ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering
(IJERMCE)
Vol 2, Issue 9, September 2017

Effect of Process Parameters on Mrr and Surface Roughness in Turning Process of En8

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Abstract: **Good surface quality and better material removal rate are desired for the proper functioning of the produced parts. It was seen that the desired surface roughness and material removal rate were not obtained consistently in turning of EN 8 steel applications (Camshaft). These higher values of surface roughness results in rework and increases cost hence the main objective is optimization of surface roughness and material removal rate a general optimization of surface roughness and material removal rate are deemed to be necessary for the most of manufacturing industry The surface quality and material removal rate are influenced by cutting speed, feed rate and depth of cut and many other parameters.**

In this study the effect of the machining parameters like spindle speed, feed and depth of cut on material removal rate and surface roughness are investigated, also optimum process parameters are studied. An L9 orthogonal array (mixed level design), analysis of variance (ANOVA) and the signal to noise (S/N) ratio are used in this study. Mixed levels of machining parameters are used and experiments are done on conventional lathe machine. EN8 or 080M40 is unalloyed medium carbon steel material is used it is suitable for manufacture of shafts, studs, keys, general purpose axles etc. The most significant parameters for material removal rate are depth of cut, speed and least significant factor for MRR is Feed, For surface roughness speed, depth of cut the most significant parameters and least significant factor for surface roughness is feed

***Index terms*— Reliability Analysis; Rackwitz-Fiessler Algorithm; Reliability Index; Probability of failure.**

I. INTRODUCTION

1.1 Turning operation

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 shave 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:-

1) ¾ with the work piece rotating.
2) ¾ with a single-point cutting tool, and
3) ¾ 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.

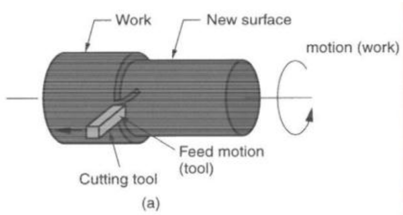

Fig 1.1: Adjustable parameters in turning operation

Taper turning is practically the same, except that the cutter path is at an angle to the work axis. Similarly, in contour turning, the distance of the cutter from the work axis is varied to produce the desired shape Exclude multiple-tool setups, which are often employed in turning. In such setups, each tool operates independently as a single-point cutter.

1.2 Adjustable cutting factors in turning

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.

1.2.1 Speed

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.

$$V = \frac{\pi}{1000} DN\ mm/min$$

Here, v is the cutting speed in turning; D is the initial diameter of the work piece in mm, and N is the spindle speed in RPM

1.2.2 Feed

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.

$$F = f \times N\ mm/min$$

1.2.3 Depth of cut

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

$$d_{cut} = D\text{-}d/2\ mm$$

Here, D is the initial diameter (in mm) of the job and d is the final diameter (in mm) of the job respectively.

1.2.4 Material Removal Rate (MRR)

The material removal rate (MRR) in turning operation is the volume of material/metal that is removed per unit time in mm3 /min. for each revolution of the workpiece, a ring shaped layer of material of material is removed.

MRR = {π× (D2-d2) ×l}/ {t×4} mm3 /min

Here, D is the initial diameter in mm,

d is the final diameter in mm,

l is the length in mm

t is the time taken for machining in

min

1.2.5 Surface Roughness

Surface roughness, frequently reduced to roughness ad it can be measure by the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. if these deviation are large, the surface is rough, if they are small the surface is smooth

2. METHODOLOGY

In full factorial design, the number of experimental runs exponentially increases as the number of factors, as well as their level increases. This results in a huge experimentation cost. So, in order to compromise these two adverse factors and to search for the optimal process condition through a limited number of experimental runs Taguchi's L9 orthogonal array consisting of 9 sets of data was selected to optimize the multiple performance characteristics of the turning process.

