A REVIEW ON OPTIMIZATION OF CUTTING PARAMETERS IN MACHINING USING TAGUCHI METHOD

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Abstract - *CNC End milling is a unique adaption of the conventional milling process which uses an end mill tool for the machining process. CNC Vertical End Milling Machining is a widely accepted material removal process used to manufacture components with complicated shapes and profiles. During the End milling process, the material is removed by the end mill cutter. The effects of various parameters of end milling process like spindle speed, depth of cut, feed rate have been investigated to reveal their Impact on surface finish using Taguchi Methodology. Experimental plan is performed by a Standard Orthogonal Array. The graph of S-N Ratio indicates the optimal setting of the machining parameter which gives the optimum value of surface finish. The optimal set of process parameters has also been predicted to maximize the surface finish.*

Key Words: **Taguchi method, signal to noise ratio, ANOVA, Optimization, cutting parameters.**

1. INTRODUCTION

Industries around the world constantly focus on the quality of the product. But, along with quality, cost of production and productivity is also a very important factor. Productivity can be interpreted in terms of material removal rate in the machining operation and quality represents satisfactory yield in terms of product characteristics as desired by the customers. Moreover, machining environment also plays a very important role. Industries have been trying to reduce the cost of production, so that they can survive the competition in the market. For this purpose, researches have been carried out to get optimal quality at optimal production cost. Some of the important factors that have been considered are (a) Cutting speed (b) Depth of cut (c) Feed rate. For measuring the quality surface finish has been considered as a parameter. To find the right combination of above parameters and to find the most influential parameter Taguchi method and analysis of variance is used. The experiments are conducted by using Taguchi L**9** orthogonal array as suggested by Taguchi. Signal-to-Noise (S/N) ratio and Analysis of Variance (ANOVA) is employed to analyse the effect of milling parameters on material removal rate.

1.1 End milling

The cutter, called end mill, has a diameter less than the workpiece width. The end mill has helical cutting edges carried over onto the cylindrical cutter surface. End mills with flat ends (so called squire-end mills) are used to generate pockets, closed or end key slots, etc. End milling is the most common metal removal operation encountered. The end mill has edges in the side surface and the bottom surface. The fundamental usage is that the end mill is rotated, and makes a plane of a material in the right-and-left direction or a plane of a bottom side of the end mill. We can make various shapes of mechanical parts with the end mill. The edge of the end mill is very weak. In case beginning of cuttings, we have to take care so that the end mill may touch to a material as slowly as possible. It is widely used to mate with other part in die, aerospace, automotive, and machinery design as well as in manufacturing industries. The tool changer is controlled by the CNC program.

