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RESEARCH ARTICLE

OPTIMIZATION OF CUTTING PARAMETERS ON SURFACE ROUGHNESS OF MILD STEEL EN-8 USING TURNING OPERATION

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ABSTRACT

Machining is a vital part of production process in the manufacturing industries. With the advancing technology, chip cutting based machining (turning, milling, drilling etc.) methods still conserve their importance. Good surface finish not only assures quality, but also reduces manufacturing cost. Thus, the selection of cutting parameters, such as cutting speed, feed rate, depth of cut and cutting fluid, is very important as they directly affect the surface finish. In this study the cutting operations were carried out on a conventional lathe machine making turning operation at a different depth of cuts and spindle speeds keeping the feed rate constant with the help of uncoated carbide cutting tool bit. The operations were done in dry as well as wet conditions using vegetable oil as cutting fluid. After conducting the experiments, it has been found that surface roughness decreases with the increase of cutting speed and increases with increase in depth of cut. Also, the surface roughness decreases with use of the cutting fluid.

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INTRODUCTION

Metal cutting processes are industrial processes in which metal parts are shaped or the removal of unwanted materials (Ayodeji *et al*., 2015). In turning, higher values of cutting parameter offered opportunities for increasing productivity but it also involves greater risk of deterioration in surface quality and tool life. Turning operation is very important material removal process in modern industry. At least one fifth of all applications in metal cutting are turning operations (Saraswat *et al*., 2014). Turning is a form of machining, a material removal process, which is used to create rotational parts by cutting away unwanted material. The turning process requires a turning machine or lathe, work piece, fixture, and cutting tool. The work piece is a piece of pre-shaped material that is secured to the fixture, which itself is attached to the turning machine, and allowed to rotate at high speeds. The cutter is typically a single-point cutting tool that is also secured in the machine, although some operations make use of multi-point tools. The cutting tool feeds into the rotating work piece and cuts away material in the form of small chips to create the desired shape (Ayodeji *et al*., 2015).

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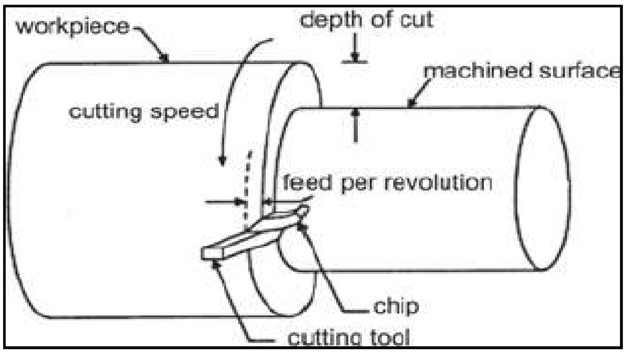

Fig. 1. Schematic Diagram of Turning Process

The main objective in present industrial era is to produce low cost quality product with required dimensions in an optimum time. Therefore the optimum cutting parameters are to be recognized first (Sonowal *et al*., 2015). In the study of metal cutting, a significant improvement in output quality may be obtained by optimizing the cutting parameters and this also ensures low cost manufacturing. For the optimum machining, these parameters should be in proper consideration like nature of cut to be made, feed, depth of cut, speed (Survase *et al*., 2015). The product quality depends on surface roughness (Ayodeji *et al*., 2015). Roughness plays an important role in

determining how a real object will interact with its environment. Surface roughness plays important role in many areas and is a factor of great importance in the evaluation of machining accuracy. Process parameter must have to control to obtain the desirable surface finish, because process parameters have significant influence on surface roughness (Patel and Patel, 2012). The need for selecting and implementing optimal machining conditions and the most suitable cutting tool has been felt over the last few decades (Rawat and Potdar, 2014). Thus, the selection of machining parameters, such as cutting speed, feed rate and depth of cut, is very important because they directly influence the problem (Abdallah *et al*., 2014).
Steel material used in manufacturing industries keeps improving progressively. Steel enjoys its diverse applications in areas such as food industry, health sector, automotive industry and space craft industry. It is for this reason that researches involving machinability of steel materials, their manufacturing efficiency and cost reduction are still among the most important studies (İNCE and ASİLTÜRK, 2015). Carbon steel is a metal alloy, a combination of two elements that are iron and carbon. The feasibility of using carbon steels depend on whether or not their properties (tensile, yield and fatigue, strength, impact resistance, need for heat treating etc.) are suitable for parts to be used (Ayodeji *et al*., 2015). Carbon steel is by far the most widely used kind of steel.

