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Optimization of Cutting Parameters of AISI H13 with Multiple Performance Characteristics

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ABSTRACT: Increasing productivity, arising cost & maintains high product quality at the same time are the main challenges of manufacturing today the proper selection of machining parameter is an important step towards meeting the desired goal. Thus optimal selection gives the competitive advantage in the market. From the study we can conclude that the machine parameter (spindle speed, feed rate & depth of cut) gives the significant effect on the surface finish & material removal rate in the end milling. It is impossible to get high material removal rate & low surface roughness at the same time. When we increase the MRR ultimately surface finish decreases so it is necessary to use the optimized vale of Input Parameters to increase the productivity & quality.

I. INTRODUCTION

The advance of modern technology and a new generation of manufacturing equipment, particularly Computer Numerical Control (CNC) machine, have brought enormous changes to the manufacturing sector. Generally, the handbook or human experience is used to select convenient machine parameters in manufacturing industry. In process planning of conventional milling, selecting reasonable milling parameters is necessary to satisfy requirements involving machining economics, quality and safety. The machining parameters in milling operations consists of cutting speed, depth of cut, feed rate and number of passes. These machining parameters significantly impact on the cost, productivity and quality of machining parts. The affect dramatically the cost and production time effective optimizations of these parameters affect dramatically the cost and production time of machined components as well as the quality of final products. In order to get specified surface roughness, selection of controlling parameters is necessary. There has been a modeling surface roughness and optimization of the controlling parameters to obtain a surface finish of desired level since only proper selection of cutting parameters can produce a better surface finish. But such studies are far from complete since it is very difficult to consider all the parameters that control the surface roughness for a particular manufacturing process. In CNC milling there are several parameters which control the surface quality. The analysis of surface roughness on CNC end milling process is a big challenge for research development several factors involved in machining process have to be optimized to obtain a desired surface quality. In this study, three machining parameters are considered viz. spindle speed, feed rate and depth of cut.

II. LITERATURE SURVEY

A. Milling

Milling is a process of producing flat and complex shapes with the use of multi-tooth cutting tool, which is called a milling cutter and the cutting edges are called teeth. The axis of rotation of the cutting tool is perpendicular to the direction of feed, either parallel or perpendicular to the machined surface. The machine tool that traditionally performs this operation is a milling machine.

Milling is an interrupted cutting operation: the teeth of the milling cutter enter and exit the work during each revolution. This interrupted cutting action subjects the teeth to a cycle of impact force and thermal shock on every rotation. The tool material and cutter geometry must be designed to withstand these conditions. Cutting fluids are essential for most milling Operations.

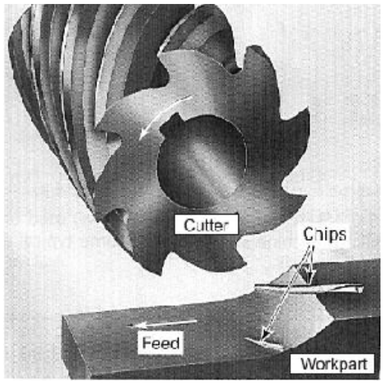

Fig. 1. Milling operation.

Milling operation: The cutter is lifted to show the chips, and the work, transient,
and machined surfaces. Cutting conditions in milling: In milling, each tooth on a tool removes part of the stock in the form of a chip. The basic interface between tool and work part is pictured below. This shows an only a few teeth of a peripheral milling cutter: Cutting velocity V is the peripheral speed of the cutter is defined

$$V = \pi dn.$$

Where D is the cutter outer diameter and N is the rotational speed of the cutter.
As in the case of turning, cutting speed V is first calculated or selected from appropriate reference sources, and then the rotational speed of the cutter N, which is used to adjust milling machine controls, is calculated. Cutting speeds are usually in the range of 0.1~4 m/s, lower for difficult-to-cut materials and for rough cuts, and higher for non-ferrous easy-to-cut materials like aluminum and for finishing cuts.

