

# **Optimization of MRR using Fuzzy logic with TAGUCHI method for Micro- drilling**

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**ABSTRACT:** Micro- drilling is the precision hole drilling technology to use in anufacturing and workshop. It is one of the most fundamental machines technologies and it is moving high and Increasing productivity and quality. It is an important machining process having attractive applications like Printed circuit boards, Fuel injection nozzles, Watch parts, Camera parts, Medical needles, Aeronautics., Mobile phones, Computers etc Taguchi design of experiment and analysis of signal to noise ratio has been used to evaluate optimization of Material Removal Rate. This paper presents optimization of MRR depending upon various input parameters for like speed, feed and depth of hole and tool material. Based on the Taguchi design of experiments (DOE) with orthogonal array, and then followed by optimization of the Fuzzy parametric deduction to optimize MRR.

**KEYWORDS:** Micro-drilling, Cutting tool, Material removal rate, Fuzzy logic, Taguchi.

## **I. INTRODUCTION**

Micro drilling is one of the most fundamental machines technologies and it is moving high precision and high spindle speed application in manufacturing field and increasing productivity and quality. Now a day's micro drillings have a great use for manufacturing to apply special parts and items. Micro hole drilling is the precision hole drilling technology to use in manufacturing and work shop. The micro drill tools play a critical role is increasing the productivity of a cutting process. Although the price of a cutting tool itself is relatively low, the costs caused by tool failures are considerably higher. Therefore, from the viewpoint of cost and productivity, modeling and optimization of drilling processes are extremely important for the manufacturing industry. The poor removal of chips in deep drilling of small diameter is often the cause of tool breakage and poor quality surface. High speed machining technology, the smaller the tools, the higher the spindle speed you will need to efficiently machine quality parts and avoid tool breakage. High-frequency spindles with speed ranges.[3]

This is a conventional micro drilling processes in order to find the best quality of drilling for different types of work piece material (MS, Aluminum alloy & PCB) to using number of size of drill bit (0.5mm-0.1mm) were performed by different high spindle speed (10,000-20,000 rpm) and feed at three different levels. The results were analyzed using optimization of process parameters, MRR.[3]

Material removal rate is commonly considered as a major manufacturing goal in machining operations in many of the existing research. Taguchi method, an experiment design method, has been widely applied to many industries. It cannot only optimize quality characteristics through the setting of design parameters, but also reduce the sensitivity of the system performance to sources of variation.[19]

To achieve the deduction in optimization, it is necessary to first describe the dynamic behavior of the system to be controlled. Because of the number, complexity and unclear, vague nature of the variables of the dynamic systems that may influence the decision maker's decision, fuzzy set theory is the most suitable solution. Fuzzy linguistic models permit the translation of verbal expressions into numerical ones. Therefore, the input output relationship of the process

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can be described by the collection of fuzzy control rules involving linguistic variables rather than a complicated dynamic mathematical model.[14]

**II.CONSTRUCTION OF ORTHOGONALARRAYANDTAGUCHI METHOD**

It is testing is a black box testing technique which 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. It is particularly effective in finding errors associated with faulty logic within computersoftware systems. Orthogonal arrays can be applied in user interface testing, system testing, regression testing, configuration testing and performance testing. The net effect of organizing the experiment in such treatments is that the same piece of information is gathered in the minimum number of experiments. The Taguchi method is a robust design method technique, which will 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 will be proposed and adopted[15]. Using Minitab 17 for Taguchi Design of Experiment considering three input parameters , three level orthogonal array is constructed as given below intable no 1.Taguchi Orthogonal Array Design L9(3^3),Factors: 3,Runs: 9

Columns of L9(3^4) Array,1 2 3

Speed	Feed	DOH
10000	0.03	0.2
10000	0.04	0.4
10000	0.05	0.6
15000	0.03	0.4
15000	0.04	0.6
15000	0.05	0.2
20000	0.03	0.6
20000	0.04	0.2
20000	0.05	0.4

Table no. 1

**III.PERFORMANCE OF EXPERIMENT**

Using the combinations of input parameters form orthogonal array, experiment is carried out for Aluminum material and Material Removal Rate and Machining time are recorded for nine turns.

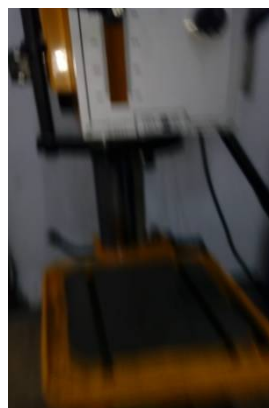


Fig.no.1

The performance measure, signal-to-noise ratio(S/N) can be used to obtain the optimal parameter combinations. In the Taguchi method, a loss function will be 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. To obtain optimal machining performance, the minimum Machining time and the maximum MRR are desired. Therefore, the lower-the-better MT and the higher-the-better MRR should be selected. This method, the S/N ratio is used to determine the deviation of the performance characteristic from the desired value. [5]. The S/N ratio is found by using Taguchi Analysis in Minitab 17[16]

