A Hybrid approach of Fuzzy Logic Based Optimization in Machining of Glass Fiber Reinforced Polymer Composites

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Abstract

Glass fibre-strengthened polymer (GFRP) composites are significantly used now-a-days in production diverse components in aerospace, oil, gasoline and process industries. It replaces traditional materials due to their tremendous properties together with mild weight, corrosive resistance and advanced properties. Development of predictive modeling and optimization of machining process in generating components is important for machining industries. In this paintings, fuzzy common sense based multi reaction predictive model improvement and multi goal optimization of tactics parameters the use of Desirability Function Analysis (DFA) in turning GFRP composite has been attempted. The input variables are reducing speed (v), feed rate (f) and intensity of cut (d). The responses are floor roughness (Ra), steel removal charge (MRR) and device put on (VB). The average percentage mistakes in fuzzy good judgment prediction obtained as 2.74 %, 12.67 % and 3.06 % for Ra, MMR and VB respectively. The most effective degree of input parameters for composite desirability was determined v2 f1 d3. The corresponding surest parameter is v=100 m/min, f= 0.10 mm/rev and d= 1.5 mm for acquiring combine optimization of Ra, MRR and VB having same weightage. The analysis of variance of composite desirability at 95 % self-belief degree confirmed that intensity of reduce is the maximum sizeable parameter with 39.38 % contribution followed via feed..

Keywords: GFRP Composites; Fuzzy good judgment; Multi response optimization; DFA; ANOVA.

1. Introduction

Glass fibre strengthened plastic (GFRP) composites are emerging as an inexpensive substitute to chrome steel and other substances for adverse surroundings in unique commercial packages which includes aerospace, oil, fuel and technique industries. The prominent functions include excessive dimensional accuracy, mild weight, specific modulus of elasticity, corrosive resistance, precise strength and so on. The components are produced specially with conventional machining methods viz., turning and milling.

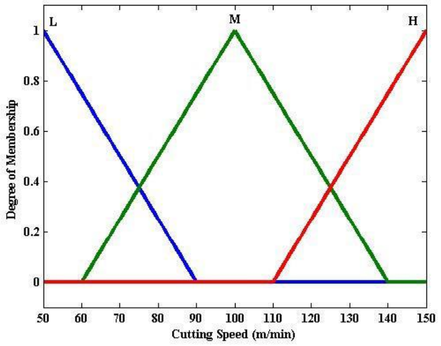
For financial production of the excellent components the research on machinability, development of predictive modeling and optimization of machining technique for obtaining top-quality procedure parameters for one or greater objectives is essential, by using [1]. Researchers have taken into consideration special optimization targets together with minimization of production value, maximization of metallic elimination rate, minimization of surface roughness, maximization of productiveness, minimization of device put on fee, and many others.

Investigated the machinability of GFRP substances in turning process with chamfered main cutting edge of P and K type carbide gear experimentally. He determined that K type is better than the P kind of chamfered principal reducing side equipment. [2] Completed multi reaction optimization in turning of GFRP composite by the use of carbide (K10) cutting device. They employed Taguchi and application idea thinking about the method parameters as device nostril radius, device rake attitude, feed charge, slicing speed, intensity of reduce and slicing environment. Surface roughness (Ra) and Material elimination charge (MRR) had been considered as system responses. It changed into located that the contribution of intensity of cut (d), reducing speed (v), feed charge (f) are 37.30%, 15.54 % and 15.16% respectively [3]. Carried out experimental research on turning fibre-bolstered plastics (FRPs) through using polycrystalline diamond (PCD) slicing tool. They optimize Ra through using a couple of regression evaluation (MRA) and pronounced that Ra increases with f and reduce with the v [4]. Attempted to optimize the more than one machining responses viz., surface roughness (Ra), machining pressure (F) and tool wear (VB) of GFRP pipes on both of hand lay-up and filament wound composites. They employed particle swarm optimization (PSO) and genetic set of rules (GA) as optimization device and PSO determined higher compared to GA. The slicing situations (v1–f2–d2) as 100 m/min, 0.1 mm/rev., 1 mm found ideal machining situations for the hand lay-up kind and (v2–f1–d3) as a hundred and fifty m/min, 0.05 mm/rev., 2 mm are for the filament wound type GFRP pipes.

