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Multi –Objective Optimization in Drilling Of Nfrp Composites: Application of a Fuzzy Embedded Algorithm

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ABSTRACT- Widespread applications of Natural fiber reinforced polymer (Tectonagrandis) composites results in automobile, structural and aerospace engineering leads to vital concern for attaining usable shapes with accuracy through machining. Performance characteristics in the drilling of Tectonagrandiscomposites are incredibly affected by varying method such as drill speed, feed and drill diameter. Usually thrust, torque, delamination and surface roughness are considered as output performance in drilling. Multi performance characteristics are converted into an identical single performance characteristics by utilizing Algorithm.

I. INTRODUCTION

The development of composite materials and related design and manufacturing technologies is one of the vital advances within the history of materials. Composites are multifunctional materials having unexampled mechanical and physical properties which will tailor to satisfy the requirements of a specific application. Several composites additionally exhibit great resistance to high-temperature corrosion and reaction and wear. These distinctive characteristics give the engineer with design opportunities not possible with typical monolithic (unreinforced) materials. Composites technology additionally makes attainable the utilization of acomplete category of solid materials, ceramics in applications that monolithic versions square measure ill-sorted as a result of their great strength scatter and poor resistance to mechanical and thermal shock. Various researchers in technology education have indicated that a major difference between the technological design method and therefore the engineering design method is analysis andoptimization.

In the optimization stage methodology could also be a scientific method exploitation style constraints and criteria to permit the designer to find the best answer. In an engineering design approach, each analysis and optimization are employed before any prototype work is started. Recently, the author conducted an analysis to look at the standing of technology education concerning the infusion of engineering design concepts (Kelley, 2008). Participants for this study discovered that technology education regarding content presently doesn't emphasize optimization techniques as a neighborhood of the engineering style method. Engineers are often usually forced to spot a number of acceptable style solutions so decide that one best meets the necessity of theconsumer.

This decision-making method is understood as an improvement. There are many teaching strategies that can be employed to include the optimization process Certainly, any technology education program that includes engineering design projects should include an optimization phase of the design process. This could be accomplished by requiring students to stay records Teaching-learning-based improvement (TLBO) could be a population-based metaheuristic search algorithmic program impressed by the teaching and learning method during a schoolroom. It's been with success applied to several scientific and engineering applications within the past few years. Within the basic and most of its variants, all the learners have an identical chance of obtaining data from others. However, within the planet, learners square measure completely different, and every learner‟s learning, enthusiasm aren't identical, leading to completely different possibilities of getting data.This study introduces a learning, enthusiasm mechanism into the fundamental firefly and proposes a learning enthusiasm based mostly algorithmicprogram.

II. EXPERIMENTATION

Figure.1 Vertical milling machine

Figure.2 Drill bit used

State of art:

Davim[2003][1] have explored Taguchi technique and analysis of variance (ANOVA) to select cutting parameters for damage-free drilling on carbon fiber reinforced epoxy composites using high speed steel (HSS) and cemented carbide (K10) drills. The study also establishes a correlation between cutting velocity and feed rate with the delamination in a CFRP laminate by using multiple regression analysis. **K. Palanikumar and J. Paulo (2006)** presented a paper on the title:„Mathematical model to predict tool wear on the machining of glass fibre reinforced plastic composites‟. In their work a mathematical model has been developed to predict the tool wear on the machining of GFRP composites using statistical analysis in-order-to study the main and interaction effects of machining parameters namely cutting speed, work piece (fibre orientation) angle, depth of cut and feed rate. This technique is convenient to predict the effects of different influential combinations of machining parameters by conducting minimum number of experiments. Cutting speed was the factor, which has great influence on tool wear, followed by feed rate. The accuracy of the developed model can be improved by including more number of parameters and levels. **Tsao[2008]** [3] have studied the effect of drilling parameters (diameter ratio, feed rate and spindle speed) on thrust force in drilling of CFRP composites using a step-core drill. The results indicate that diameter ratio and feed rate have Fig. 1. Experimental set up. Fig. 2. Drill bits used during experimentation. K. Abhishek et al. / Measurement 77 (2016) 222–239 223 the most significant influence on the overall performance of step-core drills. **Rawat and Attia[2009]**[4] have investigated the influence of speed and feed rate on the damage mechanisms, namely, delamination, surface roughness, fiber pull-out, thermal damage, hole circularity and hole diameter error in drilling of carbon fiber composites using machinability maps. The results shows that effect of tool wear can be established due to changes in the thrust and cutting forces using the quality maps. **Krishnamoorthy et al.[2009]**[5] have established a second-order mathematical using response surface methodology (RSM) for predicting delamination in drilling of CFRP composites by „„„BRAD and SPUR"type made of carbidetool.**Krishnamoorthyet al.[2012]**[6] have utilized grey-fuzzy methodology along with ANOVA to investigate the effect of drilling parameters on five different output performance characteristics, namely, thrust force, torque, entry delamination, exit delamination and eccentricity of the holes in drilling of CFRP composites. The results indicate that feed is the most significant factor during drilling of CFRP composites. **Craig M. Clemons and Daniel F. Caulfield [2013]**[7] presented a paper on "Natural fibers". The aim of their study is to present a various properties, availability, chemicalcontents,dimensions,and various applications of the natural fiber reinforced composites. U.A. Khashaba, M.A. Seif and

