ANALYSIS AND OPTIMIZATION OF SURFACE ROUGHNESS IN CNC MILLING MACHINE USING GENETIC ALGORITHM

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ABSTRACT

Owing to the significant role that machining parameters play in performing successful and efficient machining operation, determining of the best or optimum machining parameters is still the subject of many studies. By optimization of various parameters of CNC milling process like spindle speed, feed rate and depth of cut, improvement can be achieved in surface finishing. Here Genetic Algorithm will implemented for better and nearest result. Number of experiments will done by using CNC milling machine. An L9 Taguchi standard orthogonal array (OA) will choose for design of experiments and the main influencing factor will determined for each given machining criteria by using Analysis of variance (ANOVA). The predicted values are confirmed by using validation experiments.

Keyword: - *Milling Machine, ANOVA, Genetic Algorithm, Surface roughness*

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1. INTRODUCTION

Milling is a cutting process that uses a milling cutter to remove material from the surface of a workpiece. The milling cutter is a rotary cutting tool, often with multiple cutting points. As opposed to drilling, where the tool is advanced along its rotation axis, the cutter in milling is usually moved perpendicular to its axis so that cutting occurs on the circumference of the cutter. As the milling cutter enters the workpiece, the cutting edges (flutes or teeth) of the tool repeatedly cut into and exit from the material, shaving off chips (swarf) from the workpiece with each pass. The cutting action is shear deformation; material is pushed off the workpiece in tiny clumps that hang together to a greater or lesser extent (depending on the material) to form chips. This makes metal cutting somewhat different (in its mechanics) from slicing softer materials with a blade2.

The milling process removes material by performing many separate, small cuts. This is accomplished by using a cutter with many teeth, spinning the cutter at high speed, or advancing the material through the cutter slowly; most often it is some combination of these three approaches. The speeds and feeds used are varied to suit a combination of variables. The speed at which the piece advances through the cutter is called feed rate, or just feed; it is most often measured in length of material per full revolution of the cutter.

Fig. 1.1 Milling Process

2. LITERATURE REVIEW

In this research work they have selected the material Aluminium alloy 6082 for optimization of machining parameters spindle speed, feed and depth of cut for minimum surface roughness in dry end milling operation. Taguchi method is used to optimize these parameters. According to L27 orthogonal array 27 experiments are performed. The experimental data is analysed in Minitab software and we get the following result. Factor Rank Speed 1 Feed 2 Depth of cut 3 Speed, feed and depth of cut have rank 1, 2 and 3 respectively. It means that the surface roughness is maximum affected by the speed followed by feed and depth of cut. The surface roughness decreases with increasing spindle speed and increases with increasing feed rate. The optimum values of machining parameter for minimum surface roughness in dry end milling operation are speed 1600 rpm, feed 100 mm per min. and depth of cut 1.0 mm.**[1]**

This had investigated the use of Taguchi technique and Genetic Algorithm (GA) for minimizing the surface roughness in machining mild steel with three zinc coated carbide tools inserted into a face miller of 25 mm diameter. The experimental study was carried out in a FANUC series CNC vertical machining center (VMC). The experiments have been planned using Taguchi's experimental design technique. The machining parameters used are Number of passes (P), Depth of cut (dc), Spindle speed (N), and Feed rate (f). The effect of machining parameters on surface roughness is evaluated and the optimum cutting condition for minimizing the surface roughness is determined. The predicted values are confirmed by using validation experiments **[2].**

They had investigated work on to check whether quality lies within desired tolerance level which can be accepted by the customers. So, optimizing surface roughness and metal removal rate using various CNC machining parameters including spindle speed (N), feed rate (f) and depth of cut (d) and insert nose radius (r). By developing a mathematical model in CNC milling on a hard steel specimen. And this mathematical model is developed with the help of the design of Matrix.. This experimental study aims at response surface methodology has been applied for finding the effect on surface roughness and metal removal rate by various process parameters. And after that we can easily find out that which parameter will be more affect.