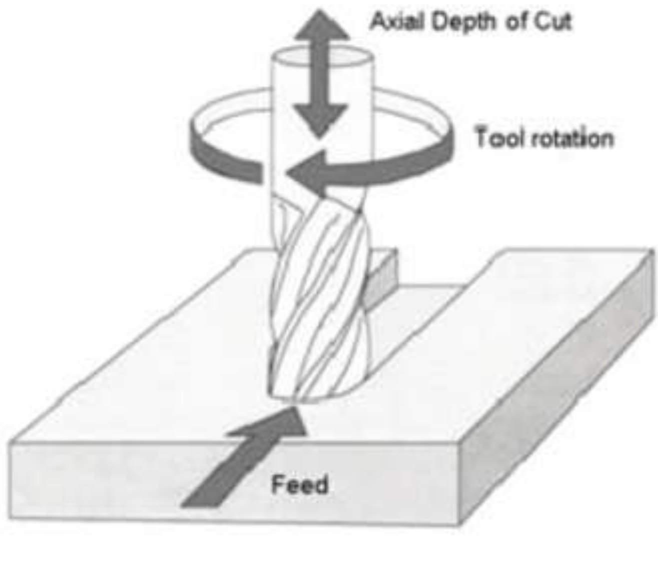

Fig -1: End Milling Operation

1.2 Taguchi method

Taguchi method is statistical method developed by Professor Genichi Taguchi of Nippon Telephones and Telegraph Company Japan for the production of robust products. According to Taguchi, total loss generated by a product to the society after shipped is the quality of the manufactured product. Taguchi has used experimental design as a tool to make products more robust to make them less sensitive to noise factors. Currently, Taguchi method is applied to many sectors like engineering, biotechnology, marketing and advertising. Taguchi developed a method based on orthogonal array experiments, which reduced "variance" for the experiment with "optimum settings" of control parameters. Hence, the optimal results can be achieved by implementing the combination of Design of Experiments (DOE) with optimization of control parameters. Signal-to-noise (S/N) ratio and orthogonal array are two major tools used in robust design. Signal to noise ratio, which is log functions of desired output measures quality with emphasis on variation, and orthogonal arrays, provide a set of well-balanced experiments to accommodate many design factors at the same time.

1.3 Design of experiment (DOE)

Design of experiments (DOE) or experimental design is the design of any information-gathering exercises where variation is present, whether under the full control of the experimenter or not. However, in statistics these terms are usually used for controlled experiments. Formal planned experiment is often used in evaluating physical objects, chemical formulation, structures, components and materials. Design of experiments (DOE) capabilities provides a method for simultaneously investigating the effects of multiple variables on an output variable (response). These experiments consist of a series of runs, or tests, in which purposeful changes are made to input variables or factors, and data are collected at each run. Quality professionals use DOE to identify the process conditions and product components that influence quality and then determine the input variable (factor) settings that maximize results.

2. Literature review

V V K Lakshmi and Dr. K Venkata Subbaiah [1] conducted end milling operation on EN24 grade steel with a hardness of 260 BHN using solid coated carbide tool. Input variables consist of cutting speed, feed rate and depth of cut. The output variables are surface roughness and Material removal rates. Average surface roughness were modelled and optimized by using RSM method. Their results showed that feed rate is the most affecting parameter on surface roughness followed by cutting speed. However, depth of cut appears to have very little effect over roughness value.

B Vijaya Krishna Teja, N. Naresh, K. Rajasekhar [2] conducted milling on AISI 304 stainless steel using grey taguchi method. The surface roughness and material removal rate were the responses. The proposed Grey based Taguchi method is constructive in optimizing the multiresponses. It was identified that cutting speed (56.90%) influences more on milling of AISI 304 stainless steel followed by depth of cut (22.43%) and feed rate (8.58%).

Mohammed T. Hayajneh, Montasser S. Tahat, Joachim Bluhm [3] used ANOVA to optimize cutting parameters during end milling of aluminium. The effect of spindle speed, feed rate, depth of cut on surface roughness of aluminium samples was studied. They found that feed rate is most dominant influencing parameter which affects the surface roughness.

Nikhil Aggarwal and Sushil Kumar Sharma [4] used Taguchi based grey relational analysis to optimize machining parameters in end milling of AISI H11 Steel Alloy. They found that cutting speed is the only significant machining parameter for surface roughness. The increase in cutting speed produces better surface finish. Depth of cut has the least effect on surface roughness and material removal rate.

Dimple Rani, Dinesh Kumar [5] conducted end milling operation on AISI D2 steel with carbide tool by varying feed, speed and depth of cut and the surface roughness was measured using Surface Roughness Tester. They found that, for achieving good surface finish on the D2 work piece, higher cutting speed, lower feed and lower depth of cut are preferred. As speed increases surface roughness decreases and feed increases surface roughness also increases.

Bhargav V. Patel, Prof. P. J. Panchal [6] investigated optimal machining parameters and their contribution on producing better Surface quality and higher Productivity. They carried out end milling on AISI 316 steel. It is observed that the effect of No of flutes and cutting speed are most significant factors varying linearly with the response.