M.A. Elhamid (2014)[8] presented a paper on "Drilling analysis of chopped composites" The main objective of the present study is to investigate the effects of the cutting variables, speed and feed, on the thrust force, torque, and delamination in drilling chopped composites with different fiber volume fractions. Based on the results from this investigation, empirical formulas are developed. Although it is known that the thrust force and torque increases with the increase of the feed, this work provides quantitative measurements of such relationships for the present composite materials. On the other hand, increasing the cutting speed reduces the thrust force and the torque.

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Empirical formulas that determine the cutting forces based on fiber volume fractions, feeds, and speeds are obtained using multivariable linear regression analysis. **C.C. Tsao and H. Hocheng (2015)**[9] presented a paper on Title: „Evaluation of Thrust Force and Surface Roughness in Drilling Composite Material Using Taguchi Analysis and Neural Network". An experimental approach to the evaluation of thrust force and surface roughness produced by candlestick drill using regression analysis of experiments and RBFN were proposed in their study. The authors found the feed rate and the drill diameter are recognized the most significant factors affecting the thrust force, while the feed rate and spindle speed are seen to make the largest contribution to the surface roughness. In the confirmation tests, RBFN is demonstrated more effective than multivariable regression analysis for the evaluation of drilling-induced thrust force and surface roughness in drilling of compositematerial.

K.Vijayakumar, G.Prabhaharan(2016)[10]This paper describes Evaluation of Thrust Force and Surface Roughness in Drilling of glass fiber Composite by Optimization of multi-pass turningoperationsusingAntcolony algorithm.**T. Keerthi vasan, S. Padmavathy, S. Nandhakumar (2017)**

[11] Natural fibre reinforced polymer composites became more attractive due to their high specific strength, light weight, and environmental concern. The incorporation of natural fibres with the combination of E – Glass has gained many industrial applications. Naturally fibres are of little use unless they are bonded together to take the form of structural element that can carry load. Hence the combination of fibres and the matrix can have high strength and stiffness yet they have low density. The fibres used here are Tectonagrandis and with Epoxy as the matrix. These composite material has different mechanical properties. **B.RaviSankar,P.Umamaheswarrao[2018]**

[12] Multi objective optimization of CFRP Composite Drilling Using Ant Colony Algorithm.**ShaoZhenyu, Tang Hui[2020]**[13]Information feedback self-adaptive harmony search algorithm for the bovine cortical bone vibration-assisted drilling optimizationS. The VAD drilling experiments and parameters analysis are carried out. Experimental results have shown that the VAD has the potential to reduce the thrust force. Compared with conventional drilling(CD).

COMPOSITE PREPRATION:

The specimen used in this study is a Rectangular plate of 200x100 mm made of natural fiber reinforced composite material. The composite is made of Tectonagrandis natural fibers. Commercially available natural fibers are taken.

COMPRESSION MOULDING:

Compression molding is a high-volume, high-pressure method suitable for molding complex, high-strength fiberglass reinforcements.it is a method of molding in which the molding material, generally preheated, is first placed in an open, heated mold cavity. The mold is closed with a top force or plug member, pressure is applied to force the material into contact with all mold areas, while heat and pressure are maintained until the molding material has cured