In this study the optimal cutting condition for face milling was selected by varying adjustable cutting parameters. With the L9 orthogonal array, experimental runs and determining suitable optimal cutting parameters for surface finish. The surface finish achievement of the confirmation runs under the optimal cutting parameters indicated that of the parameter settings used. In this study, response surface methodology will apply to produce the best surface roughness in this milling operation. Also, RSM is an efficient and effective method for optimizing surface roughness in a milling. **[3].**

They had work of By optimization of various parameters of CNC milling process like spindle speed, feed rate and depth of cut, Improvement can be achieved in surface finishing. Various methods are used for predict surface roughness in CNC milling machine. Here Artificial Neural Network has been implemented for better and nearest result. By using this paper, mathematical model can be developed easily for milling process. Number of experiments have been done by using Hy-tech CNC milling machine. Conclusion from Taguchi method, Surface roughness is most influenced by Feed rate followed by spindle speed and lastly depends on depth of cut. Predicted surface roughness has been obtained, average percentage error is calculated by ANN method. The mathematical model is developed by using Artificial Neural Network (ANN) technique shows the higher accuracy is achieved which is feasible and more efficient in prediction of surface roughness in CNC milling. The result from this paper is useful to be implemented in manufacturing industry to reduce time and cost in surface roughness prediction.The main purpose of this work is to provide an nearest result for predict surface roughness in CNC end milling. The model developed is reliable to predict surface roughness with respect to all previous research. **[4].**

These study on CNC end milling, influence of various machining parameters like, tool feed (mm/min), tool speed (rpm), tool diameter (mm) and depth of cut (mm). In the present study, experiments are conducted on AL 6351 –T6 material with three levels and four factors to optimize process parameter and surface roughness. An L9 (3*4) Taguchi standard orthogonal array (OA) is chosen for design of experiments and the main influencing factor are determined for each given machining criteria by using Analysis of variance (ANOVA). The surface finish have been identified as quality attributes and are assumed to be directly related to productivity. In this experiment we were found that order of significant of main parameter decreasing order is M3>N2>O2>P1.(Tool feed(M), Tool speed(N), Tool diameter(O) and Depth of cut (P)).

In this study the analysis of confirmation experiment and the design of control parameter with there level & four parameters to find the optimal control parameter to minimize the surface roughness that the parameter is Tool feed (M) as shown in fig.1 and table V, and the order of significance parameter is M3>N2>O2>P1.This is the successful validations of the Taguchi methodology **[5].**

This paper gives information about Taguchi method which involves reducing the variation in a process through robust design of experiments. The overall objective of the method is to produce high quality product at low cost to the manufacturer. Taguchi developed a method for designing experiments to investigate how different parameters affect the mean and variance of a process performance characteristic that defines how well the process is functioning. The experimental design proposed by Taguchi involves using orthogonal arrays to organize the parameters affecting the process and their appropriate levels. The experiments are conducted using L-18 orthogonal array on EN 33 material as suggested by Taguchi. Signal-to-Noise (S/N) ratio and Pareto Analysis of Variance (ANOVA) will be employed to analyze the effect of milling parameters on cutting force. Main effects of process parameters on the quality characteristics can be analyzed **[6]**

In this paper the method is applied to find optimum process parameters for finishing operation of mild steel with the help of CNC milling machine and high speed steel tool used. The signal-to-noise ratio applied to find optimum process parameter for CNC finishing machining .A L9 orthogonal array and analysis of variance(ANOVA) are applied to study the performance characteristics of machining parameter (spindle speed, feed, depth, width) with consideration of high surface finish and high material removal rate(MRR) .The surface finishing and material removal rate have been identified as quality attributes and assumed to be directly related to productivity improvement. Results obtained by taguchi method and signal-to-noise ratio match closely with (ANOVA) and the feed is most effective factor for MRR. And spindle speed is the most effective factor for surface roughness. Multiple regression equation are formulated for estimating predicted value surface roughness and material removal rate Keywords: CNC milling machine**.[7]**

3. OBJECTIVES

- To Study the effect of variable on performance.
- To get the optimum input & output parameters for selected wire & work piece material.
- To Analyse and tp contrue based on SR & MRR.
- Functional relationship of various variables (speed, feed, depth of cut, SR and MRR) will be produced that will be close to the experimental results.

4. EXPERIMENTAL SETUP

- **Specification of machine:**

Table 1. Machine specification

SPECIFICATION	DESCRIPTION
Main axes X	1100.0 mm
Main axes Y	500 mm
Main axes Z	500 mm
Table length	1200.0 mm
Table width	500.0 mm
Spindle motor power	7.5 K W
Tool changer	24*BT40
Tool change time	4 sec
Rapid traverses x/y/z	48m/min
Total power requirement	18kVA
Machine weight (about)	5t

- **Work piece material:** EN–31 tool steel

  EN 31 has the wide applications in for Making Ball & Roller Bearings**.** for Making Punches & Dies. Stamping dies, metal cutting tools or any other industries because of its high strength and heavy weight.

