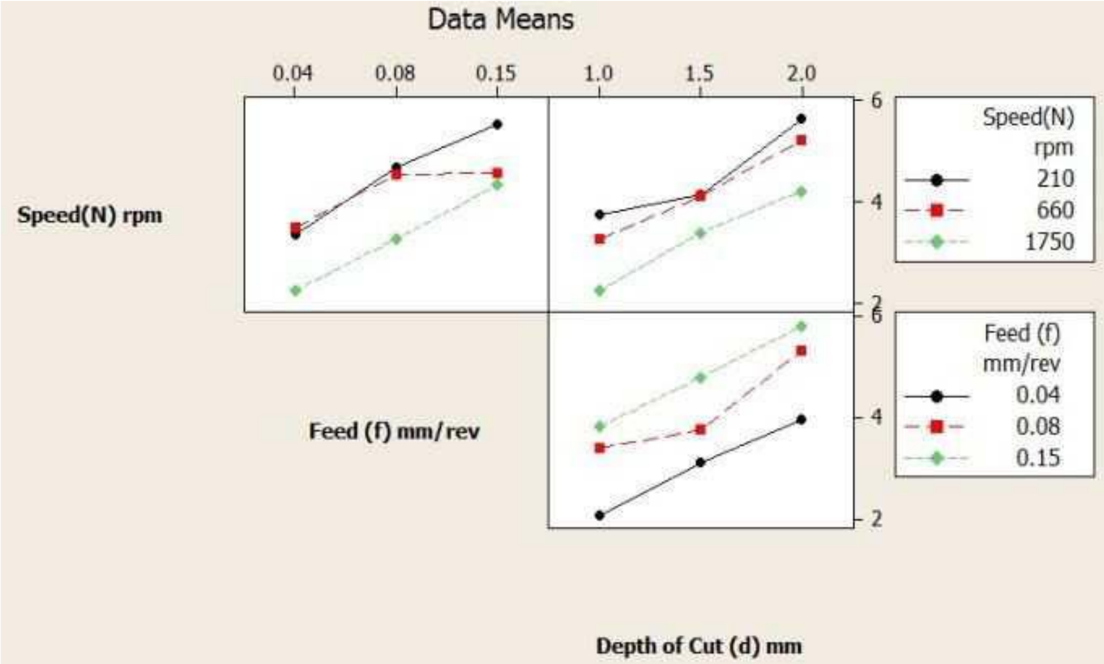

Figure 4. Plots of the interactions for torque

The next stage of fuzzy is the de-fuzzification process. This reduces the membership vector into a scalar quantity, presumably to the most representative value. Fuzzy logic works by considering a series of IF-THEN statements containing inputs and outputs. In this study, the inputs x1, x2 and x3 were assigned to cutting speed, feed rate and depth of cut, respectively, while the outputs y1 and y2 were assigned to thrust force and torque, respectively. From these values, the percentage error between the experimental ones and fuzzy predictions were calculated. The average percentage error for thrust and torque were found to be 0.87% and 1 .32% respectively. From the above discussions on the effects and characteristics of thrust force and torque on the natural fibre reinforced composites, the following conclusions can be drawn. Firstly, speed and depth of cut were found to be the most influencing factors for thrust force whereas speed, feed and depth of cut are the predominant factors for torque. In addition, both thrust force and torque closely behave similar as the main and predominant effects. As speed increases, both responses decreases. However, the thrust force and torque are increased when feed and depth of cut are increased. Furthermore, high speed, high feed and medium depth of cut are the optimum machining conditions while considering the thrust force factor. Meanwhile, high speed, low feed and low depth of cut are the optimum condition for torque. Moreover, thrust force and torque were modeled using fuzzy rule and the models were closely correlated with the experimental data with an average error of 0.87% and 1 .32%

respectively. Hence, the fuzzy modeling of thrust and torque can be taken to be highly satisfactory. Also, fuzzy modelling helps to accurately predict the responses for any values of cutting speed, feed rate and depth of cut combinations within a specific range of values.

CLAIM (S)

1) Fuzzy logic based on prediction of Thrust force and Torque in Drilling of Natural Fiber Particle Reinforced Polymer Composite Material works by considering a series of IF-THEN statements containing inputs and outputs.

2) According to claim 1,wherein fuzzy is the de-fuzzification process this reduces the membership vector into a scalar quantity, presumably to the most representative value.

3) According to claim 1,wherein , the inputs x1, x2 and x3 were assigned to cutting speed, feed rate and depth of cut, respectively while the outputs y1 and y2 were assigned to thrust force and torque, respectively.

4) According to claim 1,wherein the percentage error between the experimental ones and fuzzy predictions were calculated. The average percentage error for thrust and torque were found to be 0.87% and 1 .32%

5) According to claim 1,wherein the speed and depth of cut were found to be the most influencing factors for thrust force whereas speed, feed and depth of cut are the predominant factors for torque.

6) According to claim 1,wherein the both thrust force and torque closely behave similar as the main and predominant effects. As speed increases, both responses decreases. However, the thrust force and torque are increased when feed and depth of cut are increased

7) According to claim 1,wherein the high speed, high feed and medium depth of cut are the optimum machining conditions while considering the thrust force factor. Meanwhile, high speed, low feed and low depth of cut are the optimum condition for torque.