2.1 Taguchi Method

Taguchi method is a powerful tool for the design of high-quality systems. It provides a simple, efficient and systematic approach to optimize the designs for performance, quality, and cost. The methodology is valuable when the design parameters are qualitative and discrete. Taguchi parameter design can optimize the performance characteristics through the settings of the design parameters and reduce the sensitivity of the system performance to sources of variation. In recent years, the rapid growth of interest in the Taguchi method has led to numerous applications of the method in a world-wide range of industries and countries.

The DOE is sometimes too complex, time consuming and not easy to use. More trials have to be carried out when the number of process factors increases. The TM uses special, highly fractionated factorial designs and other types of fractional designs obtained from orthogonal (balanced) arrays to study the entire experimental region of interest for the experimenter, with the minimum number of trials as compared with the classical DOE, especially with a full factorial design. Fewer trials imply that time and cost is reduced. For example, for experiment with 3 factors at 3 levels, a full factorial design would require =27 trials. Using Taguchi's experimental design, the standard OA denoted by the symbol L9 requires only 9 trials.

2.2 ANOVA Method

In this section, ANOVA analysis is performed and experimentally it is observed that when different types of analysis methods such as Taguchi's methods, Regression Analysis etc…are used then we get accurate results. Taguchi's comprehensive system of quality engineering is one of the greatest engineering achievements of the 20th century.

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 9, September 2017

Taguchi methods focus on the effective application of engineering strategies rather than advanced statistical techniques. It includes both upstream and shop-floor quality engineering. In the present work Taguchi's parameter design approach is used to study the effect of process parameters on the various responses of the centre lathe on en8 material. The Taguchi philosophy and its associated experimental design method have been extensively used in the manufacturing environment to improve production processes.

Taguchi Design was applied in planning and conducting the experiments. In performance analysis we can also analyze the experimental data by using Minitab 18 software in some cases. But here it was not required. Generally S/N ratio and ANOVA analysis is the tool used for analysis purpose which measures the performance and contribution of individual process parameters towards the surface roughness, material removal rate and machining time. The regression model was postulated in obtaining the relationship between surface roughness, material removal rate, machining time and the input process parameters. Finally, the comparison between experimental and predicted values of the response was carried out.

3.EXPERIMENTATION EXPERIMENTAL EQUIPMENT

The Centre Lathe is used to machining cylindrical shapes from a range of materials including steels and plastics. Many of the components that go together to make an engine work have been machining using lathes. These may be lathes operated directly by people (manual lathes) or computer controlled lathes (CNC machines) that have been programmed to carry out a particular task. A basic manual centre lathe is shown in below fig 3.1 this type of lathe is controlled by a person turning

Fig 3.1: Centre Lathe Used For Turning

3.1 Table Specifications of Lathe

Name Of The Company	Samrat
Established Year	2004
Manufactured Place	Rajkot,Gujarat
Serial Number	G18
Type	2
Belt Drive Type	B Type
Minimum Speed	325
Maximum speed	775
Type Of Chuck	3-Jaw
Spindle bore	3 inch
Motor range	3 H.P
Current usage range	3 phase,440V
Gearing Drives	3 front,3 back drives
Centre height	10 inch

the various handles on the top slide and cross slide in order to make a product / part. The headstock of a centre lathe can be opened, revealing arrangements of gears. These are gears are sometimes replaced to alter the speed of rotation of the chuck. The lathe must be switched off before opening, although the motor should automatically cut off if the door is the speed of rotation of the chuck is usually set by using the gear levers. Accordingly the present study has been done through the following plan of experiment.

a) Checking and preparing the Centre Lathe ready for performing the machining operation.
b) Cutting EN8 bars by power saw and performing initial turning operation in Lathe to get desired dimension of the work pieces.
c) Calculating weight of each specimen by the high precision digital balance meter before machining.
d) Performing straight turning operation on specimens in various cutting environments involving various combinations of process control parameters like: spindle speed, feed and depth of cut.
e) Calculating weight of each machined plate again by the digital balance meter.
f) Measuring surface roughness and surface profile with the help of Portable Surface Roughness Tester (SURFTEST SJ-210 Series).
g) Measuring cutting tool flank wear in tool makers microscope.

