# Parameter Optimization of MRR for EN31 Alloy

**Sohan Saini[1] Vijayesh Rathi[2]**
[1]M. Tech. Student [2]Faculty
[1,2]Department of Mechanical Engineering
[1,2]Geeta Institute of Management & Technology (G.I.M.T), Kanipla, Kurukshetra, Haryana, India

*Abstract*— Turning is used to produce typically rotational and axis- symmetric parts that have amenities such as threads, grooves, holes, contoured surfaces, tapers and many other applications of commercial importance. In this study, the experiments have been conducted on central lathe machine on EN31. The tool used for turning process is a cemented carbide coated insert of rectangular shape. From the experiment work it is concluded that the process parameters cutting speed, depth of cut and feed rate with different readings which are taken into consideration affects the metal removal rate. In this study there are two output variables are calculated which are surface roughness and metal removal rate. Metal removal in turning is the removal of metal from outer periphery of a cylindrical work piece. It is used to minimize the diameter of the work piece to a specified dimension and to produce a smooth lustrous finish over the metal. In the beginning of experimental phase, pilot experiments will be performed for preliminary study. The various parameters speed (220,330,550), feed (0.15, 0.18, 0.23) and depth of cut (0.8, 1.2, 1.5) their ranges and levels will be selected based on results of the pilot study. Suitable Technique for orthogonal arrays will be used for design of experiments after the pilot experiments. Based on the findings done, actual experimentation work will be designed and input machining parameters and their values are finalized. The results are expected to show that the response variables (output parameters) strongly influenced by the control factors (input parameters). So, the results which are obtained after experimentation analysed and modelled for their application in manufacturing industry. The result shows that there is a significant increase in MRR with required combination of rotational speed, feed and depth of cut.

***Key words:*** MRR, MRR for EN31 Alloy

## I. INTRODUCTION

The lathe was very important to the Industrial Revolution. It is known as the mother of machine tools, as it was the first machine tool that leads to the invention of other machine tools. The lathe is an ancient tool, dating at least to ancient Egypt and known to be used in Assyria and ancient Greece. The origin of turning dates to around 1300 BCE when the Ancient Egyptians first developed a two-person lathe. One person would turn the wood work piece with a rope while the other used a sharp tool to cut shapes in the wood. Ancient Rome improved the Egyptian design with the addition of a turning bow. [1/34] In the middle Ages a pedal replaced hand-operated turning, allowing a single person to rotate the piece while working with both hands. The pedal was usually connected to a pole, often a straight-grained sapling. An important early lathe in the UK was the horizontal boring machine that was installed in 1772 in the Royal Arsenal in Woolwich. It was horse-powered and allowed for the production of much more accurate and stronger cannon used with success in the American Revolutionary War in the late 18th century. One of the key characteristics of this machine was that the work piece was turning as opposed to the tool, making it technically a lathe. Henry Maud slay who later developed many improvements to the lathe worked at the Royal Arsenal from 1783 being exposed to this machine in the Verbruggen workshop.

Turning is the removal of materials outside diameter of a rotating cylindrical work piece. As, is used to minimize the diameter of a work piece generally to a specific dimension and to produce a smooth finish over the metal. Also, the metal piece is turned so that the parts have different diameters. As machining operation produces cylindrical shape, in its first form, it can be defined as an outer surface machining with the work piece to be rotated, with the use of the cutting tool of single point and with the power cutter parallel to work piece to remove the outside surface of the metal piece. [1/29]

## II. EXPERIMENTAL DETAIL

### A. *Experimental Setup*

For the experiment the whole work is done on a Lathe Machine at the workshop of Geeta Institute of Management and Technology, Kurukshetra. The lathe machine used for the turning is of rpm ranging from 45 to 2000 rpm. The chuck position of the lathe machine is horizontal. The longitudinal range is 2440 to 2740 mm. The rectangular shape carbide coated tool is used for turning process. Experiments are conducted with different pieces of EN31 metal alloy. The rotational speed, depth of cut and feed rate is applied in various steps. The rotational speed is adjusted by the levers given on lathe front side according to the requirements of the speed. The other two parameters can also be change over the lathe machine itself. The required speed was achieved and experimentation process starts by providing optimum feed and depth of cut to achieve maximum metal removal rate.