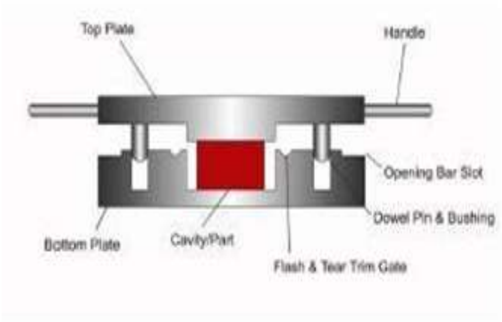

Figure.3 compression molding

DELAMINATION

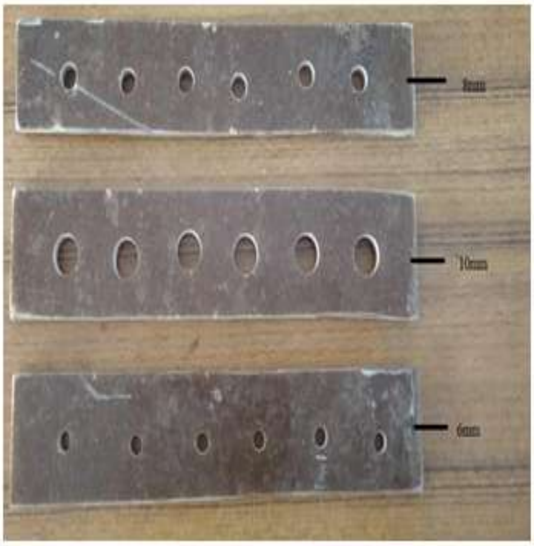

Figure.5 Drilled NFRP Specimens

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MATERIAL TEST:

Fig. 6 Tensiletest **Fig. 7** Flexturaltest

Fig.8 Impact test

Delamination occurs both at the entry and exit planes of the work piece. These delaminations could be correlated to the thrust force during the approach and exit of the drill. Delamination is one of the major concerns in drilling holes in composite materials. To understand the effects of the process parameters on delamination, numerous experiments have to be performed and analyzed mathematical models have to be built on the same. Modeling of the formation of delamination is highly complex and expensive. Hence, statistical approaches are widely used over the conventional mathematicalmodels.

(Fd) =Dmax/Dmin (1)

The first part of the equation represents thesize of the crack contribution and the second part represents the damage areacontribution.

Fda = α (Dmax / Dmin) + β (Amax /Anom) ....(2)

Where, Dmax – Maximum area related to the maximum diameter of the delamination zone.
Dnom – Area of the nominal hole.

In this work, α = (1-β), (3)
β = Amax / (Amax-Anom). (4)

Fda = (1- β)*Fd + ((Amax / (Amax - Anom)*(Fd2-Fd))

SURFACE ROUGHNESS

Surface roughness often shortened to roughness, is a component of surface texture. It is quantified by the deviations in the direction of the normal vector of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small, the surface is smooth. In surface metrology, roughness is typically considered to be the high-frequency, short- wavelength component of a measured surface.

DOMAIN OF EXPERIMENTS:

L27 orthogonal array			
Sl.no	Speed(rpm)	feed (mm\min)	Dia (mm)
1	1250	1.5	6
2	1250	1.75	6
3	1250	2.0	6
4	1250	1.5	8
5	1250	1.75	8
6	1250	2.0	8
7	1250	1.5	10
8	1250	1.75	10
9	1250	2.0	10
10	1000	1.5	6
11	1000	1.75	6
12	1000	2.0	6
13	1000	1.5	8
14	1000	1.75	8
15	1000	2.0	8
16	1000	1.5	10
17	1000	1.75	10
18	1000	2.0	10
19	1000	1.5	6
20	850	1.75	6
21	850	2.0	6
22	850	1.5	8
23	850	1.75	8
24	850	2.0	8
25	850	1.5	10
26	850	1.75	10
27	850	2.0	10

FUZZY INTERFERENCESYSTEM(FIS):

A Fuzzy Inference System (FIS) is a precise problem solving methodology based on human inexact reasoning to handle numerical data and linguistic knowledge simultaneously. It has been widely applied in fields such as automatic control, dataclassification, decision analysis, expert systems and computer vision.

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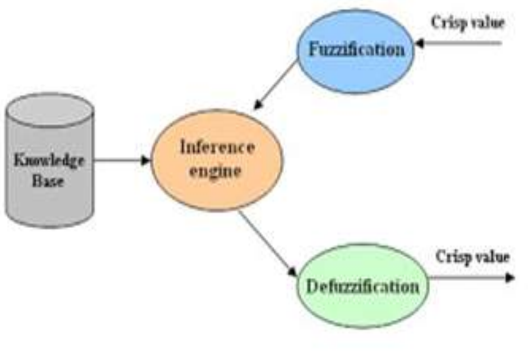


Fig,9FIS

EXPERIMENTALDATA:

