Harish Kumar, Mohd. Abbas, Dr. Aas Mohammad, Hasan Zakir Jafri / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 3, Issue 3, May-Jun 2013, pp.331-334

Optimization of cutting parameters in CNC Turning

Harish Kumar[1], Mohd. Abbas [2], Dr. Aas Mohammad[3], Hasan Zakir Jafri[4]

1, Research Scholar, Al-Falah School of Engineering & Technology
2,4, Assistant Professor, Department of Mechanical Engineering, Al-Falah School of Engineering & Technology Village Dhauj, Faridabad, Haryana
3, Associate Professor, Department of Mechanical Engineering, Faculty of Engineering & Technology, Jamia Millia Islamia, New Delhi

ABSTRACT

Many manufacturing industries involve machining operations. In metal cutting the turning process is one of the most fundamental cutting processes used. Surface finish and dimensional tolerance, are used to determine and evaluate the quality of a product, and are major quality attributes of a turned product. In this paper experimental work has been carried out for the optimization of input parameters for the improvement of quality of the product of turning operation on CNC machine. Feed Rate, Spindle speed & depth of cut are taken as the input parameters and the dimensional tolerances as output parameter. In the present work L9 Array has been used in design of experiment for optimization of input parameters. This paper attempts to introduce and thus verifies experimentally as to how the Taguchi parameter design could be used in identifying the significant processing parameters and optimizing the surface roughness in the turning operation. The present work shows that spindle speed is the key factor for minimizing the dimensional variation for minimizing the surface roughness.

Keywords - Turning operation, Taguchi Method, Dimensional Tolerance.

INTRODUCTION

Turning is the machining operation that produces cylindrical parts. In its basic form, it can be defined as the machining of an external surface:

- With the work piece rotating.
- With a single-point cutting tool, and
- With the cutting tool feeding parallel to the axis of the work piece and at a distance that will remove the outer surface of the work.

Turning is carried out on a lathe that provides the power to turn the work piece at a given rotational speed and to feed the cutting tool at specified rate and depth of cut. Therefore three cutting parameters namely cutting speed, feed and depth of cut need to be determined in a turning operation.

Whenever two machined surfaces come in contact with one and the other, the quality of the mating parts plays an important role in the performance and wear of the mating parts. The height, shape, arrangement and direction of these surface irregularities on the work piece depend upon a number of factors such as:

A) The machining variables which include
a) Cutting speed.
b) Feed.
c) Depth of cut.
d) Cutting tool wears, and
e) Several other parameters

Optimization refers to the art and science of allocating scarce resources to the best possible effect. The Taguchi method is a well known technique that provides a systematic and efficient methodology for design and process optimization. This is due to the advantage of the design of experiment using Taguchi's technique that includes simplification of experimental plan and feasibility of study of interaction between different parameters. Analysis of Variance (ANOVA) is then used to determine which process parameter is statistically significant and the contribution of each parameter towards the output characteristic.

I. Literature Review: The most readily controlled factors in a turning operation are feed rate, cutting speed, and depth of cut; each of which may have an effect on surface finish. Spindle speed and depth of cut were found to have differing levels of effect in each study, often playing a stronger role as part of an interaction. The controlled parameters in a turning operation that under normal conditions affect surface finish most profoundly are feed rate and cutting speed [1]. Recent studies that explore the effect of setup and input parameters on surface finish all find that there is a direct effect of feed rate and spindle speed's effect is generally nonlinear and often interactive with other parameters, and that depth of cut can have some effect due to heat generation or chatter [2, 3, 4, and 5]. Several studies exist which explore the effect of feed rate, spindle speed, and depth of cut on surface finish [6, 7, 5, 8]. These studies all supported the idea that feed rate has a strong influence on surface finish. Feng and Wang (2002) [9] investigated for the prediction of surface roughness in finish turning operation by developing an empirical model through considering working parameters. Kirby et al. (2004) [1]

developed the prediction model for surface roughness in turning operation. Rafi & Islam [10] present experimental and analytical results of an investigation into dimensional accuracy and surface finish achievable in dry turning. Tzeng Yih-Fang [11] has taken a set of optimal turning parameters for producing high dimensional precision and accuracy in the computerized numerical control turning process was developed. Shoukry [12] has also performed an experiment to evaluate The effects of speed, feed and depth of cut on the dimensional accuracy of aluminum bars turned on a lathe. Gilbert (1950) [13] studied the optimization of machining parameters in turning with respect to maximum production rate and minimum production cost as criteria. Armarego & Brown (1969) [14] investigated unconstrained machine-parameter optimization using differential calculus. Brewer & Rueda (1963) [15] carried out simplified optimum analysis for non-ferrous materials. Petropoulos (1973) [16] investigated optimal selection of machining rate variables, viz. cutting speed and feed rate, by geometric programming. Chanin *et al* (1990) [17] remarked that Japanese companies such as Nippon, Denso, NEC, and Fugitsu have become world economic competitors by using Taguchi's approach which has potential for saving experimental time and cost on product or process development, as well as quality improvement. The problem was to find an optimum set of conditions that were to produce minimum surface roughness and minimum dimensional tolerance.