Table 2. Chemical composition of work piece material

C	SI	MN	S	P	Cr
0.90/1.20	0.10/0.35	0.3/0.75	0.050 max	0.045 max	1.00/1.60

Fig 4.1 FV1100 FEELER milling machine

Table 3. Factors and Levels

Symbol	Input Parameters	**Level 1**	**Level 2**	**Level 3**
A	**Speed (RPM)**	**1000**	**1200**	**1500**
B	**Feed (mm/min)**	**1200**	**1500**	**1800**
C	**Depth of cut(mm)**	**0.20**	**0.25**	**0.30**

Output parameter:

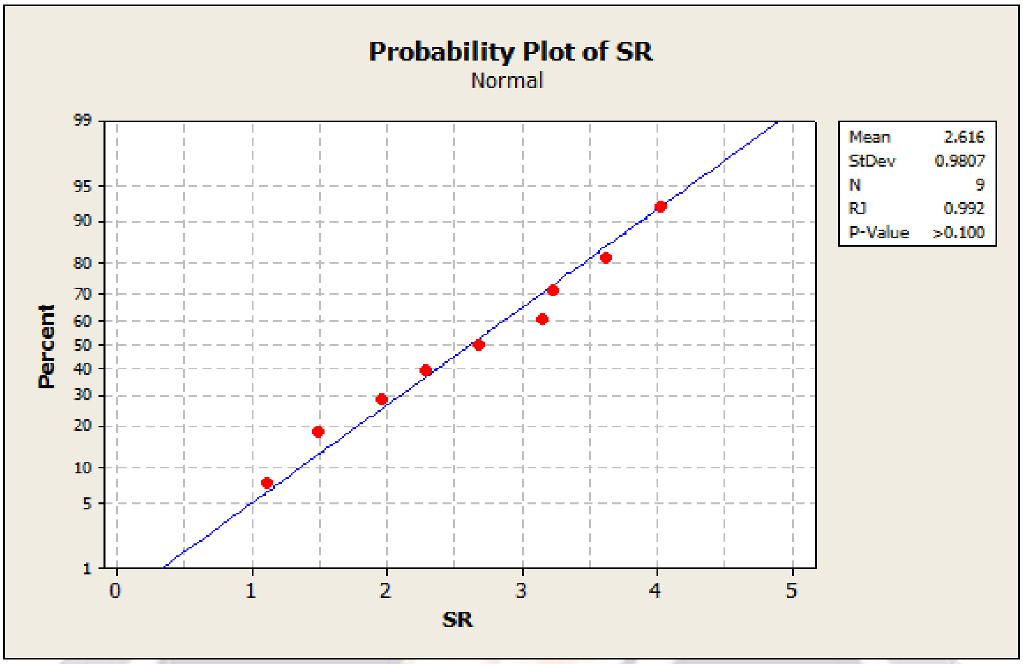
- Analysis and conclusion can be done based on SR & MRR.
- Functional relationship of various variables (speed, feed, depth of cut, SR and MRR) will be produce that will be close to the experimental results.

5. RESULTS AND ANALYSIS

Table 4. Results

SR.NO	**SPEED (RPM)**	**FEED (m/min)**	**DEPTH OF CUT(mm)**	**SR (µm)**
1	**1000**	**1200**	**0.20**	**1.961**
2	**1000**	**1500**	**0.25**	**3.145**
3	**1000**	**1800**	**0.30**	**4.02**
4	**1200**	**1200**	**0.20**	**1.492**
5	**1200**	**1500**	**0.25**	**2.675**
6	**1200**	**1800**	**0.30**	**3.617**
7	**1500**	**1200**	**0.20**	**1.112**
8	**1500**	**1500**	**0.25**	**2.289**
9	**1500**	**1800**	**0.30**	**3.23**

Fig 5.1 probability plot of SR



Here above fig 5.1 shows probability plot of material removal rate for EN31 tool steel material for different input values of feed speed and depth of cut.. Here for L9 orthogonal array there are 9 set for input parameter and for that values probability plot as shown in above fig. In which probability value is higher than 0.05 so that, results and probability plot is accurate.

