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DRILLING OF GRAPHITE-EPOXY POLYMER COMPOSITES: A HYBRID OPTIMIZATION APPROACH

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ABSTRACT

Polymer (epoxy) composite have been positively used in various engineering application especially in the aviation and automobile sector due to their outstanding properties. Machining of these polymer composites is expressively dissimilar as compared to machining of conventional materials, due to non-homogeneous in nature (that contains of specifically dissimilar stages). So that their machining process consist oscillating cutting forces, disimmilarroughnes of surface due to crumpled of reinforced particle pull out from resin matrix. The paper presents a multiobjective optimization of drilling operation using the Utility approach. The output response in the drilling of graphite reinforced polymer composite is MRR, thrust force, torque, and roughness of surface (Ra). The results indicate that the utility model can predict the process parameters with reasonable accuracy under drilling conditions.

Keywords: *Polymer, composite, Graphite, drilling operation, Utility optimization*

INTRODUCTION

Composite is the mixture of constituents different in arrangement, which is distinct elements hold, their isolated characteristics [1]. These isolated components perform composed to provide the essential mechanical strong point or toughness to the amalgamated fragment. Graphite Composite materials are prepared via joining reinforcement (graphite) to matrix. And matrix delivers features superior as related to resources only. This composite the graphite conveys majority load & are foremost article in the extensive potentials. The resin maintenances to assignment load amongst graphite & stalemates the elements composed. This composite have outstanding mechanical abilities that is unmatched via another constituent. Materials are hard, inflexible, & lighthearted. This kind of graphite amalgamated material have selected universally lighthearted load and larger performance is prevailing, similar residents designed at missiles, fighter aircrafts, & great speed car [2-3].

Bhatnagar [4] found various difficulties associated to the drilling of graphite reinforced polymer composites. The procedure of dimensional investigation was a contribution to inspect the difficult relationship among the point angle, cutting speed, drill diameter, feed, thrust force & material width throughout the process of drilling in graphite reinforced polymer composites.

Vijayan Krishnaraj [5] found optimal cutting situations specifically speed & feed in drilling of graphite reinforced polymer composite via a Genetic Algorithm (GA). Krishnamoorthy [6] directed to optimize the graphite reinforced polymer composite drilling relating conventional fuzzy procedure. The incorporated multi-criteria optimize technique joining the major constituent investigation and Taguchi process has offered to optimize the graphite reinforced polymer composite drilling.

Kumar and S. Aravindan [7] well-read about the microwave sintering of copper–graphite composites. A thicker microstructure with bigger porosity is found through these predictable sintering processes which reduce the strength and wear resistance as well. Into the microwave sintering, heat is produced internally inside the material and the model becomes on the basis of heat. Energy is delivered to the material directly via. Molecular communication results in volumetric warming. Microwave sintering delivers many benefits such as quicker heating rate, lesser sintering temperature, lesser average grain dimension, enhanced densification and an apparent discount in activation (energy) in sintering. The better microstructure with comparatively smaller and curved pores, due to microwave warming and enhance the enactment of the composite.

EXPERIMENTAL DETAILS

From the above study, CNC verticle machine has been operated for drilling experiment. Graphite reinforced polymer composite has been appied like as job material throughout excecution of the experiment (method of preparation: hand layup). High speed steel drill bit of 10 mm diameter has used for execution of drilling processes.

METHODOLOGY

Utility can be definite as the effectiveness of an artifact or a procedure in orientation to the stages of hopes to the customers (Rautara 2010). The enactment assessment of every machine procedure be influenced by on numeral of yield specialty. Thus, a mutual degree is compulsory to scale his global concert, which must gross into reason the comparative influence of entire property appearances. Then such an amalgamated directory characterizes entire usefulness of an invention or method. It delivers a operational agenda for assessment of marginal characteristics finished by personalities, organizations & firms. Usefulness states to happiness that all feature delivers to the judgment fabricator. Therefore, usefulness theory adopts that every judgment is finished scheduled source of the usefulness enlargement standard, allowing to which the finest select is 1 (one) that delivers the peak pleasure to the judgment creator.

The complete utility directory that takes calculated preserved as a particular impartial task aimed at optimization. Amongst numerous superiority features kinds that is LB (in this lower is the best), HB (in this higher is best), and NB (in this nominal is the best) recommended by Taguchi, the usefulness task would be advanced. In the projected attitude usefulness ideals of separate answers are resolute to compute global usefulness index. Complete usefulness directory is pickled by way of the solitary impartial task for the optimization.