Taguchi Analysis: MRR versus Speed, Feed, DOH  
Response Table for Signal to Noise Ratios  
Larger is better

Level	Speed	Feed	DOH
1	37.71	38.58	40.89
2	41.23	41.08	40.89
3	43.73	43.02	40.89
Delta	6.02	4.44	0.00
Rank	1	2	3

Table.no.2



Fig.no.3

Taguchi Analysis: MT versus Speed, Feed, DOH  
Response Table for Signal to Noise Ratios  
Smaller is better

Level	Speed	Feed	DOH
1	60.65	61.51	69.01
2	64.17	64.01	62.99
3	66.67	65.95	59.47
Delta	6.02	4.44	9.54
Rank	2	3	1

Table.no.3

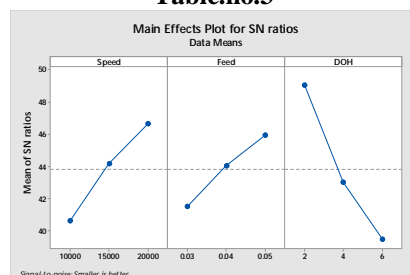


Fig.no.4

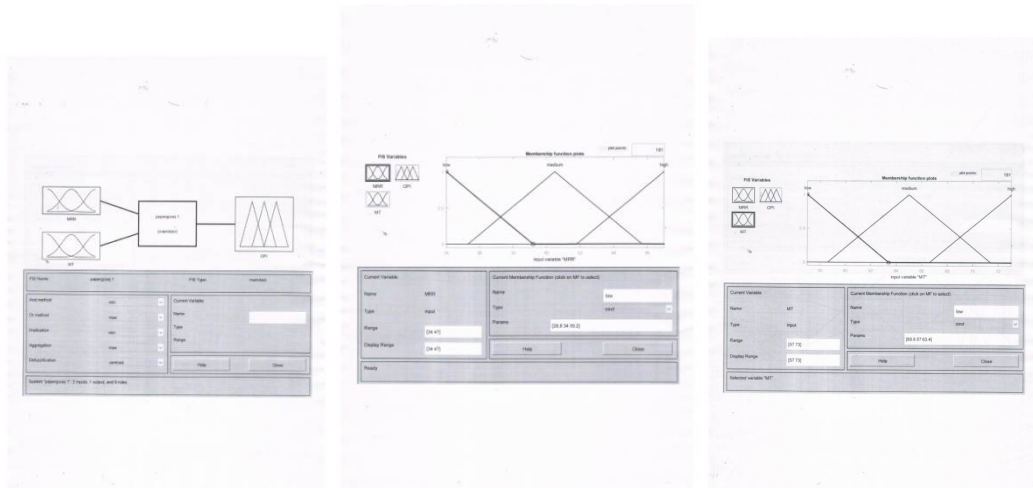
Speed	Feed	DOH	MRR	MT	SNRA1	SNRA2
10000	0.03	0.2	58.875	0.000667	35.39862	63.52183
10000	0.04	0.4	78.5	0.001	37.89739	60
10000	0.05	0.6	98.125	0.0012	39.83559	58.41638
15000	0.03	0.4	88.3125	0.000889	38.92044	61.02305
15000	0.04	0.6	117.75	0.001	41.41922	60
15000	0.05	0.2	147.1875	0.000267	43.35742	71.48063
20000	0.03	0.6	117.75	0.001	41.41922	60
20000	0.04	0.2	157	0.00025	43.91799	72.0412
20000	0.05	0.4	196.25	0.0004	45.85619	67.9588

Table.no.4

#### IV. FUZZY LOGIC

Fuzzy sets are sets whose elements have degrees of membership. Fuzzy sets were introduced by Lotfi A. Zadeh and Dieter Klaua in 1965 as an extension of the classical notion of set. At the same time, defined a more general kind of structures called *L*-relations, which were studied by him in an abstract algebraic context. Fuzzy relations, which are used now in different areas, such as linguistics decision-making (Kuzmin, 1982) and clustering, are special cases of *L*-relations when *L* is the unit interval [0, 1]. MATLAB is a convenient Software to perform fuzzy logic methodology. Considering Signal to noise ratios for MRR and MT within the intervals of 34 to 46 and 57 to 72 respectively as input variables and to get OPI i.e. Optimal performance Index form 0 to 1 intervals. It is carried out in following ways.[18]

- 1) Define the Input /Output variables.
- 2) Selecting the Member functions.
- 3) Developing fuzzy rules.
- 4) Defuzzification.
- 5) Finding OPI for respective input variables and recording in TAGUCHI Design.
- 6) Finding the mean .
- 7) Selecting the maximum OPI as optimum parameters.