Based on the above literature review there are two aspects of this work. The first is to demonstrate a systematic approach of using Taguchi parameter design of process control of individual CNC turning machine.

The second is to demonstrate the use of Taguchi parameter design in order to identify the optimum dimensional tolerance performance with a particular combination of cutting parameters in a CNC turning operation.

II. Problem Description:

The machining process on a CNC lathe is programmed by speed, feed rate and cutting depth, which are frequently determined based on the job shop experiences. However, the machine performance and the product characteristics are not guaranteed to be acceptable. Therefore, the optimum turning conditions have to be accomplished.

With all the viewpoints, this study proposes an optimization approach using orthogonal array and ANOVA, S/N ratios to optimize precision CNC turning conditions.

III. Parameter Identification:

The input parameters which affect the aforementioned output parameters are numerous such as:

a) Cutting speed
b) Feed rate.
c) Depth of cut.
d) Side cutting edge angle
e) Type of power.
f) Cutting tool material.
g) Working temperature.
h) Operator.
i) Make of the CNC machine.
j) Noise.

In order to identity the process parameters, affecting the selected machining quality characteristic of turned parts, an Ishikawa cause-effect diagram was constructed as shown in figure 1.

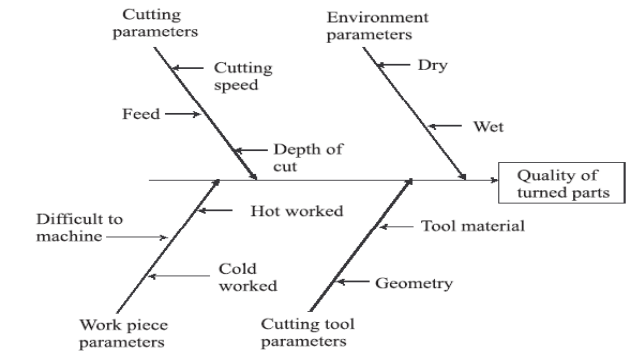

Fig. 1 Ishikawa cause-effect diagram of a turning process

Selection of input parameters:

The following process parameters were selected for the present work:

Cutting speed – (A),
Feed rate – (B),
Depth of cut – (C),
Tool material – HSS,
Work material – MS 1010,
Environment – Dry cutting.

In combination, speed, feed and depth of cut were the primary factors investigated while the secondary factors were not considered in the present study.

In this study, $L_9(3^3)$ orthogonal array of Taguchi experiment was selected for three parameters (speed, feed, depth of cut) with three levels for optimizing the multi-objective (surface roughness and dimensional tolerance) in precision turning on an CNC lathe. Through the examination of surface roughness (R_a) and the calculation of dimensional tolerance; the multiple objectives are then obtained. The multiple objectives can additionally be integrated and introduced as the S/N (signal to noise) ratio into the Taguchi experiment. The mean effects for S/N ratios are moreover analyzed to achieve the optimum turning parameters. Through the verification results, it is shown that both surface roughness and dimensional tolerance from present optimum parameters are greatly improved. Turning operation experiments

were carried out on a CNC lathe that provides the power to turn the work piece at a given rotational speed and to feed to the cutting tool at specified rate and depth of cut. Therefore three cutting parameters namely cutting speed, feed and depth of cut need to be optimized.

Therefore, three parameters (i.e. Speed, Feed & Depth of cut) as the input parameters and the dimensional tolerances & surface roughness as the output parameters are taken in the present experimental setup.

The feasible space for the cutting parameters was defined by varying the turning speed in the range 1000-1600rpm, feed in the range 0.02-0.04mm/rev. and depth of cut from 0.25 to 0.35mm. Three levels of each cutting parameters were selected as shown in table 1. Selected cutting parameters were fed with the help of in-built control panel of the CNC machine itself.

Parameters	Symbols	Units	Level – 1	Level - 2	Level – 3
Speed	A	Rpm	1600	1300	1000
Feed	B	mm/rev.	0.04	0.03	0.02
Depth of cut	C	Mm	0.35	0.3	0.25

Table 1: Parameters and their levels

1. Results:

The results have shown in the tables below

Exp.No.	Process Parameter levels		
	Speed A	Feed rate B	Depth of cut C
1	1600	0.04	0.35
2	1600	0.03	0.30
3	1600	0.02	0.25
4	1300	0.04	0.25
5	1300	0.03	0.35
6	1300	0.02	0.30
7	1000	0.04	0.30
8	1000	0.03	0.25
9	1000	0.02	0.35

Table 2: Experimental Layout Using an L-9 Orthogonal Array

Nine experiments are conducted for the above mentioned nine sets of parameters (speed, feed rate & depth of cut) and in each experiment 20 numbers of pieces are made and are checked with air gauge for dimensional tolerance and for surface roughness the pieces are tested. The average value of dimensional tolerance and surface roughness in microns are listed in table 2.