### B. *Experimental Procedure*

The experiment is done on centre lathe machine using a cemented carbide coated insert tool and EN31 alloy work piece is selected of diameter 28mm and length 812.8mm. The rod is than cut into 9 equal parts. Experiment is carried out separately for all the work pieces by changing three parameters accordingly. The surface of all the pieces is cleaned to carry out turning operation and the first work piece is placed on the lathe chuck. Carbide tip tool is fixed in the tool post for the metal removing process. Now depth of cut is given 0.8mm, cutting speed 220 rpm and feed 0.15mm. After this the lathe machine is turned ON and the material is removed from half of the work piece according to the parameters taken. For second experiment depth of cut is given 1.2mm, cutting speed 220 rpm and feed 0.18mm. Now experiment is carried out separately for all the work pieces by changing three parameters accordingly. During the turning process a situation occurs when generation of heat take place but it has a minor effect on work piece and tool so it should be considered as negligible. After inserting the work piece lathe machine is started and the chuck rotation starts to perform further operation. When tool comes in contact with work piece it automatically starts to remove material from it as it moves in forward direction. In the end after the completion of turning operation the work piece is taken out of the chuck and next piece is packed into the chuck followed by seven other experiments in the same manner. Now, material removal rate is calculated for all the work pieces. Further, surface roughness of all work pieces is checked with the help of surface roughness tester.

### *C. Tool, Materials and Process Parameters*

Cutting may be accomplished by single-point or multipoint tools. Single-point tools are used in turning, shaping, planning and similar operations, and remove material by means of one cutting edge. The tool used in this process is cemented carbide coated insert in rectangular shape. The cutting edge of a cutting tool is a very important for the performance of the cutting process. The main features of the cutting edge are form of the cutting edge radius, Cutting edge angles (free angle and rake angle) and form and size of the chamfers. The shape of the tool is shown in the figure 1.

Fig. 1: Tool-Cemented Carbide Coated Insert

The work pieces that are turned by this process are in the form of circular rods of EN31 alloy of high quality. The rod of material EN31 of length 32 inches is divided into 9 equal parts of 3.55 inches by the help of cutting power hacksaw with the use of high speed steel blade having 1.25 *14 inch length and 10 TPI (Teeth per Inch) for conducting different experiments. The chemical composition of work piece material is shown in the table 1.

| Material | C | Si | Mn | Cr |
|---|---|---|---|---|
| EN31 | 0.90-1.20 | 0.10-0.35 | 0.30-0.75 | 1-1.60 |

Table 1: Chemical Composition of Material (%)

The experiments are done in the nine different parts. Experiment is carried out separately for all the work pieces by changing three parameters accordingly. First experiment is done on the depth of cut 0.8mm, cutting speed 220 rpm and feed 0.15mm. The second experiment is done on the depth of cut 1.2mm, cutting speed 220 rpm and feed 0.18mm. Now experiment is carried out separately for all the work pieces by changing three parameters accordingly. The tool is used of rectangular shape with coating of cemented carbide. The design of the process parameter is prepared on the basis of the Taguchi approach. The process parameters used in design of the experiment is shown in the table 2.

| Level No | Depth of Cut | Rotational Speed (rpm) | Feed Rate (mm/min) |
|---|---|---|---|
| 1 | 0.8 | 220 | 0.12 |
| 2 | 1.2 | 330 | 0.18 |
| 3 | 1.8 | 550 | 0.23 |

Table 2: Process Parameters

## III. RESULT AND DISCUSSION

This chapter provides the results of the Material Removal Rate (MRR) and Surface Roughness. Firstly MRR has been calculated from the different values of parameters i.e. cutting speed, feed rate and depth of cut and has been recorded. Initially the calculation of material removal rate is taken in to the consideration and after that surface roughness is calculated with the help of surface roughness tester. The result of experiment is shown in the table 3.

