Modelling and Optimization of Process Parameters in AFM Using Taguchi and Fuzzy Logic

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Abstract— In metal cutting, completing activities speak to a basic and costly period of the general creation process. The completing costs accounts roughly 15% of the all-out machining costs [1]. Another procedure called "Abrasive Flow Machining (AFM) guarantees to give the exactness, productivity, economy, repeatability and probability of viable computerization expected to the assembling business. In the present work, the impact of various procedure parameters for example number of cycles, size of rough and Pressure on surface completion has been considered. For this reason, grating stream machining set-up is created and manufactured. The vital component of AFM setup is water powered tank, rough barrel, media chamber, pressure driven chamber and work piece installation. These parts are planned in solid works programming. Metal is utilized as a work piece material in the empty barrel shaped shape. Analyses have been performed on metal empty barrel as a working material. Surface unpleasantness is estimated when machining with the assistance of surface harshness analyser marsurf PS1. The critical info parameters for this trial examination is grating size, number of cycles and Pressure though surface harshness (ΔRa) considered as reaction parameters.

Keywords: Grating stream machine, MINITAB, Taguchi Technique, ANOVA, Surface Unpleasantness, Tangle LAB, Fuzzy Rationale Framework

I. Introduction

Abrasive flow machining (AFM) is a non-conventional machining process which is produced as a strategy for surface completing, edge forming, deburring and surface completing. It can conquer territories that are not actually reachable by conventional strategies for blending grating polymers with specific rheological completing properties. AFM produces unsurprising, predictable rehashes, garbs and many completing activities. Typically, media properties in the rough stream handling process assume an essential job. It's not sticky. You ought to likewise have viscoelastic properties. Aluminum oxide, boron carbide, silicon carbide and carbine jewel are commonly utilized as grating grains in this procedure [3]

During the time spent machining the stream of rough, the grid-based polymer of viscoelastic material that is blended with grating particles and added substances that are alluded to as a medium, forward expelled and in reverse into two vertically restricted chambers. While it is expelled through the entry framed by the workpiece to be machined, this implies endeavours to specifically end the workpiece surface. The device has a vital job in this procedure. So the device or settling configuration ought to be finished with consideration. Components influencing this procedure are pressure, No. of cycles, starting harshness and consistency. At the point when appropriate power is connected the medium with visco-versatile properties moves toward that path with hub speed and applies hub compel. Spiral power because of pressure is in charge of space and pivotal for furrowing.

II. Literature review

1) RHODES et al. In this study, In Abrasive Flow Machining process profundity of cut by rough particles relies on the relative hardness, estimate, expulsion pressure and grating molecule lucidity. He expressed that normal viscosity assumes a vital job in the completing activity.
2) William and Rajurker et al. utilized a full factorial illustration for the exploration and determined the impact of normal viscosity and expulsion pressure on material evacuation and surface wrapping up. Metal expulsion results demonstrate that the primary impact of thickness is critical, while the fundamental impact of pressure isn't as vital.
3) Rahul kumar et al Taguchi technique is connected to discover ideal procedure parameter for Grating Stream Machining (AFM). Examination of machinability for various procedure parameters influencing the procedure are depicted and the impact of the key parameters on the execution of procedure has been considered. Trials were completed on the empty round and hollow work piece. Analyses were led by the test conditions determined by the L9 Orthogonal exhibit. Each test was rehashed multiple times in every one of the preliminary conditions. Along these lines, 27 workpieces were chosen having starting surface in short proximity of (3.5- 5.8micron). In every one of the preliminary conditions and for each replication, material evacuation was estimated.
4) Mahesh Todkar, Jyoti Patkure present the fuzzy rationale standard related to the hereditary calculation to get the best advance mix of grating water Jet machining process parameters for the ideal profundity of cut on dark rock. Based on test information, the parameters (Waterjet pressure, navigate rate, grating stream separated into five rate) classes with the triangular participation work and the yield parameter arranged into 11 classifications. There are 125 distinct tenets are utilized to defuzzification of model and determined mistake accomplish 10%.

III. Objective

Creation of the AFM setup, consider the parameter by leading test and parametric advancement Fuzzy rationale has been done on my exploration work. Procedure parameters for the investigation are Expulsion Pressure, size of abrasives and Number of Cycle. In this Machining procedure empty tubeshaped Metal utilized as a work piece. Following are the principle goals of the present work:

1) Fabrication of AFM set up to lead analyze for completing the inside round and hollow surface
2) Experiment were led utilizing L9 orthogonal exhibit dependent on Taguchi Technique utilizing Minitab17.
3) Parametric examination of compelling parameter which are pressure, number of cycle and size of grating by taguchi strategy.
4) Study the impact of surface Harshness (ΔRa) with pressure, number of cycle and size of grating.
5) The arrangement of investigation acquired by L9 taguchi strategy is additionally used to recreate by fuzzy rationale master framework.
6) Result approval is finished by Fuzzy Rationale Framework in AFM and look at the trial results and Fuzzy outcomes to discover the anticipated error.