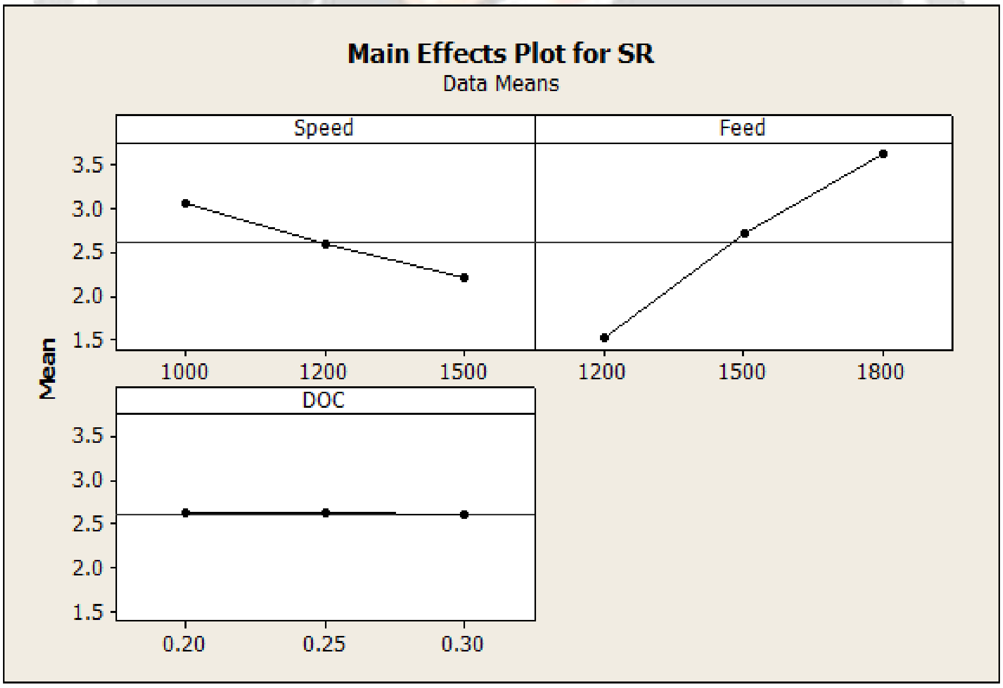


Fig 5.2 Main effect plot for SR

Here above fig 5.2 shows main effect plot for same material. In which for three input parameter we get different values for surface roughness. In first plot we can see that for the range of SR is decreases as speed is increased. And when feed is increased, surface roughness increases. Followed by depth of cut it remains constant.

- **Formulation of Problem : Regression Model For SR**

Regression model formulae for SR is,

function SR = DOE_SR(x)

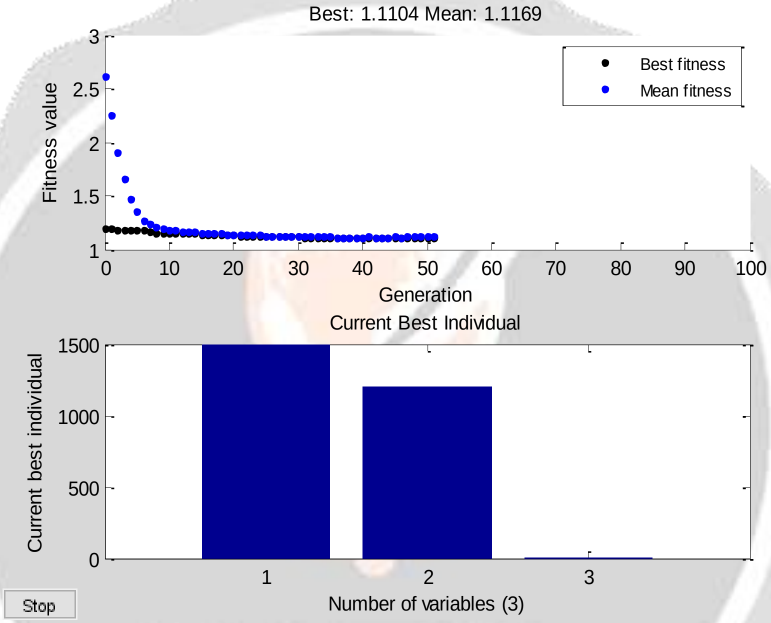
SR = - 0.747 - 0.00163 * x(1) + 0.00346 * x(2) + 0.751 * x(3);

Table.5 Regression model

Source	P
Regression	0.0001

- **Optimization Using Genetic Algorithm:**

results of optimization using GA



- **Confirmatory Experiment:**

Table.7 valedictory experiment

Input parameters	Value	Optimized value of MRR	Experimental value of MRR	% Error
Speed	1500	1.1169	1.112	0.16
Feed	1200			
Depth of cut	0.2			

6. CONCLUSIONS

In this study, weld runs were performed using an automatic VMC setup. Experiments were carried out as per taguchi design and regression analysis was conducted to determine input–output relationships of the process. A constrained optimization problem was formulated to minimize SR
Genetic Algorithm was used to solve the said problem. Following are the important

- SR is decrease with increase speed.
- SR is increase with increase feed & depth of cut.

- **The Genetic Algorithm was used for optimization. Following was concluded**

Genetic Algorithm was able to reach the optimal solution, after satisfying the constraints. This was validated in present work practically, after performing a confirmatory experiment as per process parameters optimized by

GA. Maximum error of 5% was found between the predicted weld geometry parameters and the actually measured weld geometry parameters.

7. REFERENCES

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