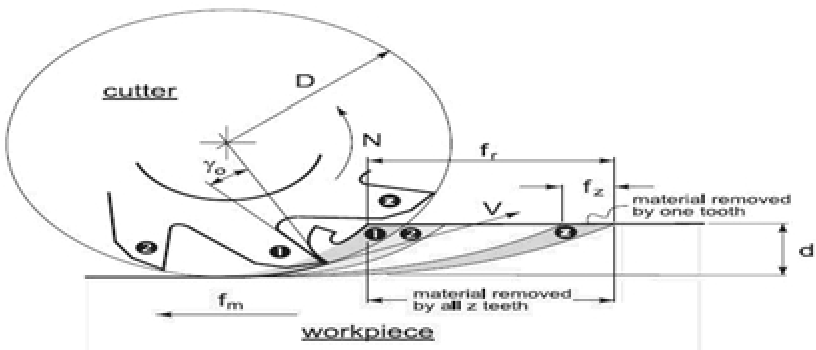

Fig. 2 Basics of peripheral(slab) milling operation

III. OBJECTIVES

(i) Review of literature based on CNC end milling.
(ii) Study of effect of various input parameters on output characteristics.
(iii) Selection of input parameters & output characteristic.
(iv) Selection of machine & material.
(v) Design of experiment using taguchi technique.
(vi) Experimental determination of the effects of the various machine parameters on the output characteristics.
(vii) Optimization of the quality characteristic using taguchi technique.
(viii) Validation of the result.

Selection of Input Parameters & output characteristics of End Milling

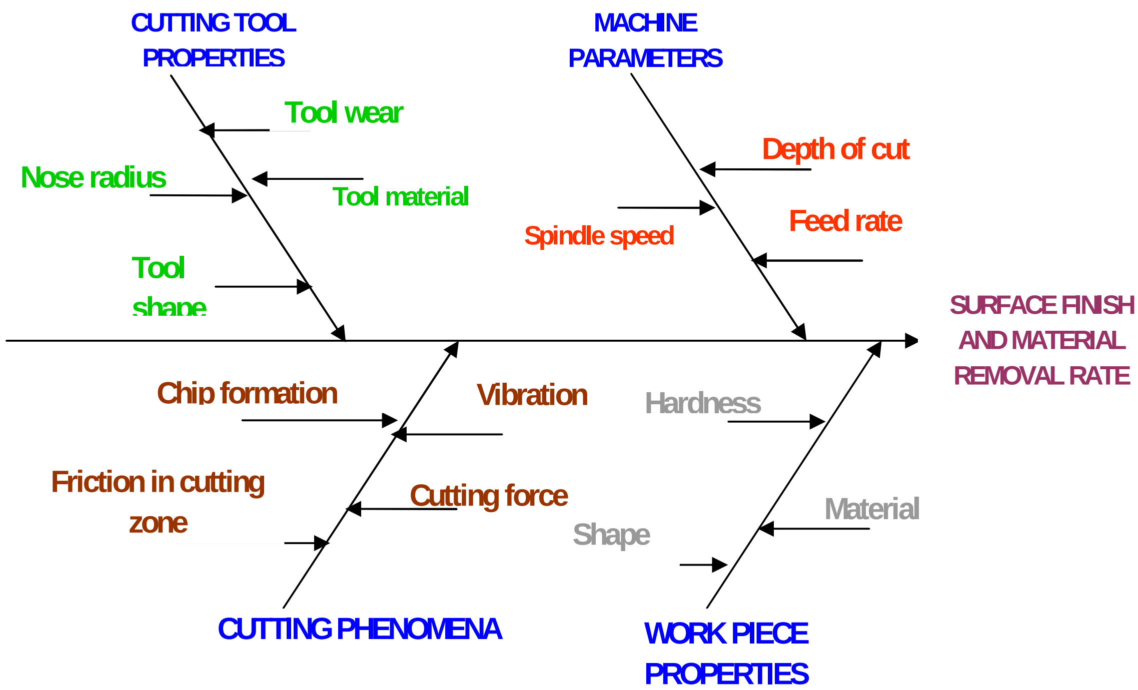

Fig. 3. Cause and effect diagram.