Conducted turning experiments on GFRP pipes with K 20 grade cemented carbide reducing device. They are optimized multi-reaction traits to optimize floor roughness, flank wear, crater put on and machining pressure employing DOE, Taguchi and Desirability Function Analysis (DFA). They also used v, f and d as input parameters [5]. Has additionally investigated on surface roughness in turning unidirectional GFRP composite using cermet device with the aid of using response floor method (RSM) and artificial neural network (ANN) with v, f, and d as machining parameters. In this work a smooth computing primarily based fuzzy good judgment modeling of more than one overall performance characteristics and simultaneous optimization of responses to gain top-quality manner parameters are acquired.

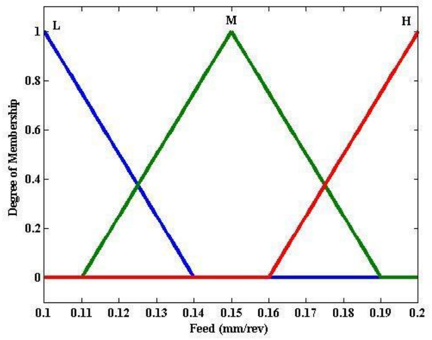
2. Fuzzy logic modelling

Fuzzy logic is one of the tender computing based totally modeling techniques evolved from the concept of fuzzy set theory proposed by way of [6]. In which the machining variables/parameters are represented as linguistic phrases consisting of low feed, medium slicing velocity, excessive depth of reduce, and many others. With the club grade varies from zero to at least one. Researchers have found fuzzy modeling as one of the success method for improvement of fuzzy based intelligent device. In this painting, multi response predictive version is developed using fuzzy logic in turning GFRP composites the use of PCD tool. The fuzzy common sense modeling consists of fuzzification of variables, improvement of rule base and rule aggregation and prediction of responses by way of defuzzification. The fuzzification of variables is executed with the selection of membership characteristic. Among one-of-a-kind membership capabilities available the triangular club function is used due to its simplicity and computational performance. Fuzzified into 3 fuzzy sets as Low (L), medium (M) and High (H) as proven in the Fig 1.

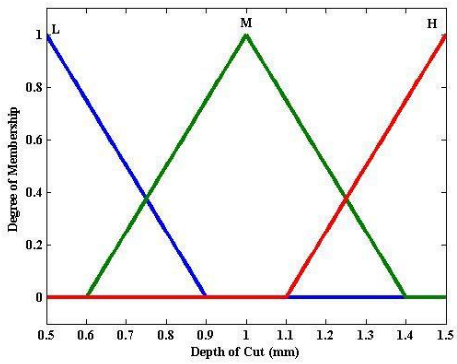


For precious prediction the output variables floor roughness (Ra), steel elimination charge (MRR) and tool wear (VB) are fuzzified into 8 fuzzy sets as Very Low (VVL), Very Low (VL), Low (L), Medium1 (M1), Medium2 (M2), High (H), Very High (VH) and Very High (VVH).

(a) Cutting speed (*v*).



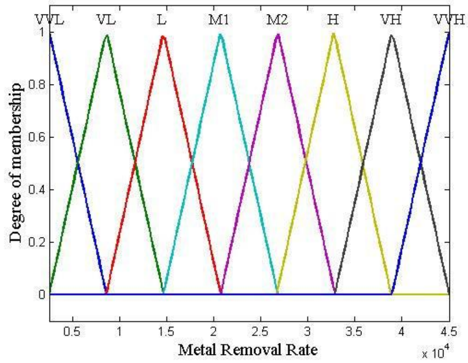
(b) Feed rate (*f*)



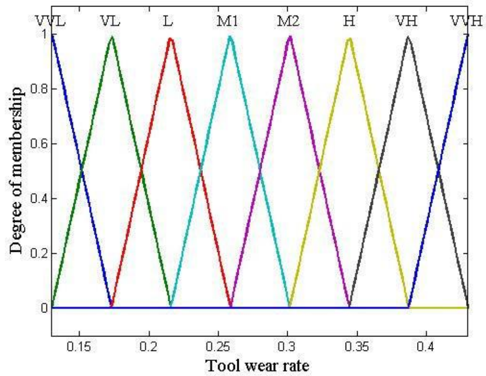
© Depth of cut (d)