3.1 Workpiece used

EN 8 grade bars (of diameter 30mm and length 105mm)

1. In this project we are using EN8 grade material. But also there are so many different types of materials such as
2. En1A, En3B, En8, En9, En14, En16, En19, En24, EN24T, En36.
3. EN means EUROPEAN NORMS.
4. EN8 is a very popular grade of through-hardening medium carbon steel, which is readily machinable in any condition. and also it costs very cheap
5. Manufacture of parts such as general-purpose axles and shafts, gears, bolts and studs.

Fig: 3.2 Raw materials

3.2 Roughness measurement

Roughness measurement has been done using a Portable Surface Roughness Tester (SURFTEST SJ-210 Series, Japan) shown in Figure 2.2. Portable SurfaceRoughness Tester SURFTEST SJ-210 Series is a portable, self-contained instrument for the measurement of surface texture

The parameter evaluations are microprocessor based. The measurement results are displayed on a 2.4" color LCD screen and can be output to an optional printer or another computer for further evaluation. The instrument is powered by rechargeable NI-MH battery. It is equipped with a stylus having a Selectable from the following items: Measuring force 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. The selection of cut-off length determines the reverse length.

Usually as a default, the traverse length is five times the cut-off length though the magnification factor can be changed. The SURFTEST has been set to a cut-off length of 0.5 mm, filter 2CR, traverse speed 5 mm/sec. Roughness measurements, in the transverse direction, on the work pieces have been repeated 0ne time of surface roughness parameter values has been recorded.

The measured test has been digitized and processed through the dedicated advanced surface finish analysis software for evaluation of the roughness parameters. Surface roughness measurement with the help of stylus has been shown in below Figure 3.3, 3.4 and surface finished materials also seen in fig 3.5

Fig 3.3: Portable Surface Roughness Tester Surf test Sj-210 Series

Fig 3.4: Photographic Of Stylus during Surface Roughness Measurement

Fig 3.5 Finished Materials

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ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
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Table 3.2 Process variable and their limits

Factors	Symbols	Level 1	Level 2	Level 3
Speed (RPM)	A	325	500	775
Feed rate mm/min	B	0.4	0.55	0.7
Depth of cut (mm)	C	0.2	0.5	1

Table 3.3 Taguchi's L9 Orthogonal Array

Exp No	A (Speed)	B (Feed)	C (DOC)
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

Table 3.4 Average Results of MRR and SR of EN8

Exp no	A (Speed)	B(Feed) mm	C (DOC)	MRR (Kg/min)	SR (µm)
1	325	0.4	0.2	124.1	5.48
2	325	0.55	0.5	968.7	9.34
3	325	0.7	1	2420.0	5.74
4	500	0.4	0.5	896.9	5.01
5	500	0.55	1	1793.8	5.36
6	500	0.7	0.2	2242.3	1.75
7	775	0.4	1	2425.6	3.22
8	775	0.55	0.2	2425.6	1.7
9	775	0.7	0.5	4746.5	2.54

3.3 Effect of machining parameters on MRR:

In response factors, the material removal rate (MRR), the larger-the- better characteristic was used. The fig in 3.6 are used to determine the optimal set of parameters from this experimental design. From the graphs, the control factor of spindle speed (A) at level 3 (775 rpm) showed the best result. Besides that, the feed control factor (B) provided the best result at the level 3 (0.7 mm/rev). On the other hand, the depth of cut control factor (C) showed the best result at the level 3 (1 mm). There were also no conflicts happening in determining the optimal spindle speed, feed rate and depth of cut while the criteria of the largest response and highest S/N ratio were followed. It is clear from the fig 3.6 shows that the spindle speed increases from 325 rpm to 775 rpm, feed from 0.4 to 0.7 rev/mm, depth of cut from 0.2 to 1mm then material removal rate also increased. Finally, speed, feed, depth of cut increases material removal rate (MRR) also increases. Material removal rate (MRR) is directly proportional to speed, feed, depth of cut