Usefulness philosophy offers a method of logical framework used for the determination of another selections prepared by personalities, organizations and firms. Usefulness states the happiness that every select offers to the judgment fabricator. Consequently, usefulness philosophy accepts every judgment is finished on the base of the usefulness intensification opinion, allowing to which the greatest selection is the 1 that offers the maximum usefulness (gratification) to the judgment fabricator.

The modern learning challenges to get most satisfactory drilling parameter on composite throughout drilling of graphite reinforced polymer composite via consuming utility approach then to displays the possessions of drilling operation factors that is weight percentage of graphite, speed of drill rotation, rate of feed, all have been diverse at four separate stages(Table 1) as DOE (presented in Table 2) on dissimilar machining routine structures specifically MRR, thrust and surface roughness, torque. In this research, the L16 orthogonal array has been secondhand. A photograph of a drilled job has been delivered in Fig.1.Table 2 exemplifies the experimentally detected principles of reaction features. Table: 3 show the complete utility index and their equivalent S/N ratios that are substantiated over confirmatory examination that shows the agreeable outcomes. These displays the optimum parametric situations are as shadows: Drill rotational speed [RPM]: 2000, Feed rate [mm/rev]:250, Graphite reinforced Percentage [mm]:40%. Utility Taguchi method has been used to convert multiresponse to single response and Taguchi method has been used to obtain the optimal setting and then predict main value 14.89577 of the signal to noise ratio. Utility Taguchi method has an effective technique for getting an efficient optimal solution.

CONCLUSIONS

The machining performances such as thrust, MRR and roughness of surface, torque through drilling of Graphite reinforced epoxy composites observe. The goal is to achieve the furthermost satisfactory parametric venue for enlightening complete procedure concert vintage. To improve these multi-response optimizations problem, utility theory was hosted, that changed the multi-objective optimization problematic into a single objective optimization problema. Via this technique a multi-response optimization problem has been changed to a corresponding single objective optimization problema that has been furthermost resolved through Taguchi approach. Precision and amount of effectiveness of numerous method factors in calculation of the classical examination can be inspected simply. Lastly, the finest constraint amalgamation attained over Taguchi method; seeing the higher is better principles upon the generally utility indexes. After overhead learning it was verified that the utility constructed Taguchi method is accomplished of given that operative drilling atmosphere in command to reduce thrust and torque, roughness of surface and to exploit the MRR. The technique is suitable to off-line value control of the method/ invention and be useful to quantity manufacture appearances.

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Figure 1: *Machining sample of Graphite reinforced polymer composite*

Table 1- *Domain of Experiment*

Factor	Units	Level 1	Level 2	Level 3	Level 4
Drill speed	rpm	1000	1500	2000	2500
Feed rate	mm\rev	150	200	250	300
FWP	%	10	20	30	40

Permitting to the utility theory (Kumar 2000 and Walia 2006) uncertainty *Ai* is the quantity of usefulness of an characteristic (or property appearances) *i*& also here *n*aspects assessing consequence planetary, formerly the combined usefulness function can be stated as:

$U(A_1, A_2 ,.......A_n) = f (U_1 (A_1),U_2 (X_2),.....,U_n(A_n))$

Where, *Ui (Ai)* denotes the usefulness of the i^{th}characteristic.

The complete usefulness function is the summation of separate conveniences if the features are self-governing, & is assumed as shadows:

$U (A_1, A2,……A_n)=\sum U_iA_i$

The complete utility function afterward conveying loads to the attributes can be stated equally:

$U (A_1,A_2,……A_n)= \sum W_{i.}U_iA_i$

The preference amount can be articulated on a the logarithmic gauge as shadows:

$P_i=C \log (A_i/A_i`)$

Where, $A_i$is the worth of any property characteristic also called qualities (attributes) *i*, '*Ai* is fair suitable magnitude of value characteristic (quality) *i*and C is known as the const. The magnitude of C can be originating through the situation, means if $A_i= A$ * (here A * is the optimum or greatest magnitude), at that time $P_i$preference number= 9 Therefore,

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$C=9/\log(A^*/A_i`)$

The complete usefulness can be stated as shadows:

$U=\sum W_i P_i$

Focus to the situation

$\sum W_i=1$

Table: 2*Experimental Data*

S.N	Drill rotational speed (rpm)	Feed rate (mm/rev)	Graphite weight percentage (GWP%)	Thrust(N)	Torque(N m)	MRR(mm^3/sec)	Ra(µm)
1	1000	150	10	0.25	0.09	10.98	1.8
2	1000	200	20	0.25	0.09	12.27	1.3
3	1000	250	30	0.33	0.16	16.36	0.6
4	1000	300	40	0.42	0.08	19.21	1.3
5	1500	150	20	0.39	0.1	7.587	1.1
6	1500	200	10	0.33	0.17	12.35	1.5
7	1500	250	40	0.28	0.1	16.42	1.8
8	1500	300	30	0.22	0.11	19.9	1
9	2000	150	30	0.36	0.06	8.01	1.3
10	2000	200	40	0.17	0.11	12.06	0.9
11	2000	250	10	0.31	0.02	16.47	1.7
12	2000	300	20	0.31	0.11	20.63	1.9
13	2500	150	40	0.19	0.12	8.29	1.9
14	2500	200	30	0.31	0.12	12.3	2.5
15	2500	250	20	0.28	0.11	18.16	1
16	2500	300	10	0.39	0.08	19.61	1

RESULT AND DISCUSSION

Table: 3 *Preference number of individual utility index and their S/N Values*

PI THRUST	**PI TORQUE**	**PIMRR**	**PIRa**	**U OVERALL**	**SNRA1**	**MEAN1**	**PSNRA1**
5.162377	2.674636	3.325721	2.071686	3.308605	10.3929	3.308605	14.89577
5.162377	2.674636	4.325148	4.123937	4.071525	12.19514	4.071525	
2.399738	0.254955	6.913484	9	4.642044	13.33419	4.642044	
0	3.16997	8.358361	4.123937	3.913067	11.85035	3.913067	
0.737428	2.231545	0	5.177451	2.036606	6.178141	2.036606	
2.399738	0	4.383619	3.221483	2.50121	7.963003	2.50121	
4.034674	2.231545	6.946421	2.071686	3.821081	11.64373	3.821081	
6.434412	1.83072	8.675861	5.778517	5.679878	15.08678	5.679878	
1.533912	4.379811	0.488139	4.123937	2.63145	8.403902	2.63145	
9	1.83072	4.169828	6.442965	5.360879	14.58472	5.360879	
3.021862	9	6.973776	2.432151	5.356947	14.57835	5.356947	
3.021862	1.83072	9	1.730715	3.895824	11.81199	3.895824	
7.893224	1.464796	0.797276	1.730715	2.971503	9.459523	2.971503	
3.021862	1.464796	4.347119	0	2.208444	6.881729	2.208444	
4.034674	1.83072	7.852631	5.778517	4.874136	13.75795	4.874136	
0.737428	3.16997	8.543781	5.778517	4.557424	13.17439	4.557424	

Table 4 : *Response Table for Signal to Noise Ratios*

Level	A	B	C
1	11.943	8.609	11.527
2	10.218	10.406	10.986
3	12.345	13.329	10.927
4	10.818	12.981	11.885
Delta	2.127	4.720	0.958
Rank	2	1	3

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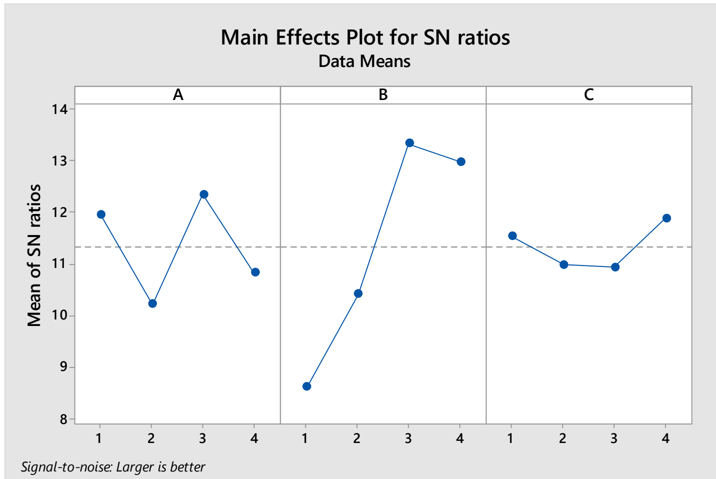

Figure 2: *Evaluation of optimal setting: s/n ratio plot of overall utility (U)*