



International Journal of Engineering, Business and Enterprise Applications (IJEBA)

www.iasir.net

Effect of machining parameters on output characteristics of CNC milling using Taguchi optimization technique

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Abstract: This paper gives the effect of different machining parameters (cutting speed, feed, and depth of cut) on Surface Roughness in end milling. Taguchi technique is being used for the various calculations. The study was conducted in machining operation for hardened die steel H-13. The processing of the job was done by solid carbide four flute end-mill tool under finishing conditions. L-9 standard orthogonal array is used for calculation of no. of variables and no. of levels. Signal to Noise Ratio and ANOVA are calculated to draw the graphs and come to the results.

Keywords: CNC Milling, Surface Roughness, Analysis of Variance, Signal to Noise Ratio

I. INTRODUCTION & LITERATURE REVIEW

With the more precise demands of modern engineering products, the control of surface texture together with dimensional accuracy has become more important. In this paper investigation outlines the Taguchi optimization methodology, which is applied to optimize machining parameters in end milling operation. The machining is conducted on hot die steel H-13. The processing of the job is done by solid carbide four flute end-mill tools under finishing conditions. The machining parameters evaluated are cutting speed, feed rate and depth of cut. The paper is conducted by using L-9 (3^4) orthogonal array as suggested by Taguchi. (S/N) ratio and Analysis of Variance (ANOVA) is employed to analyze the effect of milling parameters on surface roughness. 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.

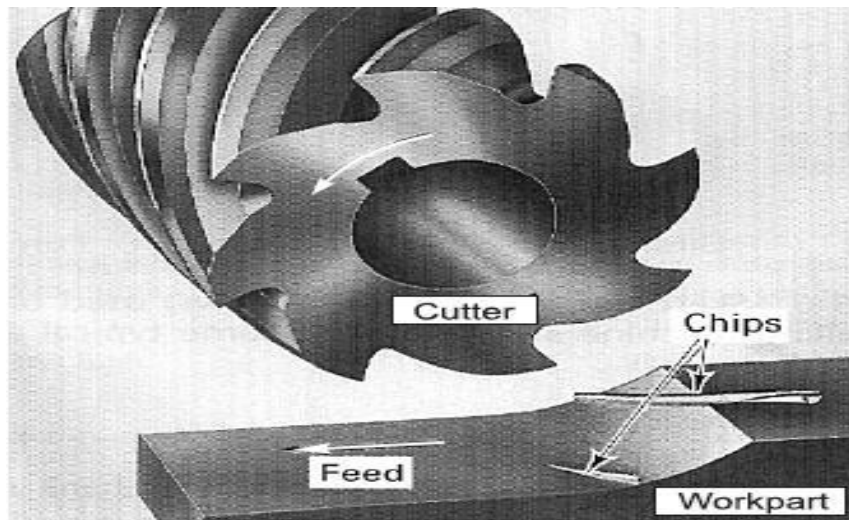


Fig. 1

Benardoas et al (2002) presented a neural network for the prediction of surface roughness (R_a) in CNC face milling. The data used for the training and checking of the networks performance derived from experiments conducted on a CNC milling machine according to the principles of Taguchi design of experiments method. The factors considered in the experiment were the depth of cut, the feed rate per tooth, the cutting speed, the engagement and wear of the cutting tool, the use of cutting fluid and the three components of the cutting force. **Dweiri et al (2003)** suggested that Fuzzy modeling proved to be effective in modeling. Down milling machining process of almic-79 was modeled using the adaptive neuro fuzzy interference system (ANFIS) predict the effect of machine variables (spindle speed, feed rate, depth of cut and number of flutes) on the surface finish (represented by the surface roughness) of Almic -79 in order to improve and increase its range of application. Optimum surface roughness 0.224 micron has been achieved for the four flutes at the spindle speed of 2000

rpm, feed rate of 0.06 mm/tooth, and depth of cut of 2mm. In the meantime, it was found for the two flutes that the minimum surface roughness of 0.327 micron is achieved at the spindle speed of 2000 rpm, feed rate of 0.05mm/tooth, and depth of cut of 2mm.

II. EXPERIMENTAL METHODOLOGY

Quality should be designed into a product, not inspected into it. Quality is designed into a process through system design, parameter design, and tolerance design. Parameter design, which will be the focus of this article, is performed by determining what process parameters most affect the product and then designing them to give a specified target quality of product. Quality "inspected into" a product means that the product is produced at random quality levels and those too far from the mean are simply thrown out.

III. EXPERIMENTAL SETUP AND PROCESS PARAMETERS SELECTED

A. Work piece material and tool:

Hot die steel H13 in the plate form of size 280x178x25 mm³ have been used to carry out experiments. H13 die steel has been chosen because of high hardness, excellent wear resistance, hot toughness and good thermal shock resistance properties. The chemical composition of H-13 die steel is given in table-1.

