RESEARCH ARTICLE OPEN ACCESS

Effect of Material Removal Rate in Micro-Drilling Process For A Copper Plate

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Abstract:

Drilling is one of the fundamental machining process. For getting holes below 1mm Micro Drilling process which is high precision process are preferred. It is used for the purpose increasing quality of special parts and items. Along with high precision it is also preferred for high spindle speed application to improve productivity and quality. It has an attractive applications like Printed circuit boards, Fuel injection nozzles, Watch parts, Camera parts, Medical needles, Aeronautics, Mobile phones, Computer set. One of the major goal in machining operation is material Removal Rate. This paper deals with how the MRR can be optimized considering the input parameters like, speed, feed and depth of hole and Optimization had done by Designing Experiment in Taguchi, Fuzzy logic and Analyzing using ANNOVA and signal to noise ratio. Fuzzy logic for improving material removal rate in Micro drilling.

***Keywords*-Micro-drilling, Cutting tool, Material removal rate, Taguchi, Fuzzy logic ANNOVA.**

1. INTRODUCTION

In current scenario micro drillings have a great influence for manufacturing to apply special parts and items. The micro drill tools play a critical role is increasing the productivity of a cutting process. The price of a micro-drill cutting tool itself is relatively low, the costs caused by tool failures are considerably higher[1]. Micro drilling is characterized not just by small drills but also a method for precise rotation of the micro drill and a special drilling cycle[7]. In addition, the walls of a micro drilled hole are among the smoothest surfaces produced by conventional processes. Taguchi method is a well-known experiment design method applied in many industries to optimize quality characteristics through the setting of design parameters with orthogonal array, followed by Analysis of variance to find influence and Significant factors on MRR.[2]

Many researchers had worked on Micro-drilling for analyzing behavior of drill tool , torques, thrust forces, stresses etc. also optimization works are carried out but the drill diameters considered were from 0.6mm to 1mm. while below that the process had carried out on Non-conventional machining processes[21]. But this research had done the investigations on two size drill i.e. 0.3mm and 0.5mm drill diameters. Here the conventional tool was used but machine used was CNC Micro-drilling with high spindle speed for a work piece material Copper.

2. METHODOLOGY

Methodology consists of Taguchi and Fuzzy logic method. Taguchi method is a robust design method technique, which provides a simple way to design an efficient and effective experiment. In order to efficiently reduce the conventional experimental tasks, the orthogonal array by using design parameters

are proposed and adopted. The performance measure, signal-to-noise ratio(S/N) used to obtain the optimal parameter combinations.[3] In the Taguchi method, a loss function is defined to calculate the deviation between the experimental value and the desired value. Usually, there are three categories of the performance characteristics in the analysis of the signal-to- noise ratio, i.e., the lower the-better, the higher the- better, and the nominal-the better as given below,

S/N=-10 (log sum y2/n) lower the better. (1)

S/N=-10 (log sum (1/ y2)/n) higher the better. (2)

S/N=-10 (log sum s2) nominal the better. (3)

To obtain optimal machining performance, the MRR should be more than medium and less than higher so nominal the better is desired optimum value. Therefore, nominal-the better MRR was selected. This method, the S/N ratio is used to determine the deviation of the performance characteristic from the desired value. [4] Orthogonal array is a systematic statistical way of software testing It is used when the number of inputs to the system is relatively small, but too large to allow for exhaustive testing of every possible input to the systems.. Orthogonal arrays formed for three levels for two different drill diameters i.e. 0.3mm and 0.5mm.Which is given in table no.1 Design of Experiment was done in most powerful tool i.e. MINITAB 17.[20]

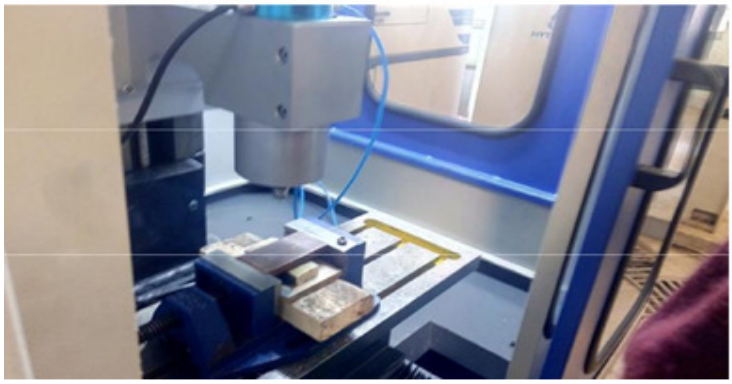

Figure 1 CNC Micro-drilling Machine

After designing the experiment, actual experiment was carried out on CNC Micro drilling machine (fig no.1) before that Machining time was calculated for each experiment and each experiment was conducted three times , that means three readings of Material removal Rate was measured. Machining time and MRR were calculated as follows,

MT= DOH (1)

Speed x Feed

MRR= Initial weight- Final weight

Density x machining time

The values of both were recorded in the table given below.