IV. DESIGN OF EXPERIMENTS

The design of experimentation has a significant role on the number of experiments needed. Therefore cutting experiments have to be designed. In this study a 3 level face centered cubic design were performed to obtain the surface roughness values a total of 20 experiments are conducted at 3 levels for the three input variables speed, feed, depth of cut. Table shows the actual design data and Table shows the measured Ra and tool wear values with coaded parameters.

Table 1. Recommended Value of Input Parameters.

Factors	Unit	Level-1	Lavel-2	Level-3
1.Speed	rpm	3500	4000	4500
2.Feed Rate	mm/t	0.01	0.03	0.05
3.Depth of Cut	mm	0.20	0.35	0.50

Table 2. Chemical Composition (wt%) of AISI H13 :

Element	Weight (%)	Element	Weight (%)
C	0.36	Cr	5.00
Si	1.00	Mo	1.22
Mn	0.40	V	0.90

Table 3. Mechanical Properties of H13 :

Properties	Measured Value
Brinal Hardness	50 HRC
Density	7760 kg/m3
Ultimatetensile Strength	1610 MPa
Liquidus Temperature	1727 k

Multi Objective Optimization: In this present investigation, an attempt has been made to optimize simultaneously the surface roughness after machining of hard material namely AISI H13. Therefore, a multi objective simultaneous optimization technique is used by incorporating response surface methodology to find out the optimal solution as combination of input process parameters as shown design of input process parameters as shown design input parameters on surface roughness. Now using RSM and desirability analysis for optimization of process.

Optimal Process Parameters with Respect to Surface Roughness: We have already seen the optimal process parameters in individual consideration. After analyzing the process parameters for surface roughness individually we again optimize the process parameters for surface roughness and tool wear together. Hence we find the optimal process parameters using Optimal Value of Process Parameters for Surface Roughness.

Table 4. Optimal Value of Process Parameters for Surface Roughness.

Speed(rpm)	Feed(mm)	DOC (mm)	Ra(µm)
4500	Tooth	0.2	0.113166

Table 5. Analysis of Variance for optimal values.

Sr.No.	Spindle speed(rpm)	Feed Rate(mm)	Depth of cut(mm)
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2
10	**3**	**1**	**1**

Table 6.

Sr.No.	Spindle speed(rpm)	Feed Rate(mm)	Depth of cut(mm)
1	3500	0.01	0.20
2	3500	0.03	0.35
3	3500	0.05	0.50
4	4000	0.01	0.35
5	4000	0.03	0.50
6	4000	0.05	0.20
7	4500	0.01	0.50
8	4500	0.03	0.20
9	4500	0.05	0.35
10	**4500**	**0.01**	**0.20**

Table 7.

Speed (rpm)	Feed(mm) tooth	DOC(mm)	Ra (µm)
4500	0.01	0.2	0.131166

Parameters Effect of Process: To visualize the influence of the designed process parameters over the two response variables and also to find their nature of variations with respect to designed parameters three dimensional surface plots have been developed as shown in Fig. 1 to 3. The surface plots physically represent the surface plot graph is showing the surface roughness parameters in Z-axis corresponding to depth of cut (X-axis) and feed rate (Y-axis).

We see that surface roughness is increased with increase in feed rate but there are slightly changes in surface roughness with increasing the depth of cut as shown in above surface plot. From Fig. 3 it is clear that at high spindle speed the value of surface roughness is very small. For the some region depth of cut is speed, we observe that value of surface roughness is increased. But at higher spindle speed and depth of cut the value of surface roughness is minimum.

