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Parametric Study on Turning of AISI 1040 Steel

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ABSTRACT

Turning is a most popular cutting process which is widely used in small as well as the large-scale industries. The selection of better combination of the input parameter be means enhancement in productivity. The aim of this paper is to the study effect of (Cutting Speed, Depth of cut, Feed rate) on surface roughness and to obtained the data.

Keywords : Turning , Cutting Surface Roughness , Design of experiment

I. INTRODUCTION

Turning is the primary metal cutting process in most of the production industries to get the critical feature with specific surface finish. In this process single point cutting tool remove the material in the form of chip from the rotating workpiece which is hold in the in three jaw chuck [1,2].In the production, industries are always facing a lot of difficulties like clamping, holding, chattering /vibration and dynamic instabilities etc. during machining of the rotating parts. Even through, it is the one of the most popular and industries processes for machining of the rotating parts. Even through, it is the one of the most popular and industrialized process for machining of the circular rotating parts among various existing traditional machining process [3, 4]. Turning generates axially symmetric with a single point cutting tool remove material by means of single cutting edge. In most cases the tool is hold in a fixed position with the workpiece which is rotating in neutral axis. The general process of turning involves rotating a part while single point cutting tool is moved parallel to the axis of rotation Turning is done on the external surface of the part as well as the internal surface [5] .The basic purpose of turning process are to remove the extra / unwanted material from the external as well as the internal surface of the rotating workpiece to get the specified dimension and surface quality [6] .The surface quality of Turned part mostly depend upon various process parameter. These parameters are controllable (cutting velocity, Feed rate Depth of cut, cutting fluid, tool material and tool signature etc) or uncontrollable (temperature, humidity, material composition, machine efficiency etc.) Among various controlled parameter, some process parameter like cutting velocity, Feed rate, Depth of cut work material and tool significantly affected the performance of the turning process [7,8]. Due to the importance of turning, researchers always make effort in improve the efficiency of the desired quality of product at low cost. The turning is also defined as the process in which a cutting tool typically a non-rotary tool bit , describable a helix tool path by moving more or less linearly while the workpiece rotates . Turning is a form of machining a material removal process while is used to create rotating part by cutting away unwanted material. The turning process required a turning or lathe workpiece is a piece of pre-shaped material that secured to the fixture itself is attached to the fixture. While itself is attached to the turning [9,10]. Turning is used for machining of the conventional as well as advanced and difficult-to machine engineering materials Due the potential in cutting technology , it accepted by small as well as large scale industries [11,12]. The wide applicability of the turning process makes it one of the better choice for the manufacturing industries to cut the material from both the surface i.e external as well as internal. Even through ,it suffer with several demerits like finish cut turning , in which several rough cut followers by finish cut turning [13,15].

II. EXPERIMENTATION

All the experiment performed on the centre lathe machine (MANUFACTURED By PAYAL MACHINE INDUSTRIES) .The workpiece is hold into chuck while tool hold into too post .The experiment is perform on the centre lathe machine. The experimental setup on lathe machine is shown in Figure -1.

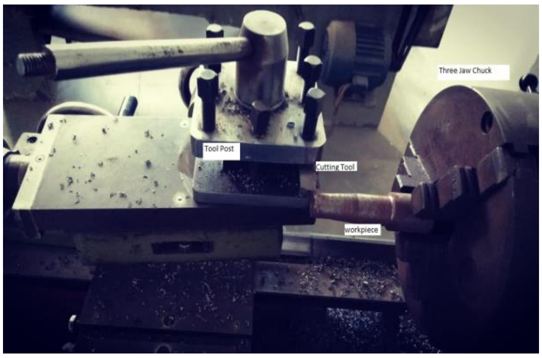

Figure -1Experimentation on Lathe Machine

The 9 –number of experiment is perform on the centre lathe machine during turning of alloys steel AISI1040 .For this experimentation Alloy Steel AISI 1040 (UNSG10400) was consider as a workpiece material .The ASISI 1040 alloy steel is used in coupling crankshaft and cold heated parts . The Chemical Composition of Alloy Steel AISI 1040 shown in Table -1

Table - 1 Chemical Composition of Alloy Steel AISI1040

Composition	Symbol	Percentage (%)
Chromium	Cr	0.80-1.10
Manganese	Mn	0.75-1.0
Carbon	C	0.380-0.430
Silicon	Si	0.15-0.30
Molybdenum	Mo	0.15-0.25
Sulphur	S	0.040
Phosphorous	P	0.035
Iron	Fe	Balance

The diameter of a workpiece is taken 30mm for easy to hold in three jaw chuck on centre lathe machine for the performing turning operation. The Single point cutting tool is removing the unwanted material for the desired workpiece. The Single point cutting tool consider for the operation made on High Speed steel (HSS) Material .The HSS cutting tool is taken for this turning operation because it is better tool for cutting of alloy steel at high Speed . High Speed steel cutting tools are subjected to intense friction, high heat wear resistance, high hardness and high red hardness to combat these problems.