S. No	NFRP				
	Thrust (KN)	Torque (KN mm)	F_d (in)	F_d (out)	R_a
1	0.021	0.12	1.076	1.081	1.76
2	0.024	0.16	1.109	1.104	1.77
3	0.05	0.11	1.070	1.093	1.90
4	0.042	0.14	1.078	1.098	1.79
5	0.019	0.17	1.071	1.077	1.81
6	0.020	0.08	1.039	1.060	1.93
7	0.029	0.13	1.076	1.078	1.81
8	0.052	0.15	1.089	1.079	1.86
9	0.033	0.21	1.064	1.076	1.97
10	0.026	0.34	1.076	1.081	1.77
11	0.018	0.10	1.087	1.076	1.79
12	0.021	0.11	1.109	1.104	1.92
13	0.023	0.38	1.070	1.093	1.78
14	0.026	0.24	1.078	1.098	1.76
15	0.016	0.20	1.059	1.067	1.89
16	0.020	0.16	1.057	1.109	1.78
17	0.017	0.10	1.071	1.077	1.80
18	0.02	0.13	1.086	1.095	1.93
19	0.041	0.09	1.037	1.060	1.79
20	0.035	0.12	1.039	1.057	1.81
21	0.016	0.14	1.051	1.040	1.90
22	0.017	0.06	1.064	1.076	1.77
23	0.024	0.11	1.089	1.077	1.82
24	0.043	0.13	1.076	1.078	1.91
25	0.028	0.18	1.064	1.078	1.79
26	0.022	0.28	1.075	1.054	1.84
27	0.015	0.09	1.087	1.079	1.97

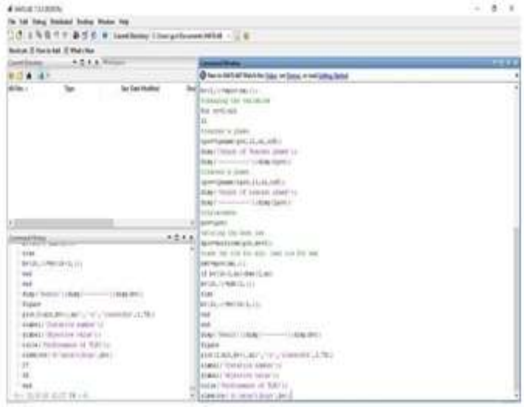
FIREFLY ALGORITHM:

The Firefly algorithm, In this attractiveness is proportional to the brightness and they both decrease as their distance increases. Thus, for any two flashing fireflies, the less brighter one will move toward the more brighter.

X'j,k,i = Xj,k,i + Difference_Meanj,k,i X"j,P,i = X'j,P,i + ri (X'j,P,i - X'j,Q,i), If X'total-P,i<X'total-Q,i

X"j,P,i = X'j,P,i + ri (X'j,Q,i - X'j,P,i), If X'total-Q,I<X'total-P,i

III. MATLAB PROGRAM:

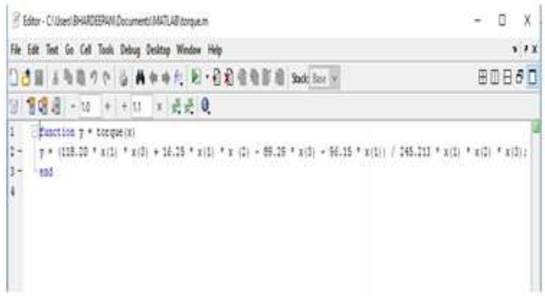


IV. OPTIMIZATION USINGMATLAB

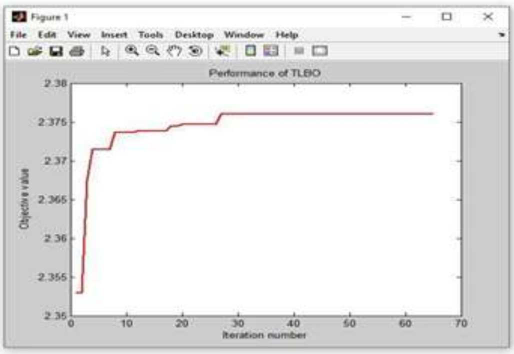
MATLAB is an elite language for specialized processing. It coordinates calculation, perception, also, programming in an easy to- use condition where issues and plans are imparted in common logical documentation.

Produces a populace of focuses at every emphasis. The best point in the populace approaches an ideal arrangement. Chooses the following populace by calculation which uses arbitrary number generators.