Shivam Goyal et al [7] investigated experimental study of turning operation and optimization of MRR and surface roughness using Taguchi method. In this research work turning operation is performed on AISI 1020 mild steel. The experiments were performed by taking Cutting Speed, Feed Rate & Depth of cut as process parameters and got the optimized value of MRR & SR. An L9 orthogonal array, the S/N ratio are employed to the study the performance characteristics in the turning using carbide insert with a nose radius of 0.8mm.

Manoj Kumar, Mahender Singh Kaswan [8] used Taguchi's Parameter Design methodology for Parametric Study of D2 Steel on End milling process. They tried to determine the best cutting parameter leading to maximum material removal rate and minimum surface roughness in machining D2 (Die Steel). They found that high cutting speed, low feed rate, low depth of cut is required for achieving high surface finish. For high material removal rate maximum speed of cut, maximum depth of cut, maximum feed rate is required.

Sourabh Kuamr Soni, Dr S.K.Moulick [9] carried out end milling process on Inconel 718 by Taguchi methodology. Three machining process parameter are chosen cutting speed, feed rate and depth of cut. The analysis prepare was created using by Taguchi's L9 Orthogonal Array. They found cutting speed has greater effect on surface roughness than feed rate and depth of cut.

Hemantsinh Pratapsinh Rao, Prof. Rajat Dave, Prof. Riddish Thakore [10] used taguchi method for carrying out end milling operation on AL 6061. From experimental analysis they found that cutting speed has greater effect on surface roughness and material removal rate.

N .V. Malvade, S. R. Nipanikar [11] performed end milling on OHNS steel using HSS tool. They found that the effect of depth of cut on MRR is maximum while cutting speed has least effect. For surface roughness, cutting speed has maximum effect.

Akhilesh Chaudhary, Vinit Saluja [12] used taguchi method to perform end milling on AL6082. They observed that speed has more influence on surface roughness.

Table -1: Summary of review papers

SNo.	Author's Name	Input Parameter	Output Parameter	Most Significant
1	V V K Lakshmi et al	Cutting, Speed, Feed rate , DOC	Surface roughness, MRR	Feed Rate
2	B Vijaya Krishna Teja et al	Cutting, Speed, Feed rate , DOC	Surface Roughness, MRR	Cutting speed
3	Mohammed T. Hayajneh et al	Cutting, Speed, Feed rate , DOC	Surface Roughness	Feed rate
4	Nikhil Agarwal et al	Cutting speed, Feed rate, DOC	Surface roughness	Cutting speed
5	Dimple Rani et al	Cutting speed, Feed rate, DOC	Surface roughness, and MRR	Cutting speed
6	Bhargav V. Patel et al	Cutting speed, Feed rate, DOC	Surface roughness	No. of flutes, cutting speed
7	Shivam Goyal et al	Cutting Speed, Feed rate, DOC	MRR & surface roughness	Depth of cut & cutting speed
8	Manoj Kumar et al	Cutting speed, Feed rate, DOC	MRR, surface roughness,	Cutting speed
9	Sourabh Kumar Soni et al	Cutting Speed, Feed rate, DOC	Surface finish	Cutting speed
10	Hemantsinh Pratapsinh Rao et al	Cutting Speed, Feed rate, DOC	Surface roughness, MRR	Cutting speed
11	N. V. Malvade et al	Cutting speed, Feed rate, DOC	Surface roughness, MRR	Cutting speed, DOC
12	Akhilesh Chaudhary et al	Cutting speed, Feed rate, DOC	Surface roughness	Cutting speed

3. CONCLUSION

After minutely going through the above discussed literatures, it is noticed that most of the researchers have considered cutting speed, depth of cut, feed rate as the input parameters. Most of them have not considered environment temperature, coolant used and other factors during their study. Majority of them came to the conclusion that cutting speed has greater influence on the surface finish. For material removal rate depth of cut is most influencing parameter. However, it has also been observed that most significant parameter changes with the change in material under consideration.

ACKNOWLEDGEMENT

It is joyful occasion for me to publish this paper. I would like to express my deep sense of gratitude to my guide, teachers and friends for giving valuable time, precious guidance which helped me in completion of paper successfully.

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