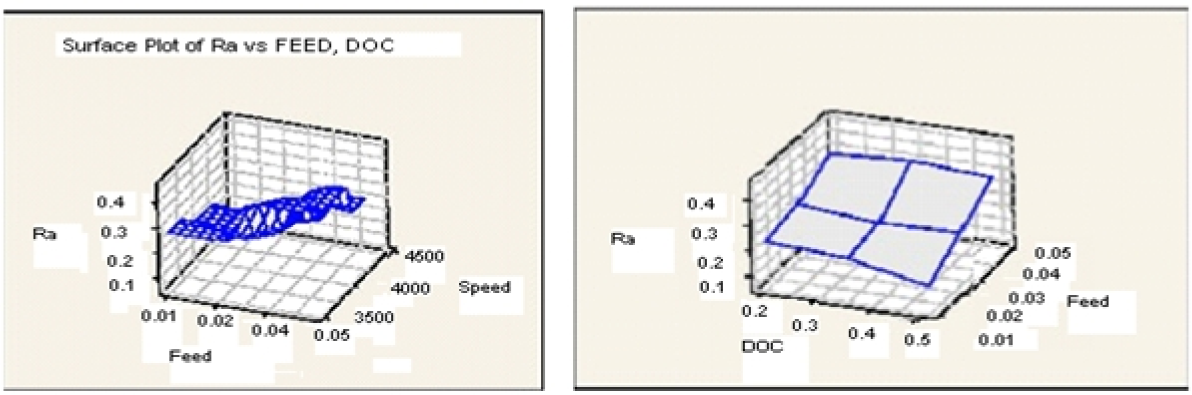

Fig. 4

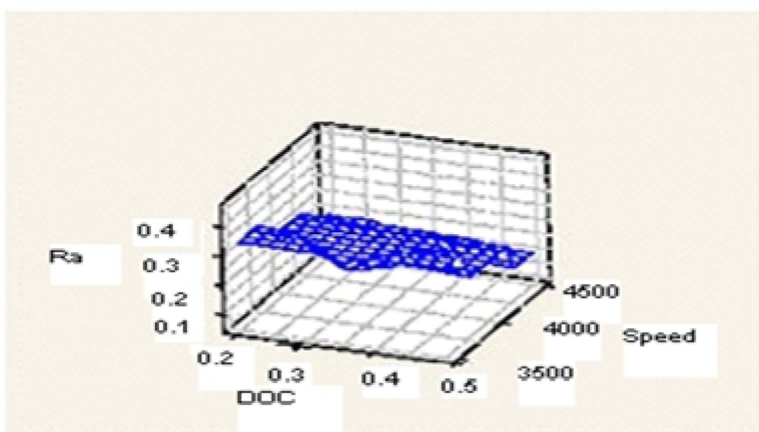

Fig. 5

V. FUTURE WORK

In future we can further work in the field of optimization of these machine parameters. The experiment would be carried in the next semester on the basis of study work in the field of optimization of these parameters can be done so as to find the desired result in the least number of experiments. The effect of various machine parameters on surface roughness and material removal rate will be experimentally determined. The experiment is to be done on the Haas Mini Mill considering the spindle speed, feed rate, and depth of cut as the input machine parameters. The work piece material is to be taken is of die material (EN8) and tool considered is four flute high speeds steel.

The testing of surfaced machine part is done with Mitutoyo Surftest SJ-201P and MRR is calculated with the help of formulation. The analysis is to be done taguchi method using H-13 Orthogonal array with Minitab software to find optimized value for surface finish and Material Removal Rate.

VI. CONCLUSION

From books, journals & study material it is found that in end milling process main effective input parameters are machine parameters, cutting tool properties, cutting phenomena & work piece properties, And output parameters are surface finish & material removal rate, but some of input parameters are not affect the output significantly & machine parameters are those who effect the output characteristics to a great extent. The main machine parameters taken in this study & future experiments are spindle speed, feed rate & depth of cut, which effect the surface finish and material removal rate.

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