The torque function is defined in MATLAB as follows,



PERFORMANCE OF FIREFLY:



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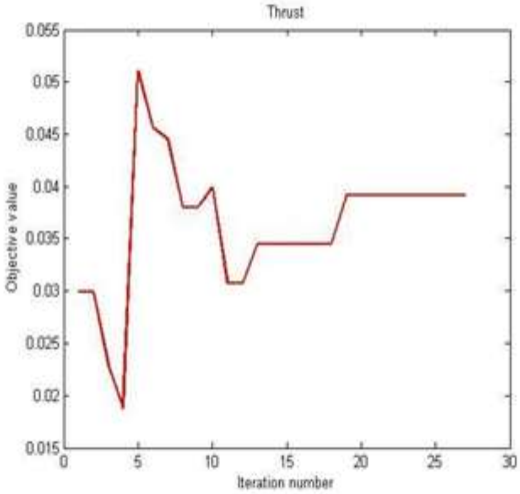
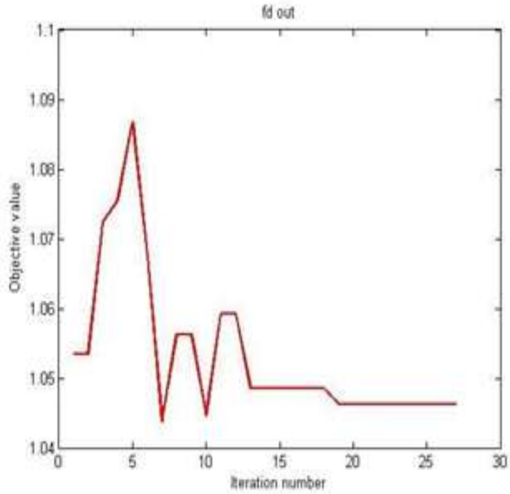
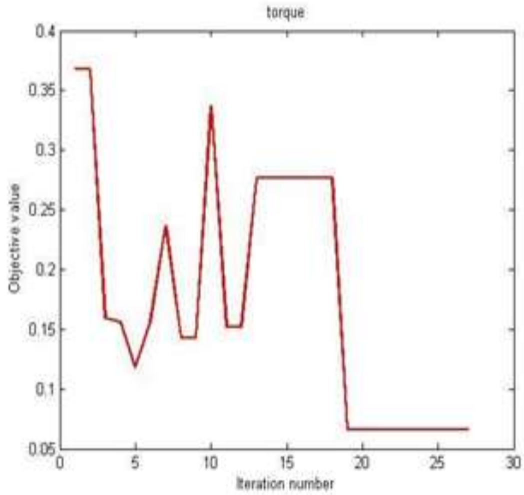
THRUST FORCE



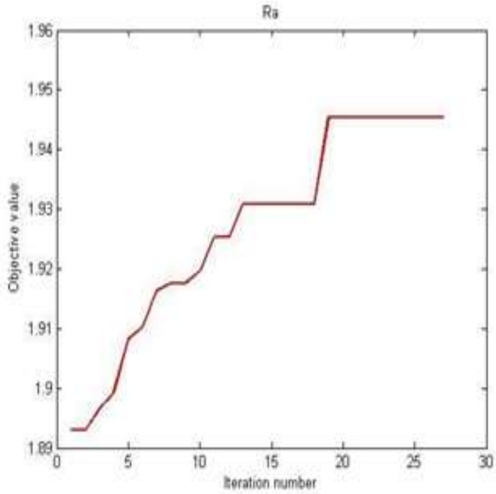
Fd(out)



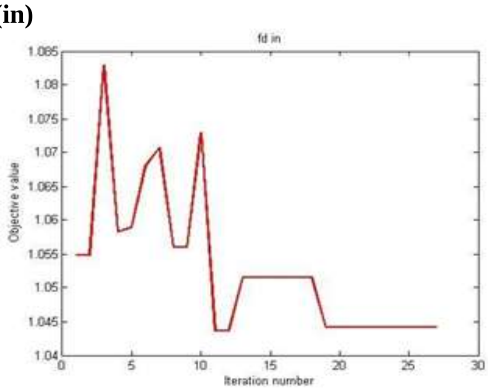
TORQUE



Surface roughness(Ra)



Fd(in)



V. RESULTS ANDDICUSSIONS

On executing the Firefly Algorithm the following optimized results were obtained,

Dia	Feed	Speed
8	1.9	1200

VI. CONCLUSION:

This project explains, the mechanical property of the composite material tensile test, flexural test, impact test and hardness of strength.in my project take can be a combination of Teak wood powder and epoxy composite. I can plan to replace the artificial fiber composite material to natural fiber (teak wood powder) are easily available and some of them used for mechanical purposes. Numerical analysis of Multi performance characteristics are converted into a single performance characteristics. The regression model is considered as fitness function and finally optimized by FireflyAlgorithm.

Optimal output value

Thrust(KN-mm)	Torque (KN-mm)	Ra (μm)	Fa(In)	Fa(out)
0.037	0.14	1.91	1.0559	1.0562

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