Table 1

Parameters	Level 1	Level2	Level3
Speed(RPM)	12000	18000	24000
Feed(mm/rev)	0.0003	0.0004	0.0005
Depth of hole(mm)	2	2.5	3

Table 2

Drill dia	Speed	Feed	DOH	MT	MRR1	MRR2	MRR3
0.3	12000	0.0005	2	0.333333	0.4239	0.41955	0.424
	12000	0.0007	2.5	0.297619	0.59346	0.6112	0.59757
	12000	0.0009	3	0.277778	0.76302	0.76225	0.76411
	18000	0.0005	2.5	0.277778	0.63585	0.63605	0.63595
	18000	0.0007	3	0.238095	0.89019	0.89105	0.8895
	18000	0.0009	2	0.123457	1.14453	1.14355	1.1456
	24000	0.0005	3	0.25	0.8478	0.85122	0.84866
	24000	0.0007	2	0.119048	1.18692	1.192	1.1955
	24000	0.0009	2.5	0.115741	1.52604	1.53722	1.52566
0.5	12000	0.0005	2	0.333333	1.1775	1.19	1.1167
	12000	0.0007	2.5	0.297619	1.6485	1.69	1.625
	12000	0.0009	3	0.277778	2.1195	2.136	2.145
	18000	0.0005	2.5	0.277778	1.76625	1.783	1.754
	18000	0.0007	3	0.238095	2.47275	2.51	2.524
	18000	0.0009	2	0.123457	3.17925	3.18	3.1654
	24000	0.0005	3	0.25	2.355	2.42	2.376
	24000	0.0007	2	0.119048	3.297	3.365	3.37
	24000	0.0009	2.5	0.115741	4.239	4.24	4.235

After that Signal to noise ratios for Machining time and Material Removal Rate was taken as input variables in fuzzy logic tool box in MATLAB 2015 and OPI i.e. Optimal performance index as output variable, different membership functions were defined and fuzzy rules were developed and centroid for respective combination of input variables were obtained as shown in figure 2.