IV. METHODOLOGY

A. Experimental Set Up-

Abrasive flow machine comprises a few sections. These parts are required to comprise some detail as per set up necessity. These parts are chosen to a few criteria simply like their shape, size and limit. These parts are associating through appropriate interfacing gadgets as per their ability. Prior to determination of parts, there are numerous parameters to chose, for example, their weight, size and material. Configuration is choosing to the point that AFM set up can withstand high powers or pressure prompted all the while. Material is chosen by extreme quality required. Nut and screw are of required trademark, for example, their length, width and of appropriate material.

B. Components of AFM-

1) Media cylinder
2) Controls which include hydraulic drive
3) Pistons
4) Pressure Gauge Meter
5) Housing and frame

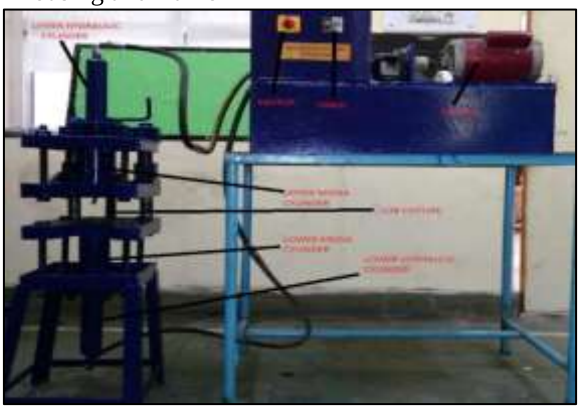
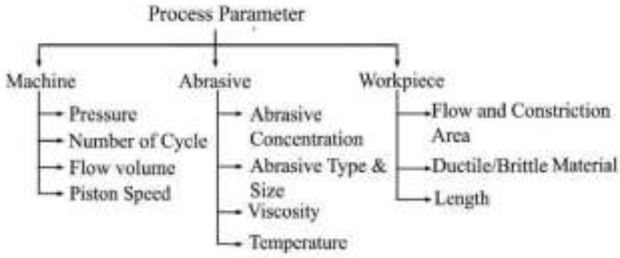


Fig. 1: Schematics arrangement of AFM setup

C. Parameter Selection



Flow chart 1: Process Parameters of AFM

D. Parametric Analysis by Taguchi Method

Experiment is conducted on the brass work piece. In this thesis Minitab16 software is used for the parametric optimization. It consists of L9 orthogonal array based on Taguchi design which reduces the number of experiments. It gives the total 9 set of experiment for the analysis of Ra. The important parameters are Pressure, number of cycles and Size of abrasives to study performance of machining process. Table 1 shows the levels of the process parameters i.e., pressure, NOC and SOA. These parameters consider three level.

PARAMETERS LEVELS AND ITS UNITS

S. No.	Process Parameters	Units	Levels		
1.	Pressure	Kgf/cm^2	10	25	40
2.	No. of cycles		100	300	500
3.	SOA (mesh size)	Microns	80	120	220

Table 1

Table 2 shows the input parameters i.e. Pressure, No. Of Cycle and Size of abrasive. Surface Roughness is used as the response. The taguchi L9 orthogonal is used to design 9 set of experiment.

OBSERVATION TABLE FOR ΔRa

	Input parameters			Response
EXP NO	Pressure	NOC	SOA	ΔRa
1	10	100	80	0.38
2	10	300	120	0.55
3	10	500	220	0.58
4	25	100	120	0.65
5	25	300	220	0.71
6	25	500	80	0.7
7	40	100	220	0.98
8	40	300	80	0.8
9	40	500	120	0.8

Table 2

Fig. 2: Brass Workpiece

Fig. 3: Mar Surf PS1 Surface Roughness Tester

E. Implementation of Fuzzy Logic System

The fuzzy logic principle is used to make the best prediction for Surface Roughness. Based on experimental data, the range of input parameters divided into three categories with the triangular membership function and its output is divided into four categories parameters. There are 9 different rules which are used to defuzzify a pattern. It is built basically in following steps-

1) STEP 1: Explain variables and terms

The experiment was conducted on internal surface Brass hollow cylinder having a diameter 6mm. In this study, the effect of three process parameters i.e. Pressure, Number of Cycles and Size of Abrasive was studied on response that is Surface Roughness.

