Journal of Basic and Applied Engineering Research
p-ISSN: 2350-0077; e-ISSN: 2350-0255; Volume 3, Issue 9; April-June, 2016, pp. 815-818

http://www.krishisanskriti.org/Publication.html

Optimization of CNC Turning Parameter for Roughness by Using Taguchi Method of EN 8

Dalip Kumar[1] and Kulbhushan Sharma[2]

[1,2]LR College of Engg. & Tech. Solan
E-mail: [1]dalipkumar57@gmail.com, [2]kulbhushan96@gmail.com

Abstract—*Quality and productivity play significant role in today's manufacturing market. From customers, viewpoint quality is very important because the extent of quality of the procured item (or product) influences the degree of satisfaction of the consumers during usage of the procured goods. Therefore, every manufacturing or production unit should concern about the quality of the product. Apart from quality, there exists another criterion, called productivity which is directly related to the profit level and also goodwill of the organization. Surface roughness is the main quality function in EN-24(carbon steel) in dry conditions. In this study, the effect and optimization of machining parameters (cutting speed, feed rate and depth of cut) on surface roughness is investigated. An L'27 orthogonal array,*

1. INTRODUCTION

Turning is the removal of metal from the outer diameter of a rotating cylindrical work piece. Turning is used to reduce the diameter of the work piece, usually to a specified dimension, and to produce a smooth finish on the metal. Often the work piece will be turned so that adjacent sections have different diameters. Turning is the machining operation that produces cylindrical parts. In its basic form, it can be defined as the machining of an external surface. Turning is practically very useful in case to produce shafts in case of all fields' aeronautical, agriculture, automobile and others. So that now we can say that to produce shape or machining operation we required to kept knowledge to produce best machining. The three primary factors in any basic turning operation are speed, feed, and depth of cut. Other factors such as kind of material and type of tool have a large influence, of course, but these three are the ones the operator can change by adjusting the controls, right at the machine. Speed always refers to the spindle and the work piece. When it is stated in revolutions per minute (rpm) it tells their rotating speed. But the important feature for a particular turning operation is the surface speed, or the speed at which the work piece material is moving past the cutting tool. It is simply the product of the rotating speed times the circumference of the work piece before the cut is started. It is expressed in meter per minute (m/min), and it refers only to the work piece. Every different diameter on a work piece will have a different cutting speed, even though the rotating speed remains the same.

Feed always refers to the cutting tool, and it is the rate at which the tool advances along its cutting path. On most power-fed lathes, the feed rate is directly related to the spindle speed and is expressed in mm (of tool advance) per revolution (of the spindle), or mm/rev.

Depth of cut is practically self-explanatory. It is the thickness of the layer being removed (in a single pass) from the work piece or the distance from the uncut surface of the work to the cut surface, expressed in mm. It is important to note, though, that the diameter of the work piece is reduced by two times the depth of cut because this layer is being removed from both sides of the work.

Nowadays, more and more Computer Numerical Controlled (CNC) machines are being used in every kind of manufacturing processes. In a CNC machine, functions like program storage, tool offset and tool compensation, program-editing capability, various degree of computation, and the ability to send and receive data from a variety of sources, including remote locations can be easily realized through on board computer. The computer can store multiple-part programs, recalling them as needed for different parts. The classes of cutting tool materials currently in use for machining operation are high-speed tool steel, cobalt-base alloys, cemented carbides, ceramic, and polycrystalline cubic boron nitride and polycrystalline diamond.

Different machining applications require Carbon steels have been used since the 1880s for cutting tools. However carbon steels start to soften at a temperature of about 180^{o}C. This limitation means that such tools are rarely used for metal cutting operations. Plain carbon steel tools, containing about 0.9% carbon and about 1% manganese, hardened to about 62 Rc, are widely used for woodworking and they can be used in a router to machine aluminum sheet up to about 3mm thick.

HSS tools are so named because they were developed to cut at higher speeds. Developed around 1900 HSS are the most highly alloyed tool steels. So as we can conclude that it is hard material with good strength.

2. EXPERIMENT DETAIL

2.1. Materials and Procedures

Highly stressed components of large cross section for aircraft, automotive & general enginery application such as propeller shafts, connecting rods, gear shafts, crane shafts & landing gear components, heavy forging, such as rotor shafts & discs. EN24 is capable of retaining good impact values at low temperatures; hence it is frequently specified for such as hydraulic bolt tensioners and ship borne mechanical handling equipment.

Table1: Chemical Composition of EN 24

C	Mn	Si	S	P	Cr	Ni	Mo
.4	.5	.2	0.35	.4	1.1	1.5	.3

Table 2: Level of turning Parameter of EN 24

LEVEL	Speed (rpm)	Feed (mm/Rev)	DOC (mm)	N.R. (mm)
L- 1	1500	0.22	0.5	0.4
L- 2	1600	0.24	0.75	0.8
L-3	1700	0.26	1	1.0