ExpNo.	Factor			Results
	Speed (A)	Feed (B)	Depth of Cut (C)	Dimensional Tolerance (Microns)
1	1600	0.04	0.35	2.192
2	1600	0.03	0.3	2.311
3	1600	0.02	0.25	2.157
4	1300	0.04	0.25	2.642
5	1300	0.03	0.35	2.810
6	1300	0.02	0.3	3.200
7	1000	0.04	0.3	2.186
8	1000	0.03	0.25	2.402
9	1000	0.02	0.35	2.900

Table 3: Experimental Results

The influence of the parameters are listed below

Sr. No	Factor	DOF	%P
1	A	2	59.99 %
2	B	2	23.18%
3	C	2	8.13%

Table 4: Analysis of Dimensional Tolerance

Conclusion

The above work, experimently verify that the Taguchi approch gives us the optimal parameters in the CNC turnning prcess using High Speed Steel cutting tools the optimum set of speed, feed rate and depth of cut and the most affecting parameters having the impact of 59.9% is Speed.

References:

[1] Kirby E. D., Zhang Z. and Chen J. C., (2004), "Development of An Accelerometer based surface roughness Prediction System in Turning Operation Using Multiple Regression Techniques", Journal of Industrial Technology, Volume 20, Number 4, pp. 1-8.)

[2] Feng, C. X., & Wang, X. F., 2003, Surface roughness predictive modeling: neural networks versus regression. IIE Transactions vol. 35(1), 11-27

[3] Gökkayaa, H., & Nalbant, M., 2007, The effects of cutting tool geometry and processing parameters on the surface roughness of AISI 1030 steel, Materials & Design, vol. 28(2), 717-721

[4] Lalwani, D.I. (2008). Experimental investigations of cutting parameters influence on cutting forces and surface roughness in finish hard turning of MDN250 steel. Journal of Materials Processing Technology, 206(1-3), 167-179.

[5] Özel, T., Hsu, T.-K., & Zeren, E. (2005). Effects of cutting edge geometry, workpiece hardness, feed rate and cutting speed on surface roughness and forces in

finish turning of hardened AISI H13 steel. International Journal of Advanced Manufacturing Technology, 25(3-4), 262-269.

[6] Benardos, P.G. & Vosniakos, G.C., Prediction of surface roughness in CNC face milling using neural networks and Taguchi's design of experiments, Robotics and computer integrated manufacturing, vol. 18 , 343-354.

[7] Dhavlikar, M.N., Kulkarni, M.S. & Mariappan, V., 2003, Combined Taguchi and dual response method for optimization of a centerless grindinrningg operation, Journal of Materials Processing Technology, vol. 132, 90-94.

[8] Vernon, A., & Özel, T. (2003). Factors affecting surface roughness in finish hard turning. Paper presented at the 17th International Conference on Production Research, Blacksburg, Virginia.)

[9] Feng C. X. & Wang X., 2002, Development of Empirical Models for Surface Roughness Prediction in Finish Turning, International Journal of Advanced Manufacturing Technology, Vol. 20, 348-356

[10] N. H. Rafai & M. N. Islam (2009) "An Investigation Into Dimensional Accuracy And Surface Finish Achievable In Dry Turning" Machining Science and Technology, Volume 13, Issue 4 October 2009 , pages 571 - 589)

[11] Tzeng Yih-fong 2006"Parameter design optimization of computerized numerical control turning tool steels for high dimensional precision and accuracy" Materials & Design, Volume 27, Issue 8, 2006, Pages 665-675

[12] Shouckry, A.S. , 1982 "The effect of cutting conditions on dimensional accuracy" Wear, Volume 80, Issue 2, 16 August 1982, Pages 197-205.

[13] Gilbert, W. W., 1950, Economics of machining. In Machining-Theory and practice. Am. Soc. Met., 476-480

[14] Armarego, E. J. A., Brown, R. H., 1969, The machining of metals (Englewood Cliffs, NJ: Prentice Hall) ASME 1952 Research committee on metal cutting data and bibliography. Manual on cutting of metals with single point tools 2nd edn.

[15] Brewer, R. C. & Rueda, R., 1963, a simplified approach to the optimum selection of machining parameters. Eng. Dig. Vol. 24 (9), 133-150

[16] Petropoulos P G 1973 Optimal selection of machining rate variable by geometric programming. Int. J. Prod. Res. 11: 305–314

[17] Chanin, M. N., Kuei, C.H. & Lin, C., 1990, Using Taguchi design, regression analysis and simulation to study maintenance float systems. Int. J. Prod. Res., vol. 28, 1939-1953