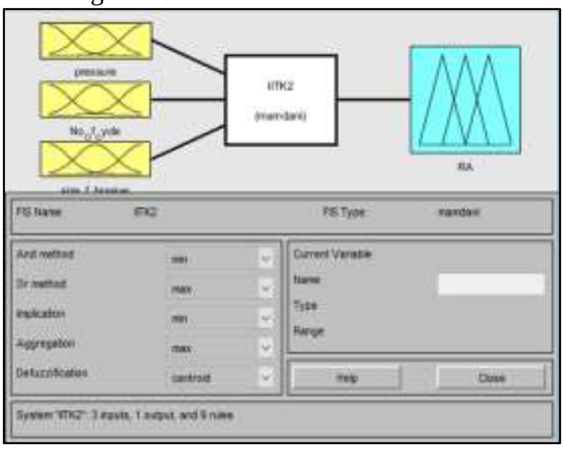
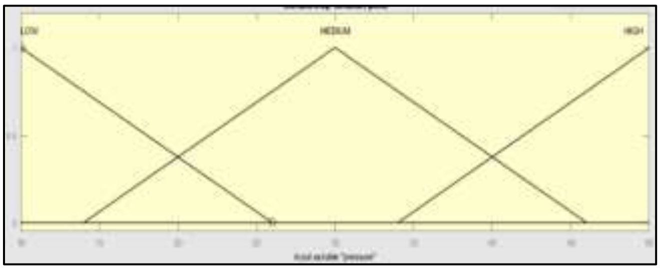


Fig. 4: FIS Editor

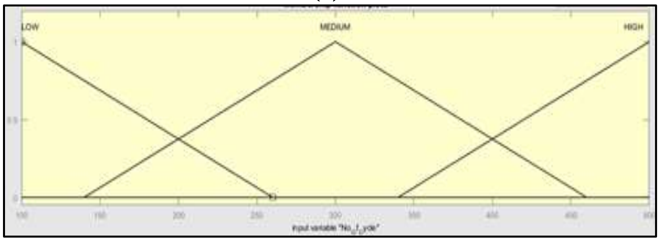
2) STEP 2: Design Membership Functions For Variables

a) Inputs for the fuzzy logic

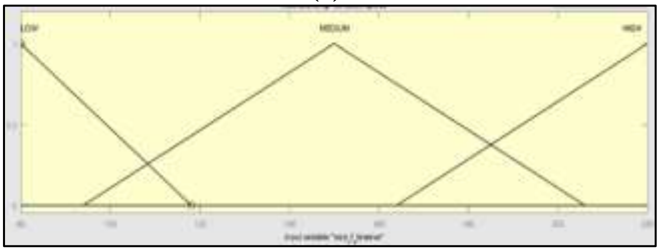
1) Pressure
2) Number of cycle (NOC)
3) Size of abrasive (SOA)



(a)



(b)



(c)

Fig. 5: Membership Function Editor For (a)Pressure, (b)NOC and (c)SOA

b) Output for fuzzy controller

The surface roughness (Ra) is considered as performance parameters for the present case study.it is necessary to categorize response by employing a suitable membership function to obtain a good result. For the reasons given in Figure 7.3, the triangular (trimf) and trapezoidal (trapmf) functions are used.