This study is aimed at obtaining the good surface finish that has been carried out under varying conditions during the machining.

Experimental Details

Design of Experiments

Design of experiment (DOE) is commonly used technique in analyzing experimental data resulting in the optimization of process parameters. A two level factorial design of (2^3 =8) eight trails were selected for determining the effect of three independent direct cutting parameters. Cutting speed, depth of cut and cutting fluid were identified as critical variables for carrying out the experimental work and to find their effect on the surface roughness. Upper and lower levels of the direct cutting parameters were carefully selected by carrying out the trail runs. The units, symbols used and limits of cutting parameters are given in the Table 1.

Table 1. Cutting Parameters and their Limits

Parameters	Units	Symbol	Upper Limit	Lower Limit
Cutting Speed	Rpm	S	+1	-1
Depth of Cut	mm	D	+1	-1
Cutting Fluid	---	O	+1	-1

The design matrix developed to conduct the eight trails run (2^3 factorial design) is given in Table 2.

Experimentation

Machining operations trails were carried out on conventional lathe machine with the help of uncoated carbide tip. cutting tool the material taken for investigation is steel grade steel grade EN-8 of diameter 50 mm and length 150 mm.

Table 2. Design Matrix

S No.	S	D	O
1	+	+	+
2	+	-	+
3	-	+	+
4	-	-	+
5	+	+	-
6	+	-	-
7	-	+	-
8	-	-	-

Work Material

EN-8 is a steel grade material used in this research work. EN-8 carbon steel is a common medium carbon and medium tensile strength steel, with improved strength through hardening medium carbon steel. EN-8 steel grade belongs to the standard of BS 970-1956, which is a standard for wrought steel for mechanical and allied engineering purpose.

Table 3. Chemical Composition of EN-8

Chemical composition	Carbon	Silicon	Manganese	Phosphorus	Sulphur
%	0.35-0.45	0.05-0.35	0.60-1.00	0.60 max.	0.60 max.

Process Parameters and their Working Range

Following are the process parameters considered in this research work.

Cutting Speed

Cutting speed (surface speed or simply speed) may be defined as the relative speed between the cutting tool and the surface of the work piece (Sharma *et al*., 2013). It is measured in terms of rpm (revolutions per minute).

Depth of Cut

The measurement of how wide and deep the tool cuts into the work piece. It is measured in terms of mm (milli-meter).

Cutting Fluid

Cutting fluids are used in metal machining for a variety of reasons such as improving tool life, improving the surface roughness and wash away chips from the cutting zone. In this study, soya bean oil is used as cutting fluid. This oil is a type of vegetable oil which comes under the category of straight cutting fluids.

Preparation of Work Piece

A rod of EN-8 material of diameter 50 mm and length of 150 mm was taken for experiment. Machining is done on convectional lathe machine using uncoated carbide cutting tool.

Table 4. Process parameters and their working range

Parameters	Units	Symbols	Upper Limit	Lower Limit
Cutting Speed	rpm	S	750	375
Depth of Cut	mm	D	3.0	1.5
Cutting Oil	………..	O	With fluid	Without fluid

Fig.2. Specimens after Machining

Testing Results

The responses or the results of surface roughness obtained by conducting experiments using design matrix are shown in Table 5.

Table 5. Observation Table for Surface Roughness

Trail Number	Surface Roughness in Set - I	Surface Roughness in Set –II
1	3.97	3.64
2	3.34	2.77
3	5.05	4.87
4	4.57	4.04
5	3.68	3.64
6	3.84	4.16
7	5.50	6.12
8	5.95	4.58

RESULTS AND DISCUSSION

Effect of Cutting Speed on Surface Roughness

It was found that increase in cutting speed results in decrease in surface roughness. Because at lower cutting speed, the built up edge (BUE) is formed and the chip fracture readily produce the rough surface. As the cutting speed increases, the BUE vanishes, chip fracture decreases and hence the surface roughness is decreased. When the cutting speed increases from 375 rpm to 750 rpm, the surface roughness decreases from 5.08µm to 3.63µm respectively. Effect of cutting speed on Surface Roughness is shown in Fig.3.

Effect of Depth of Cut on Surface Roughness

It was found that increase in depth of cut results in increase in surface roughness. Because at higher depth of cut, the cutting forces increase which results in increase in temperature of cutting zone and as a result of this, there is readily increase in the rough surface. As the depth of cut decreases, there is reduction in cutting forces and hence the surface roughness is decreased. When the depth of cut increases from 1.5 mm to 3.0 mm, the surface roughness increases from 4.15µm to 4.55µm respectively. Effect of Depth of Cut on Surface Roughness is shown in Fig.4.