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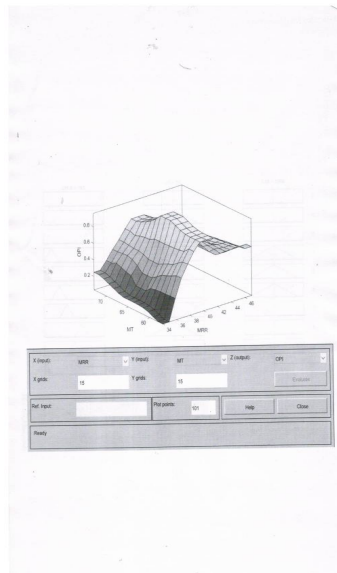
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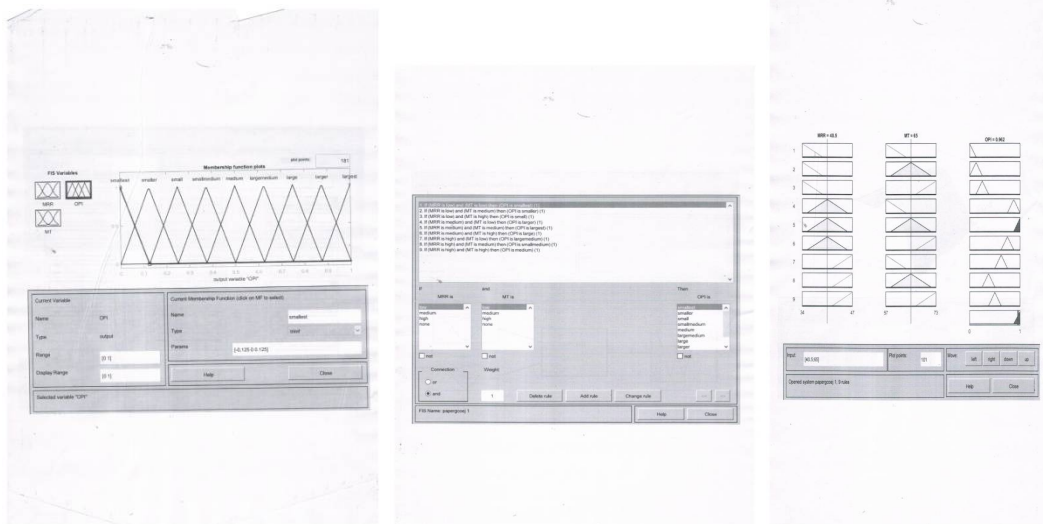
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**Fig.no-5**



**Fig.no.6**

**V.RESULTS**

By considering the parameter combinations of the nine sets of experiment based on the L9 orthogonal array, the quantified results from fuzzy deduction for the MRR are determined in the form Optimal Performance Index and shown as Table 5. Introducing the deduction results as the Mean for MRR under larger-the-best expectation, the results of factor responses are calculated and listed in Table 6. The mean effects for Means are then drawn by MINITAB 17 and shown as Fig. 7.

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Results of OPI are recorded and response table for analysis of mean is done in TAGUCHI Analysis  
Taguchi Analysis: OPI 1 versus Speed, Feed, DOH

SrNo.	OPI 1
1	0.142
2	0.6
3	0.875
4	0.812
5	0.88
6	0.644
7	0.88
8	0.613
9	0.525

**Table.no.5**

Response Table for Means

Level	Speed	Feed	DOH
1	0.5390	0.6113	0.4663
2	0.7787	0.6977	0.6457
3	0.6727	0.6813	0.8783
Delta	0.2397	0.0863	0.4120
Rank	2	3	1

**Table no.6**



**Fig.no-7**

It is found that level 2 for Speed ,level 2 for feed and level 3 for Depth of hole are optimum values which gives MRR as,

$$MRR = \pi D^2 \text{ DOH} / 4 \text{ MT} = 3.14 \times (0.5)^2 \times 6 / 4 \times 0.01 = 117.75 \text{ mm}^3/\text{min}$$

Parameters	Combinations	MRR
Fuzzy deducted	Speed-15000,Feed-0.03,DOH-0.6	117.75 mm <sup>3</sup> /min
Benchmark parameters	Speed-15000,Feed-0.03,DOH-0.4	117.16mm <sup>3</sup> /min

**Table. No.7**

## **VI.CONFIRMATION TEST**

The optimum result is achieved by our proposing deduction optimization technique, the machining operations under both fuzzy TAGUCHIOptimization parameters and benchmark parameters; Speed (medium), Feed (medium), DOH (medium), which are often introduced into the confirmation experiment in many of the studies for comparison to the optimum parameters, are performed on the CNC Micro-drilling. It is observed that the MRR under fuzzy deduction parameters meets the benchmark parameter which is slightly more than benchmark parameters.

## **VII.CONCLUSIONS**

In this study, the parametric deduction scheme was proposed parameters under the considerations of MRR. A confirmation experiment of the optimum deduction parameters was calculated to indicate the effectiveness of the proposed fuzzy TAGUCHIOptimization method. Through the confirmation test, the experimental results validate the potency that the MRR meets the benchmark parameters obtained from average value of parameters. This type optimization will suggest the manufacturers to go fuzzy logic analysis through TAGUCHI prior to manufacturing. This gives economically excitement to manufacturing industry through the proposed development in this study.

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