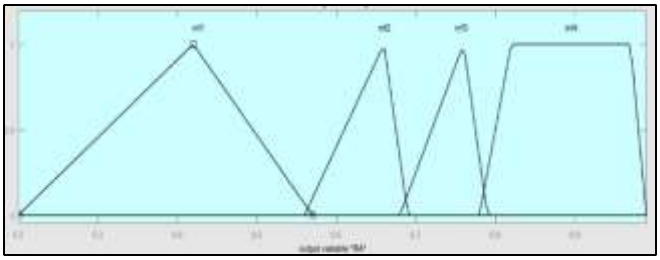


Fig. 6: Membership Functions Editor For ΔRa

3) STEP3: Construct knowledge base rules

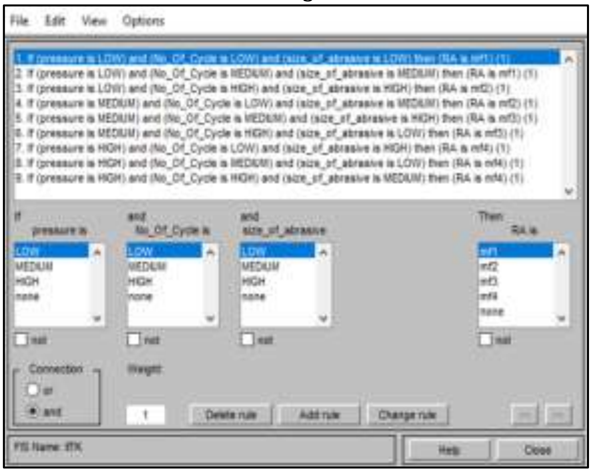


Fig. 7: Rule Editor

4) STEP 4: Obtain Fuzzy Value

Fuzzy set operations conduct rule evaluation. The OR and AND operations are Maximum and Minimum, respectively. Combine all findings to shape a final result. This result is a fuzzy attribute. Fig. 7.5 shows the surface viewer graphs between input parameters i.e. (a) the variation in pressure and number of cycle (b) the variation in pressure and size of abrasive and (c) variation in number of cycle and size of abrasive.

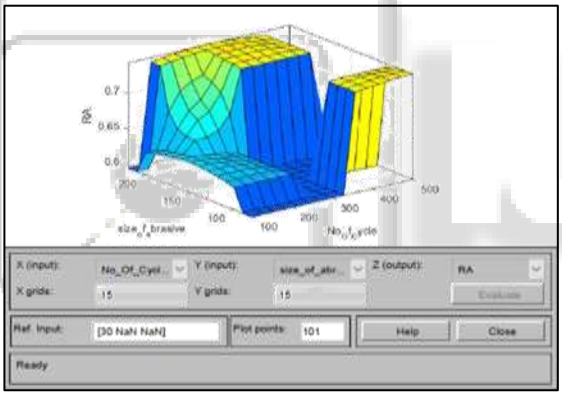


Fig. 8: Surface Viewer Dialogue Box for Input Parameters

Table 3

OBSERVATION TABLE FOR FUZZY RESPONSE

	Input parameters			Fuzzy Response
EXP NO	Pressure	NOC	SOA	ΔRa
1	10	100	80	0.397
2	10	300	120	0.392
3	10	500	220	0637
4	25	100	120	0.632
5	25	300	220	0.742
6	25	500	80	0.742
7	40	100	220	0.887
8	40	300	80	0.887
9	40	500	120	0.887

V. Result

Parametric optimization of the process parameter by conducting experiments on AFM setup is done. Taguchi method is used for the data analysis and optimization. The Surface Roughness (ΔRa) are considered as a response for where Pressure, No. Of Cycle and Size of abrasives are effective parameters Experiment were conducted with 10 mm internal diameter and 6cm length hollow brass cylinder as work material.

RESPONSE TABLE FOR S/N RATIO OF ΔRa

Levels	Pressure	NOC	SOA
1	-6.110	-4.107	-4.480
2	-3.272	-3.369	-3.624
3	-1.351	-3.259	-2.627
Delta	4.759	0.851	1.853
Rank	**1**	**3**	**2**

Table 4

A. Effects of Pressure on ΔRa

ΔRa is increased with increasing pressure proportionally. When the medium is suddenly forced into restrictive passage it slightly raises its viscosity. Significant removal of material is observed through thickening of the medium. During AFM the amount of abrasion depends on the tool design and the strain. Therefore, the strain affects the number of particles interacting with the piece of work and the force acting on individual abrasive material.

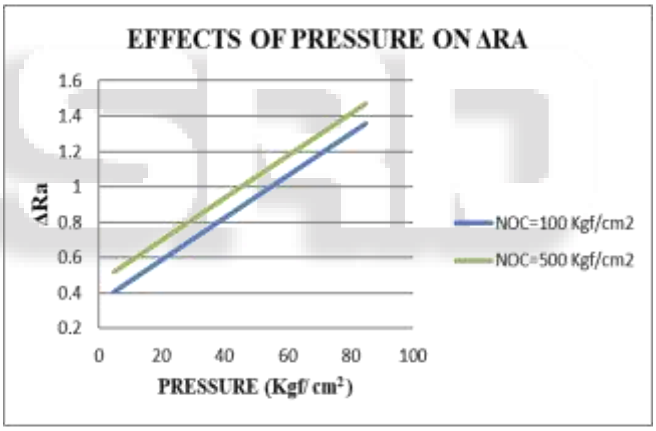


Fig. 9: Effects plot for Pressure on ΔRa

B. Effects of NOC on ΔRa

ΔRa is increased with increasing number of cycle (NOC) proportionally, by keeping mean value of variables (Pressure, Mesh number) as constant. It is seen from the above plot that as the number of cycles is increased the value of ΔRa is also increased up to 400 cycles. After 400 cycles curve tend to move towards horizontal line. It means that after 400 cycles change in ΔRa is decreased. This is because up to 400 cycles abrasive grain are new and after 400 cycles edges of abrasive grain are destroyed and their roughness removal capability is also destroyed.