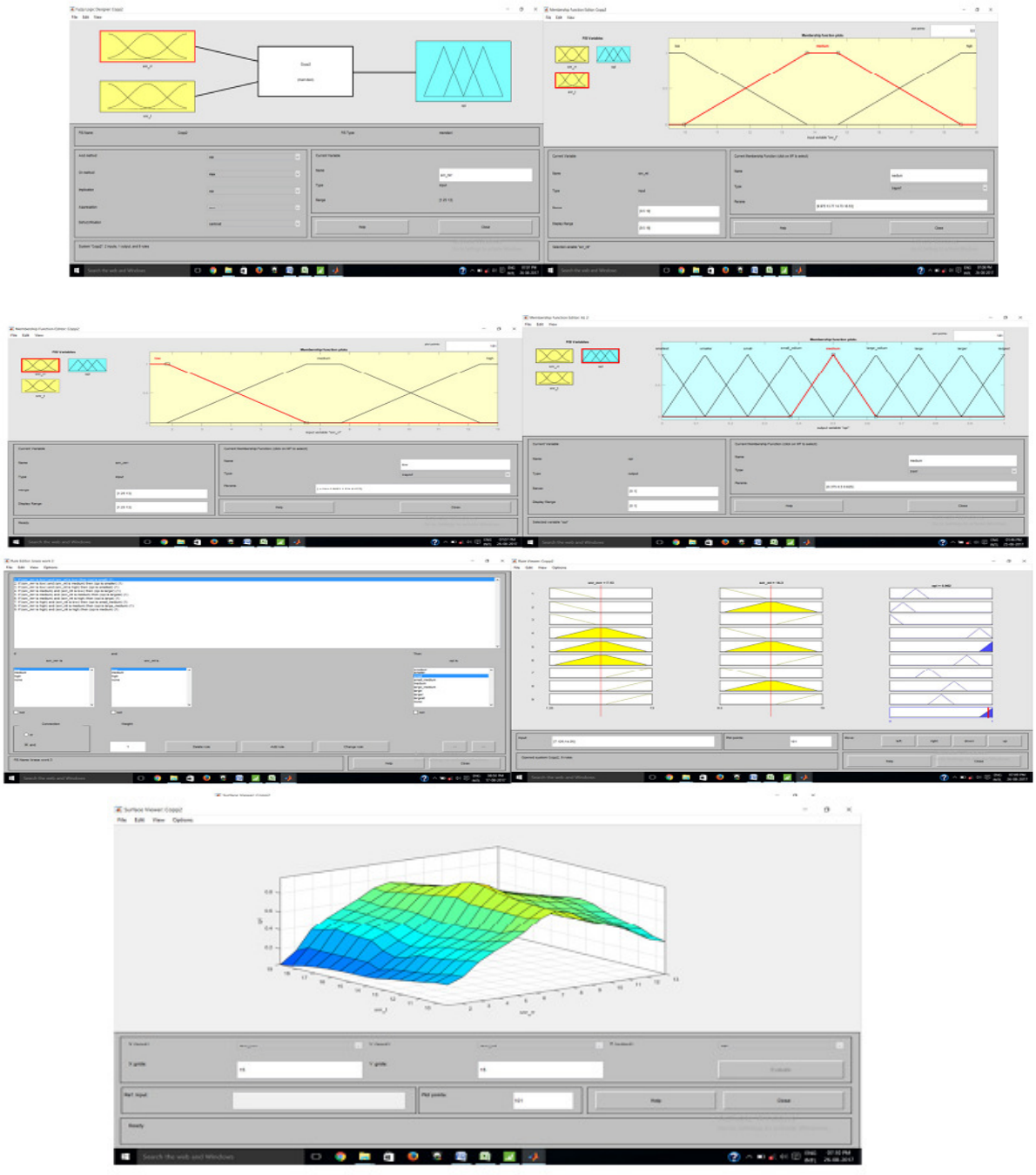

Figure 2

Table 3

Drill dia	SNRA1	SNRA2	OPI
0.3	9.542425	-7.45473	0.25
	10.52679	-4.53217	0.25
	11.12605	-2.34928	0.25
	11.12605	-3.93291	0.25
	12.46499	-1.01035	0.426
	18.1697	1.172544	0.766
	12.0412	-1.43413	0.337
	18.48559	1.488429	0.702
	18.73027	3.671318	0.5
0.5	9.542425	1.419218	0.25
	10.52679	4.341779	0.577
	11.12605	6.524668	0.882
	11.12605	4.941043	0.554
	12.46499	7.863604	0.8
	18.1697	10.04649	0.635
	12.0412	7.439818	0.896
	18.48559	10.36238	0.605
	18.73027	12.54527	0.5

3. ANALYSIS

After performing experimentation task , analysis of Signal to Noise Ratios for experimental values and Mean for OPI obtaine by Fuzzy logic method was done for both drill diameter , where optimization was done for nominal-the-better given in table no4,5,7 and table no,8 for diameter 0.3mm and 0.5mm respectively. After that Analysis of variance(ANNOVA) technique was carried out from which maximum influencing factor and significant factors were sort out[15]. It is quite clear from table no 6 and 9 that influence of Speed from F value is more on MRR and also more significant as P value is low and below 0.5. Accordingly the surface plot shown from fig no.3 to 5 and fig 7 to 9.[15].

Analysis for Signal to noise ratio for Drill diameter 0.3mm

Response Table for Signal to Noise Ratios

Nominal is best (-10×Log10(s^2))

CONFIRMATION TEST

The confirmation test was carried out for all combinations of Machining parameters for Taguchi and Fuzzy logic.After conducting experiment for concern values ,we get the MRR as 0.76 and 0.89 mm3/min for drill diameter 0.3mm and 2.35 and 2.47 mm3/min for drill diameter 0.5mm

CONCLUSION

This type of optimization is a difficult method .As this work not only optimization using orthogonal array, but will also be used for improving material removal rate in Micro drilling, where drilling is very risky because of chances of breaking tool. Therefore instead of considering to optimize for maximum MRR , form tool life point of view the method in Taguchi was selected Nominal–the-better. Also minimum or medium MRR is not considered which may decrease production rate. Many Researchers had gone optimization to maximize the output which was not feasible for Micro-drilling. Going for Non-conventional machining would feasible from production point of view but not from investment cost which more botheration for small scale industries.[15]The competition of small scale manufacturing industry will then be economically excited through this paper**.**

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