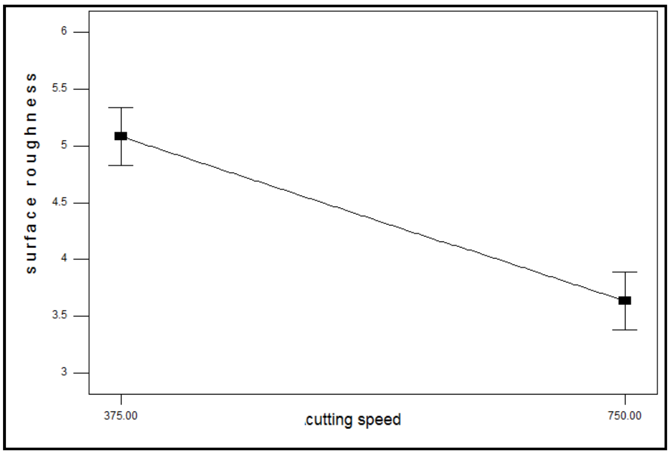

Fig. 3. Effect of Cutting Speed on Surface Roughness

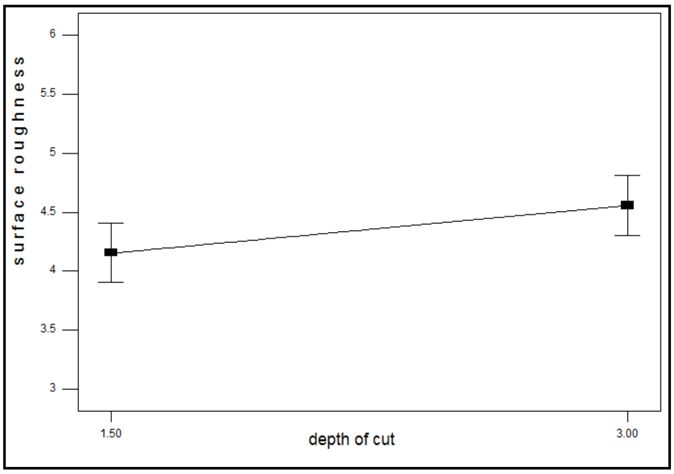

Fig. 4. Effect of Depth of Cut on Surface Roughness

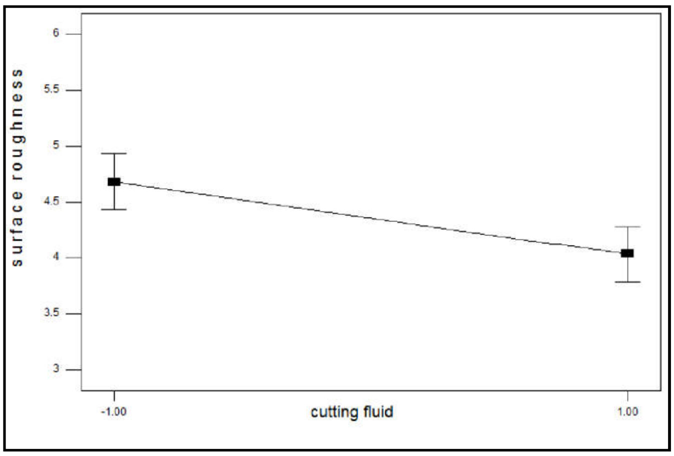

Fig 5. Effect of Cutting Oil on Surface Roughness

Effect of Cutting Oil on Surface Roughness

It was found that when the cutting oil is used the surface roughness decreases. This is because when the cutting oil is used the heat produced in the cutting zone becomes low which results in smooth cutting operation and hence the surface roughness decreases. When the cutting oil is used, the surface roughness comes out is 4.03µm. Effect of cutting oil on Surface Roughness is shown in Fig.5.

Conclusions

Following conclusions had been drawn from this research work:

1. Surface roughness is decreased with the increase of cutting speed. Surface roughness was maximum (5.08µm) at 375 rpm and minimum (3.63µm) at 750 rpm.
2. Surface roughness is increased with increase of depth of cut. Surface roughness was maximum (4.55µm) at 3.0 mm and minimum (4.15µm) at 1.5 mm.
3. Surface roughness is decreased with the use of cutting fluid. Surface roughness was maximum (4.68µm) by using of cutting fluid and minimum (4.03µm) at no use of cutting fluid.
4. Cutting parameters have significant effects on the surface roughness.
5. In wet condition, the machining surface is found smooth as compared to dry conditions due to reduction in temperature.

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