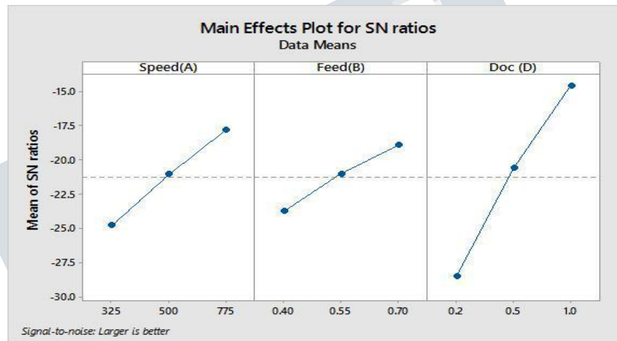

Fig: 3.6 Influence of machine parameters on S/N ratio for MRR

Optimum parameter settings (A3B3C3) A1=775rpm, B1= 0.7mm/rev, C1=1mm

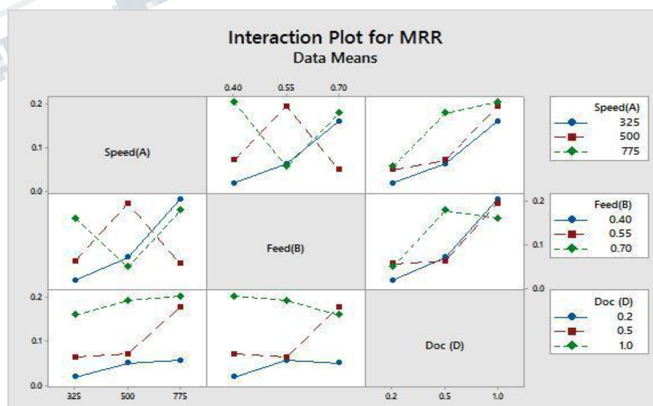

Fig: 3.7 Interaction with machine parameters on Signal to noise ratio of MRR

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 9, September 2017

Table 3.5 ANOVA for MRR

Source	DF	Ad$_J$ SS	Ad$_J$ MS	F-Value	P-Value
Speed (A)	2	0.006782	0.003391	3.50	0.222
Feed (B)	2	0.001708	0.000854	0.88	0.531
Doc (C)	2	0.032163	0.016081	16.62	0.057
Error	2	0.001936	0.000968		
Total	8	0.042588			

3.4 Effect of machining parameters on SR:

In response factors, the surface roughness (SR), the smaller-the-better characteristic was used. The fig. in 3.8 are used to determine the optimal set of parameters from this experimental design. From the fig, the control factor of spindle speed (A) at level 1 (325 rpm) showed the best result. Besides that, the feed control factor (B) provided the best result at the level 1 (0.40 mm/rev). On the other hand, the depth of cut control factor (C) showed the best result at the level 2 (0.5 mm). There were also no conflicts happening in determining the optimal spindle speed, feed rate and depth of cut while the criteria of the lowest response and lowest S/N ratio were followed.

It clear from the fig 3.8 it shows that the spindle speed increases from 325 to 775 rpm, the surface roughness is also increased. So, minimum surface roughness attained at 325 rpm only. The feed i.e. constant from 0.40 to 0.55 rev/mm, the surface roughness is minimum and acceptable range. Further, increases the feed, the surface roughness also increased. The depth of cut from 0.2 to 0.5mm, the surface roughness is increased. The minimum surface roughness attained at 0.5mm. Further, increase the depth of cut then the surface roughness also increases.