Table 3: L_{27} orthogonal array by Tguchi method

S.no.	Speed (rpm)	Feed (mm/rev.)	D.OC (mm)	Nose rad.	Ra
1	1500	0.22	0.5	0.4	2.442
2	1500	0.22	0.5	0.4	2.546
3	1500	0.22	0.5	0.4	2.402
4	1500	0.24	1	0.8	3.132
5	1500	0.24	1	0.8	2.316
6	1500	0.24	1	0.8	2.726
7	1500	0.26	1.25	1.2	1.652
8	1500	0.26	1.25	1.2	1.6
9	1500	0.26	1.25	1.2	2.26
10	1600	0.22	1	1.2	2.02
11	1600	0.22	1	1.2	1.61
12	1600	0.22	1	1.2	1.148
13	1600	0.24	1.25	0.4	2.656
14	1600	0.24	1.25	0.4	2.834
15	1600	0.24	1.25	0.4	2.72
16	1600	0.26	0.5	0.8	1.692
17	1600	0.26	0.5	0.8	2.464
18	1600	0.26	0.5	0.8	3.12
19	1700	0.22	1.25	0.8	2.332
20	1700	0.22	1.25	0.8	2.02
21	1700	0.22	1.25	0.8	2.37
22	1700	0.24	0.5	1.2	1.692
23	1700	0.24	0.5	1.2	1.86
24	1700	0.24	0.5	1.2	1.384
25	1700	0.26	1	0.4	2.55
26	1700	0.26	1	0.4	3.028
27	1700	0.26	1	0.4	2.452

2.2. Thermal Fatigue Test

The Roughness measurement has been done using a portable stylus-type Talysurf instrument. It is a portable, self-contained instrument for the measurement of surface texture. It is equipped with a diamond stylus having a tip radius 5 µm. The measuring stroke always starts from the extreme outward position. At the end of the measurement the pickup returns to the position ready for the next measurement. Roughness is defined as closely spaced, irregular deviations on a scale smaller than that of waviness. Roughness may be superimposed on waviness. Roughness is expressed in terms of its height, its width, and its distance on the surface along which it is measured.

3. RESULT AND DISCUSSION

3.1. Optimizing by Taguchi method

Experiments were designed using Taguchi method so that effect of all the parameters could be studied with minimum possible number of experiments. Using Taguchi method, Appropriate Orthogonal Array has been chosen and experiments have been performed as per the set of experiments designed in the orthogonal array. Signal to Noise ratios are also calculated for analyzing the effect of machining parameters more accurately.

Traditional experimental design methods are very complicated and difficult to use. Additionally, these methods also require a large number of experiments when the number of process parameters increases. In order to minimize the number of tests required, Taguchi experimental design method, a powerful tool for designing high-quality system, was developed by Taguchi. Taguchi method [1, 11, 18] uses a design of orthogonal arrays to study the entire parameter space with small number of experiments only. Taguchi recommends analyzing the mean response for each run in the array, and he also suggests to analyze variation using an appropriately chosen signal-to-noise ratio (S/N). There are 2 Signal-to-Noise ratios of common interest for optimization of static problems used in the study.

3.2. Roughness tester for EN24 material.

Before start using Minitab, need to choose control factors for the inner array and noise factors for the outer array. Control factors are factors that can control to optimize the process. Noise factors are factors that can affect the performance of a system but are not in control during the intended use of the product

Step 1|
Go to Minitab17 then **Stat > DOE > Taguchi > Create Taguchi Design** to generate a Taguchi design (orthogonal array). Each column in the orthogonal array represents a specific factor with two or more levels. Each row represents a run; the cell values identify the factor settings for the run. By default, Minitab's orthogonal array designs use the integers 1, 2, 3, to represent factor levels. If you enter factor levels, the integers 1, 2, 3, will be the coded levels for the design.

Step-2

After you create the design, you can use **Stat > DOE > Modify Design** to rename the factors, change the factor levels, add a signal factor to a static design, ignore an existing signal factor (treat the design as static), and add new levels to an existing signal factor.

Step-3

Conduct the experiment and collect the response data. The experiment is done by running the complete set of noise factor settings at each combination of control factor settings (at each run). The response data from each run of the noise factors in the outer array are usually aligned in a row, beside the factor settings for that run of the control factors in the inner array. Design to analyses the experimental data. It must analyses each response variable separately with Taguchi designs. . Although Taguchi analysis accepts multiple response columns, these responses should be the same. As the taguchi method is mostly used in the optimization.

Fig.2. Testing With the help of Roughness Tester

Fig.1. CNC Turning Machine

Table4:Ranking of Experiments

EXP. NO.	VALUE	RANK
26	0.757004	1
27	0.521942	2
15	0.520741	3
25	0.513665	4
8	0.506067	5

4. CONCLUSIONS

In the study as the work piece surface roughness tested by surface roughness tester.

Surface finish in turning has been found to be influenced by a number of factors such as cutting speed, feed rate and depth of cut. The various simple surface roughness parameters used in the industries such as average roughness (Ra), where f= feed rate (mm/rev) and R= tool nose radius (mm). It means that surface roughness increases with increasing feed rate and a large tool nose radius reduce surface roughness of the work piece.

- The analysis it reveals that feed rate and cutting speed are the main factors affecting more the surface roughness and vibration. Principal cutting edge angle and depth of cut are the least affecting factors.
- Feed is the most influential controlling factor on surface finish variation followed by turning speed.
- The depth of cut was found to be less insignificant on surface roughness but with decrease depth of cut surface roughness will decrease.
- Direct effect of cutting speed, depth of cut & cutting speed has influence on the measurement of surface roughness.

5. ACKNOWLEDGMENT

First of all, I would like to thank my worthy supervisor Mr. Kulbhushan Sharma Assistant Professor in the Department of Mechanical Engineering and Dr. Abhay Sharma, Principal, in L.R. Institute of Engineering and Technology, Solan. They provided me all possible guidance and support. They suggested me many ideas and solved my puzzles when I was in need.

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