Table: 1 Chemical composition

Element	Weight percent	Element	Weight percent
Carbon	0.4	Chromium	5.25
Manganese	0.4	Molybdenum	1.35
Silicon	1.0	Vanadium	1.0

A four flute solid carbide type flat end mill tool of 10 mm diameter is used in this experiment with dry cutting condition.



Fig. 2 Experimental set up

Table: 2 Orthogonal array along with Roughness at Various Conditions

	C1	C2	C3	C4	C5	C6	C7	C8	C9
	CS	FR	DOC		SR1	SR2	SR3	SNRA1	MEAN1
1	214.8	0.08	0.1		0.79	0.61	0.87	-8.8144	0.75
2	214.8	0.12	0.2		0.23	0.34	1.20	-10.2569	0.59
3	214.8	0.15	0.3		0.99	0.86	1.93	-11.8813	1.26
4	286.8	0.08	0.2		1.77	1.87	1.90	-5.3317	1.84
5	286.8	0.12	0.3		1.45	0.46	1.58	-7.9496	1.61
6	286.8	0.15	0.1		0.72	0.67	0.68	-11.3407	0.70
7	358.8	0.08	0.3		0.51	1.64	0.73	-4.2393	0.96
8	358.8	0.12	0.1		0.75	0.92	0.64	-8.8571	0.77
9	358.8	0.15	0.2		1.00	0.90	1.22	-9.8077	1.04

Response Table for Signal to Noise Ratios
Smaller is better

Level	CS	FR	DOC
1	-10.318	-6.128	-9.671
2	-8.207	-9.021	-8.465
3	-7.635	-11.010	-8.023
Delta	2.683	4.881	1.647
Rank	2	1	3

Response Table for Means

Level	CS	FR	DOC
1	3.313	2.077	3.072
2	2.678	2.841	2.731
3	2.496	3.569	2.683
Delta	0.818	1.492	0.389
Rank	2	1	3

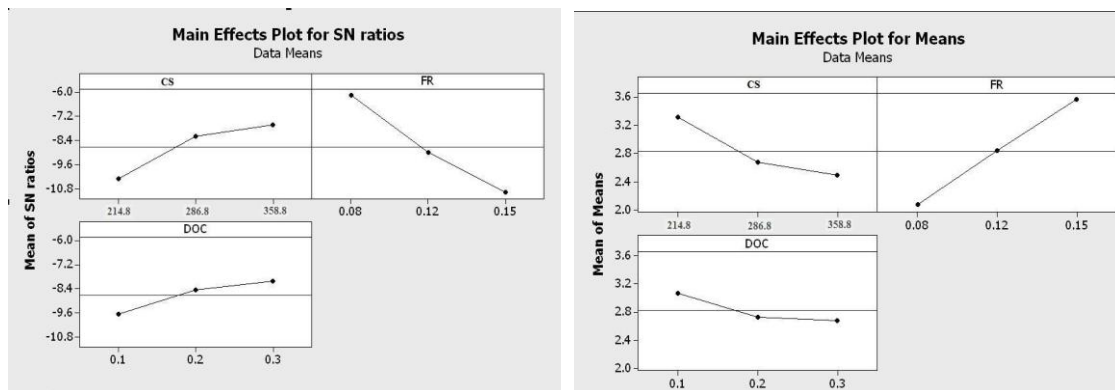


Fig. 3 Main effect plots for SN ratio and means

IV. RESULTS

Effect of cutting speed on SR:

The higher the cutting speed less will be the surface roughness. Surface roughness is minimum at the higher level of cutting speed. The higher cutting speed causes the low burr size thus the surface finish increases.

Effect of feed rate on SR:

With the decrease of feed rate, surface roughness also decreases. It is observed that the minimum surface roughness value obtained at the first level (.08 m/tooth). Higher the feed rate, higher will be the tool wear thus increases the value of surface roughness.

Effect of depth of cut on SR:

It is observed that the increased value of depth of cut will decrease the value of surface roughness. The level considered in this investigation is finishing range. At the lower depth of cut the tool deflection high and it will decrease with increase of depth of cut in.

V. CONCLUSION

1. The feed rate and cutting speed are by far the most dominant factor then the depth of cut for surface finish.
2. In end milling, increase in cutting speed, decrease in feed rate and increase in depth of cut will decrease the surface roughness within specified test range.
3. Taguchi's robust design method is suitable to analyze the metal cutting problem as described in the present work.
4. Low cutting speed should be used for long cutter life.
5. High cutting speed and low feeds give best surface finishes; depth of cut should be low but not so low that it led to the vibration of tool.

VI. FUTURE RESEARCH DIRECTION

Further study could consider higher orthogonal array (L18, L27 etc.), different analysis methods (Response Surface methodology, Particle Swarm Optimization etc.) and multiple responses could be considered and more factors like tool vibration, coolant pressure can be used.

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