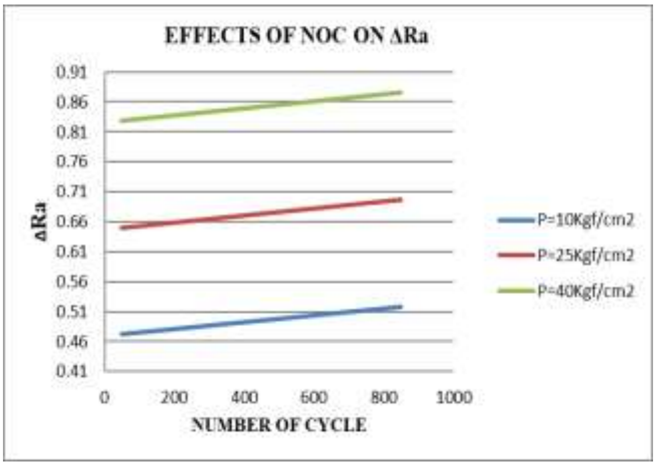


Fig. 10: Effects plot for NOC on ΔRa

C. *Effects of SOA on ΔRa*

ΔRa is increased with increasing Size of abrasive (SOA) proportionally, by keeping mean value of pressure and number of cycles as constant. It is found that with increase in the mesh number ΔRa value is also increasing initially. But after certain mesh size or say mesh number of near 180 ΔRa value tend to decrease slowly.

Fig. 11: Effects plot for SOA on ΔRa

Validation of Fuzzy Logic Results with Experimental Results

$$Prediction\ Error = \frac{Fuzzy\ Logic\ Pridicted\ Result - Experimental\ Result}{Fuzzy\ Logic\ Pridicted\ Result} \times 100$$

Validation of the expected results from Fuzzy Logic is required to know the variation from the actual results of the experiment. The differences in outcomes is calculated by the percentage of the results of predictions.

OBSERVATION TABLE FOR PREDICTION ERROR

	Input parameters			Taguchi Results	Fuzzy results	
EXP NO	Pressure	NOC	SOA	ΔRa	ΔRa	%ERROR
1	10	100	80	0.38	0.397	4.2
2	10	300	120	0.55	0.392	4.3
3	10	500	220	0.58	0637	8
4	25	100	120	0.65	0.632	2
5	25	300	220	0.71	0.742	4
6	25	500	80	0.7	0.742	5
7	40	100	220	0.98	0.887	10
8	40	300	80	0.8	0.887	9
9	40	500	120	0.8	0.887	9

Table 5

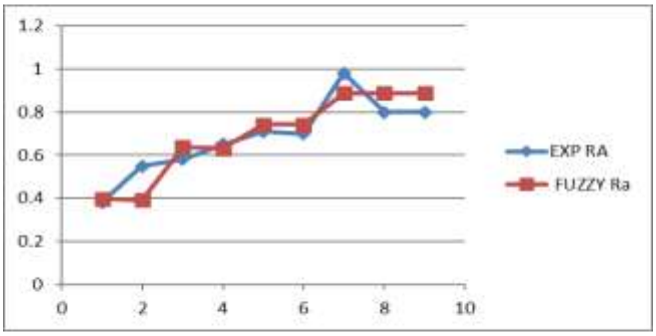


Fig. 11: Graph between Experimental and Fuzzy Results

Hence predicted results are almost to experimental results.

VI. CONCLUSION

Based on exploratory investigation and information examination following end can be assembled.

1) It is seen from the parametric examination by Taguchi strategy that Pressure, Number of cycle and Size of grating are the most huge procedure variable which influences the Surface unpleasantness (ΔRa).
2) Regression examination is done Taguchi Orthogonal exhibits (OA) strategy. Most extreme surface harshness (ΔRa) 0.98 is acquired at a Pressure of 40 Kgf/cm2, NOC 100 and SOA 220 by Taguchi L9.
3) FLS is actualized for reaction forecast and it is seen that there is no critical mistake between an anticipated outcome acquired by FLS and test information. The scope of got is 5 to 10%.
4) The fuzzy rationale framework are structured in MATLAB16 which is very reasonable for reactions forecast and gives preferable outcomes over in traditional strategy.
5) A relative investigation have been done between result acquired by FLS. It is seen from the outcome that general anticipated blunder is 7%.

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