Fig.1 Fuzzification of input Machining Parameter

(a) Surface roughness (*R*a)



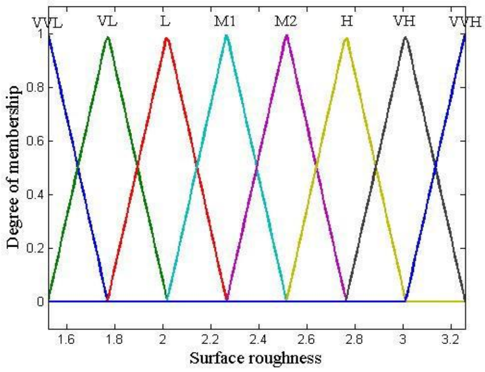
(b) Metal Removal Rate (*MRR*)



(c) Tool Wear (*VB)*

Fig.2 Fuzzification of output Machining Parameter

The fuzzy rule base consists of a collection of IF-THEN statements. In the prevailing work 3 enter variable and it is divided into 3 memberships characteristic it makes 27 fuzzy rules. The experimental values of responses had been used for forming the guideline base. The AND (min) operator became used to combine the antecedent parts of the regulations.



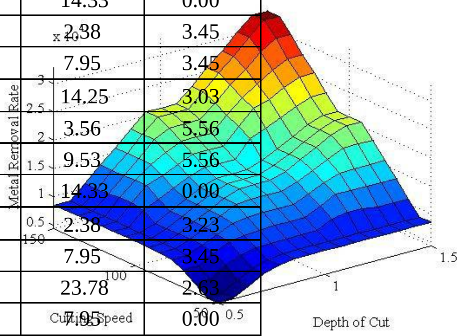
The implication technique min changed into used to correlate the rule consequent with its antecedent. The first rule of the FIS can be written as Rule 1: IF v is L and f is L and d is L THEN Ra is M2 THEN MRR is VVL THEN VB is L. In terms of real variables, the Rule 1 can be expressed as "IF reducing pace is Low and feed charge is Low and depth of cut is Low THEN floor roughness is Medium2 THEN MRR is Very Very Low THEN VB is Low. Similarly the whole 27 fuzzy rules are generated from output club characteristic.

Erro	*Experimental Value*			**FL Predicted**					
No.	***Ra***	***MRR***	***VB***	***Ra***	***MRR***	***VB***	*Ra*	*MRR*	*VB*
1	2.54	2500	0.21	2.51	4387	0.22	1.18	75.48	4.76
2	2.36	5000	0.17	2.27	4387	0.17	3.81	12.26	0.00
3	2.29	7500	0.13	2.27	8575	0.14	0.87	14.33	7.69
4	3.02	3750	0.25	3.01	4387	0.26	0.33	16.99	4.00
5	2.86	7500	0.24	2.76	8575	0.26	3.50	14.33	8.33
6	2.56	11250	0.22	2.51	8575	0.22	1.95	23.78	0.00
7	3.26	5000	0.28	3.18	4387	0.26	2.45	12.26	7.14
8	3.11	10000	0.30	3.01	8575	0.30	3.22	14.25	0.00
9	2.76	15000	0.31	2.76	14643	0.30	0.00	2.38	3.23
10	2.18	5000	0.27	2.27	4387	0.26	4.13	12.26	3.70
11	2.05	10000	0.22	2.02	8575	0.22	1.46	14.25	0.00
12	1.92	15000	0.18	2.02	14643	0.17	5.21	2.38	5.56
13	2.73	7500	0.30	2.76	8575	0.30	1.10	14.33	0.00
14	2.34	15000	0.29	2.27	14643	0.30	2.99	2.38	3.45
15	2.19	22500	0.29	2.27	20711	0.30	3.65	7.95	3.45
16	3.12	10000	0.33	3.01	8575	0.34	3.53	14.25	3.03
17	2.88	20000	0.36	2.76	20711	0.34	4.17	3.56	5.56
18	2.47	30000	0.36	2.51	32858	0.34	1.62	9.53	5.56
19	1.76	7500	0.34	1.77	8575	0.34	0.57	14.33	0.00
20	1.62	15000	0.31	1.60	14643	0.30	1.23	2.38	3.23
21	1.52	22500	0.29	1.60	20711	0.30	5.26	7.95	3.45
22	2.34	11250	0.38	2.27	8575	0.39	2.99	23.78	2.63
23	2.11	22500	0.39	2.02	20711	0.39	4.27	7.95	0.00
24	1.86	33750	0.36	1.77	32858	0.34	4.84	2.64	5.56
25	3.11	15000	0.42	3.01	14643	0.42	3.22	2.38	0.00
26	2.57	30000	0.39	2.51	32858	0.39	2.33	9.53	0.00
27	2.18	45000	0.43	2.27	43114	0.42	4.13	4.19	2.33