| C.S | Feed | D.O.C | Time | Initial Wt. | Final Wt. | Reduction in Wt. | $(W_i - W_f)/\rho_s t$ in $mm^3$ / sec |
|---|---|---|---|---|---|---|---|
| 220 | 0.15 | 0.8 | 46 | 310.5 | 303.0 | 7.5 | 163 |
| 220 | 0.18 | 1.2 | 32.2 | 296.5 | 284.5 | 12.0 | 364 |
| 220 | 0.23 | 1.5 | 25.8 | 292.0 | 279.5 | 7.5 | 484 |
| 330 | 0.15 | 1.2 | 33.5 | 299.5 | 289.0 | 10.5 | 313 |
| 330 | 0.18 | 1.5 | 23.4 | 290.0 | 277.5 | 12.0 | 534 |
| 330 | 0.23 | 0.8 | 17.8 | 299.0 | 292.0 | 7.0 | 393 |
| 550 | 0.15 | 1.5 | 20 | 301.0 | 284.0 | 17.0 | 850 |
| 550 | 0.18 | 0.8 | 13.1 | 301.5 | 293.5 | 8.0 | 610 |
| 550 | 0.23 | 1.2 | 10.6 | 300.0 | 290.5 | 9.5 | 896 |

Table 3: Calculation of MRR- Density 0.0077 $gm/mm^3$

### *A. Analysis for Signal to Noise Ratio*

The signal to noise (S/N) ratio is calculated for each factor level combination. The formula for the larger-is-better S/N ratio using base 10log is:

– S/N = -10log [mean of sum of squares of reciprocal of measured data]
– S/N = -10log [$1/Y^2$] Here Y= response for the given factor level combination. With the help of this formula we calculate the S/N ratio. The value of S/N Ratio is shown in table 4.

| C.S | Feed | Depth of Cut | MRR | S/N Ratio |
|---|---|---|---|---|
| 220 | 0.15 | 0.8 | 163 | 44.2437 |
| 220 | 0.18 | 1.2 | 364 | 51.2220 |
| 220 | 0.23 | 1.5 | 484 | 53.6969 |
| 330 | 0.15 | 1.2 | 313 | 49.9108 |
| 330 | 0.18 | 1.5 | 534 | 54.5508 |
| 330 | 0.23 | 0.8 | 393 | 51.8878 |
| 550 | 0.15 | 1.5 | 850 | 58.5883 |
| 550 | 0.18 | 0.8 | 610 | 55.7065 |
| 550 | 0.23 | 1.2 | 896 | 59.0461 |

Table 4: Signal to Noise Ratio

From the experiments it can be calculated that we obtained the best material removal rate at the speed of 550 rpm, depth of cut 1.2 mm and feed rate 0.23 mm/min. The test material after MRR is shown in Fig.2.

Fig. 2: Prepared Work Pieces

## IV. CONCLUSIONS

From the above experimental work it is concluded that the parameters which are taken in the considerations affect the mechanical properties of the material. It is also to be noted that some of the parameters have significantly affect the mechanical behaviour of EN 31.

The maximum MRR is obtained on the parameters i.e. cutting speed 550 rpm, feed rate 0.23 mm/min and depth of cut 1.2 mm.

There is also a considerable effect on surface roughness of the work piece while turning operation. The surface roughness is minimum with the parameters cutting speed 330 rpm, feed rate 0.15 mm/min and depth of cut 1.2mm.

Based on the above results and discussion, the following conclusions can be drawn accordingly.

| Physical | Optimal Combination | | |
|---|---|---|---|
| Requirements | C.S | F | D.O.C. |
| Maximum MRR | 550 | 0.23 | 1.2 |
| | Level-3 | Level-3 | Level-2 |

Table 5: Conclusions

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