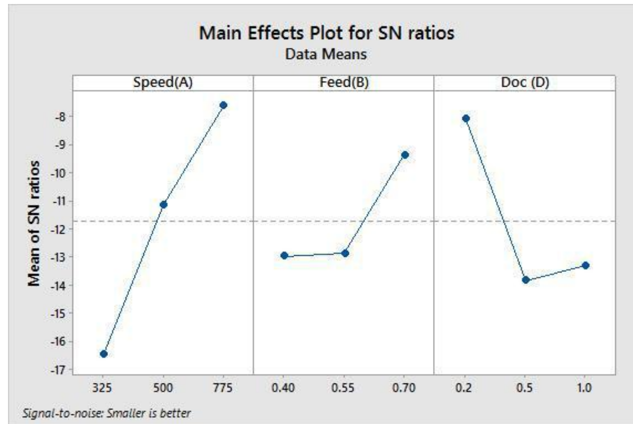

Fig: 3.8 Influence of machine parameters on S/N ratio for SR

Optimum parameter setting (A1B1C2) A1=325rpm, B1= 0.4mm/min, C2=0.5mm

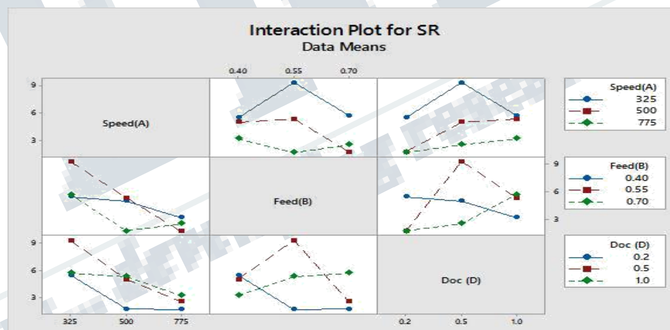

Fig: 3.9 Interaction with machine parameters on Signal to noise ratio of SR

Table: 3.6 ANOVA for SR

Source	DF	Ad$_J$ SS	Ad$_J$ MS	F-Value	P-Value
Speed(A)	2	29.3955	14.6977	50.39 8	0.019
Feed(B)	2	6.8173	3.4086	11.82	0.078
Doc (C)	2	11.0021	5.5010	19.08	0.050
Error	2	0.5766	0.2883		
Total	8	47.7914			

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
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3.5 Analysis of Variance (ANOVA) for MRR

3.5.1 Material Removal Rate (MRR)

Table 3.5 shows the F-test of each parameter on the material removal rate. It is showed that depth of cut has the most significant effect on the output response (MRR). Other significant parameters are spindle speed and feed

3.6 Analysis of Variance (ANOVA) for SR

3.6.1 Surface Roughness (SR)

Table 3.6 shows the F-test of each parameter on the surface roughness. It is showed that spindle speed has the most significant effect on the output response (MRR). Other significant parameters are depth of cut and feed

4. CONCLUSIONS

The present project work was carried out to study the effect of process parameter such as spindle speed, feed and depth of cut on the performance parameter such as material removal rate and surface roughness. The following conclusion has been drawn from the study. Material removal rate is mainly affected by spindle speed (15%), Feed (4%) and depth of cut (75%) while surface roughness is mainly affected by spindle speed (61%), feed (14%) and depth of cut (23%). The least significant parameter for material removal rate is feed (4%) and for surface roughness feed is (14%). Linear regression model and Taguchi mean estimation method is used to predict material removal rate and surface roughness. The process parameters considered in the experiments are optimized to attain maximum material removal rate. The best combination of process parameters for turning within the selected range is as follow: Cutting Speed 775 rpm, Feed 0.7 mm/rev, Depth of cut 1 mm. The process parameters considered in the experiments are optimized to attain minimum Surface Roughness (Ra). The best combination of process parameters for turning within the selected range is Cutting Speed 325 rpm, Feed 0.4 mm/rev Depth of cut 0.5 mm.

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