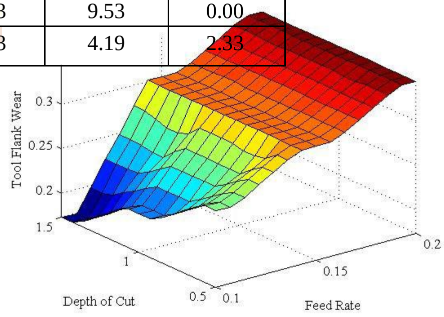
3. Surface Model Variations

The variables that are greater influencing on responses are proven with the assist of manner interactions floor plot. The plot is used to validate the fuzzy rules and the club functions on figuring out the effect of the input variables at the responses. Fig 3 (a) shows the variant of floor roughness (Ra) with cutting pace and feed rate. As slicing velocity growing Ra decreases and feed price increases the surface roughness detoriates as a consequence increasing Ra fee. This is due to speedy tool movement produces bad surface end. For minimal Ra cost the choice of high cutting speed and occasional feed rate is desired. Fig 3 (b) indicates the variation of steel elimination fee with reducing speed and intensity of cut. The enter parameters are without delay proportional with MRR. Higher MRR is acquired at high reducing speed and excessive intensity of cut. Fig 3 (c) shows the have an impact on of device wear (VB) on depth of reduce and feed price. It is apparent from the surface plot that for minimum tool put on the feed has to be low and intensity of cut need to be at excessive.

(a) Surface roughness (*R*a)



(b) Metal removal rate (*MRR*)



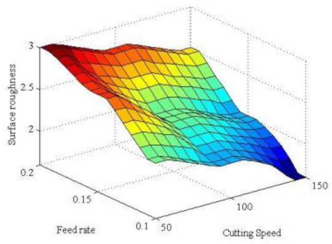


Fig. 3 Surface model variations of machining responses

4. Conclusion

Fuzzy logic modelling and DFA optimization of turning GFRP composite the usage of PCD device has been executed on this work. Multiple performance traits viz., fabric elimination fee, surface roughness and tool wear have been modeled and most suitable parameters are obtained. Cutting speed, feed and intensity of reduce was considered as manner parameters. Taguchi's L_{27} orthogonal array turned into hired to optimize the responses. The following conclusions had been drawn from this observe.

- The fuzzy common sense version determined greater correct inside the prediction of floor roughness and device put on with 2.74 % and 3.06 % average errors.
- Desirability useful evaluation determined very compatible to cope with multi-reaction optimization to acquire the surest slicing conditions.
- The most excellent reducing parameter combination for composite desirability said as v2–f1–d3 which corresponds to cutting velocity of a hundred m/min, feed charge of 0.10 mm/rev and intensity of cut of 1.5mm.
- The maximum influencing parameter on composite desirability discovered to be depth of cut with 39.38 % contribution. The precent contribution of reducing pace and feed fee suggested 14.11 and 21.76 respectively.
- The confirmation take a look at confirmed higher parameter mixture for floor roughness with 7.04 % blunders accompanied by means of 14.29 % mistakes for MRR and 17.61 % for VB respectively.

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