8) According to claim 1,wherein the fuzzy modeling of thrust and torque can be taken to be highly satisfactory. Also, fuzzy modelling helps to accurately predict the responses for any values of cutting speed, feed rate and depth of cut combinations within a specific range of values.

ABSTRACT

Evaluation of Thrust force and Torque in Drilling of Natural Fiber Particle Reinforced Polymer Composite Material using fuzzy logic

In this work, a new composite plate with natural Abaca, Mudar and Hemp reinforced polymer composite material by using bio epoxy resin was manufactured and subjected to a series of drilling operation by changing three input factors namely speed, feed rate and depth of cut. During each operation, the output responses namely thrust force and torque were measured. The responses were analyzed using Taguchi method to examine the relation between the input factors and output responses, and also to know the most influencing factors on the responses. The data was also analyzed using fuzzy rule model for prediction of responses for a range of input factors. The results showed that all three factors chosen have significant effect on the responses. The fuzzy model data in comparison with the experimental values shows only a marginal error and hence the prediction was highly satisfactory.

FORM 3
THE PATENTS ACT 1970
(39 of 1970)
&
The Patent Rules, 2003
STATEMENT AND UNDERTAKING UNDER SECTION 8
(See Section 8, rule 12)

NAME OF APPLICANTS& INVENTORS

EVALUATION OF THRUST FORCE AND TORQUE IN DRILLING OF NATURAL FIBER PARTICLE REINFORCED POLYMER COMPOSITE MATERIAL USING FUZZY LOGIC

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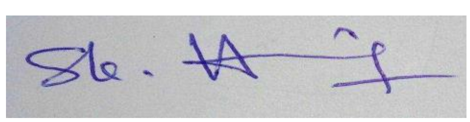
Hereby declare, We have not made any application for the same / substantially the same invention outside India.

NAME	SIGNATURE	DATE
Dr.SHAIK HUSSAIN		11-02-2021

Dr.V.SIVA RAMA KRISHNA		11-02-2021
Dr.R. DHARMALINGAM		11-02-2021
Mr.T. NARESH KUMAR		11-02-2021

To
The Controller of patents, The Patent office at CHENNAI.

FORM 5
THE PATENTS ACT, 1970 (39 of 1970)
&
THE PATENTS RULES, 2003
DECLARATION AS TO INVENTORSHIP
(See section 8, rule 12)

1. Name of Applicant & Inventors

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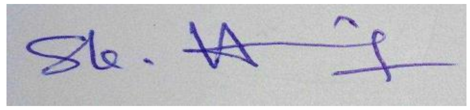
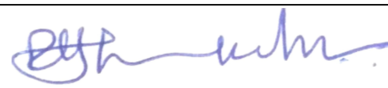
Hereby declare that the true and first inventor of the invention disclosed in the complete specification filed in pursuance of my application numbered ____________ dated __________________

TITLE OF THE INVENTION:

EVALUATION OF THRUST FORCE AND TORQUE IN DRILLING OF NATURAL FIBER PARTICLE REINFORCED POLYMER COMPOSITE MATE USING FUZZY LOGIC

3.Declaration to be given when the application in India is filed by the Applicant in the convention country: -
I the applicant in the convention country hereby declare that our right to apply for a patent in India is by way or assignment from the true and first inventor.

NAME	SIGNATURE	DATE
Dr.SHAIK HUSSAIN		11-02-2021
Dr.V.SIVA RAMA KRISHNA		11-02-2021
Dr.R. DHARMALINGAM		11-02-2021
Mr.T. NARESH KUMAR		11-02-2021

To
The Controller of Patents, The Patent office at CHENNAI.

FORM 9
THE PATENTS ACT, 1970
(39 of 1970)
&
THE PATENTS RULES, 2003
REQUEST FOR PUBLICATION
(See section 11A(2); rule 24A)

We (state name, address and nationality of Applicant & Inventors)

TITLE OF THE INVENTION: EVALUATION OF THRUST FORCE AND TORQUE IN DRILLING OF NATURAL FIBER PARTICLE REINFORCED POLYMER COMPOSITE MATERIAL USING FUZZY LOGIC

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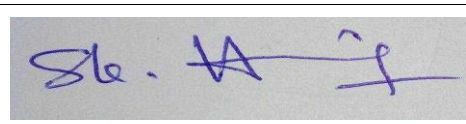
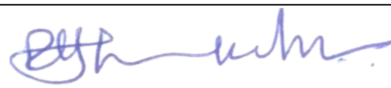
Hereby request for early Publication of our application for Patent No. ____________________ dated _______________ under section 11A(2) of the act.

NAME	SIGNATURE	DATE
Dr.SHAIK HUSSAIN		11-02-2021

Dr.V.SIVA RAMA KRISHNA		11-02-2021
Dr.R. DHARMALINGAM		11-02-2021
Mr.T. NARESH KUMAR		11-02-2021

To
The Controller of patents, The Patent office at CHENNAI.