Table -2 Specification of cutting tool

S. No	Parameter	Symbol	Value
1	Back Rack Angle	αb	5^0
2	Side Rack Angle	αs	5^0
3	Side Cutting Edge Angle	Υs	5^0
4	End cutting Edge	γ_e	7^0

	Angle		
5	Side clearance edge angle	Δs	15⁰
6	End Clearance Angle	δ_e	15⁰
7	Nose Radius	R	0.05mm

High speed steel (HSS) is subset of tool steels commonly used as cutting tool material. It is often used in power –saw Blades and drill bits. It is superior to the older high –carbon steel tool used extremely through the 1940s. In that it can withstand higher temperatures without losing its temper (hardness). This property allow HSS to cut faster than high carbon steel , hence the name high –speed steel . At room temperature, in their generally recommended heat treatment , HSS grade generally display hardness (above Rockwell 60) and abrasion resistance (generally linked to tungsten and vanadium content often used in HSS) compared with common carbon and tool steels .

A single point cutting tool consists of sharpened cutting parts called its point and the shank. The point of the tool is bounded by face (along which the chips slide as they are cut by the tool) , the side flank or major flank , the end flank and base . The side cutting Edge a-b formed by interaction of face and the flank .The chip are cut from the workpiece by side –cutting edge .The point where the end and side –cutting meet is called nose of the tool [9] . High speed steel are alloys that gain their properties from a variety of alloying metals added to carbon steel, typically including tungsten and molybdenum or a combination of the ,often with other alloy as well .They belong to the Fe –C-X multi-component alloy system where X represents chromium, Tungsten and Molybdenum, Vanadium or cobalt .Generally , the X component is present in excess of 70 % along with more than 0.60% carbon . The addition of about 10%of Tungsten and molybdenum in total maximizes efficiently the hardness and Toughness of High speed Steels and maintain those properties at the high temperatures generated when cutting metals.

This case of increased in depth of cut reduce the cutting speed and reduce the spindle speed of the three jaw chuck in centre lathe machine .The surface roughness value measured by a TR-200 surface measuring instrument in this instrument least count (1 micron) .The surface roughness measured by TR-200 instruments in three different condition of a cylindrical workpiece .The TR-200 instrument show that Figure-2

Figure-2 Measurement of Surface Roughness (Ra)

For Experimentation three Parameter are selected for turning of AISI1040 Alloy steel (AISI1040) the range and Level of each parameters summarised in Table -3

Table -3 Experiment and their values

Parameter	**symbol**	**Value**		
Cutting Speed (mm/min)	V	20	30	40
Feed Rate(mm/rev)	F	0.25	0.5	0.75
Depth of cut(mm)	D	0.5	1	1.5

III. RESULTS AND DISCUSSION

A. Parametric Studies:

The effect of each control Parameter (Cutting Speed , Feed rate , Depth of cut) on Ra of the turned surface of alloy steel (AISI1040) workpiece were analysed . All experiment was performed according to one parameter at a time approach. Which was a factorial design of experiment technique.According to this technique one parameter is varied within a range while the other parameter is varied within a range while the other parameters are kept constant .This approach is suitable for identifying the appropriate ranges of the control parameters lathe machine setup .

The factors and their corresponding values that were used in the experiment were performed using a centre lathe machine and the experimental observation are summarised in the Table -4.The influence of each parameters on Ra was analysed for three difficult categories of the depth of cut (0.5mm),Semi finish cut (1mm) and (1.5mm) to identify quality of turned surface .

Effect of Cutting Velocity: The effect of varying cutting velocity on Ra is shown in Figure -3 for constant values of feed rate (0.25mm/rev) and depth of cut (0.5mm) .The Ra value of turned surface decrease with increasing cutting velocity during the finish cut turning, which is followed by semi finish cut turning .This is because the workpiece material become softer with increasing cutting velocity owing to the generation of the heat and subsequent thermal softening of workpiece. As a result result softening of workpiece .As a result there is a reduction in the required cutting force and cutting tool remain cutting abilities for a long time consequent, the turning become easier and a better surface finish has been obtained.

Figure-3 also show that Ra decrease when the cutting velocity increase from 20 to 30 mm/min .After that roughness of turned surface increased the cutting velocity during rough turning, while semi finish turning and finish turning show only small improvement in surface quality .Initially a better surface finish was obtained owing the thermal softening of the workpiece with increased cutting velocity. During rough cut turning, the cutting resulted in a larger depth of cut .Crosses ponding, higher cutting force were required along with higher cutting force were required along with higher frictional forces at the tool –chip interface.

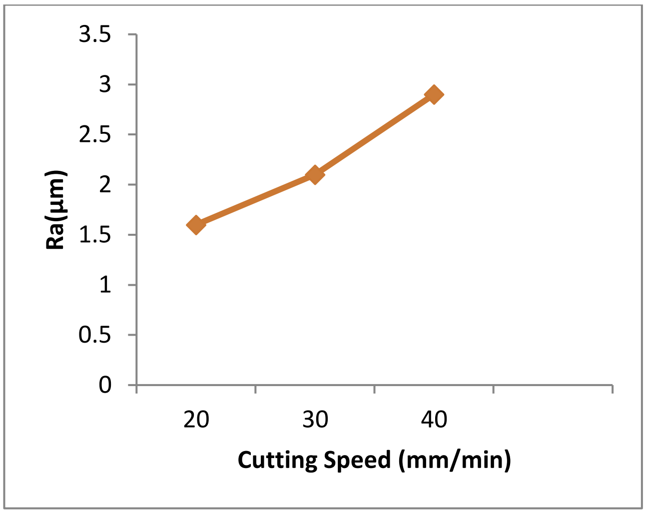

Figure-3 Effect of Cutting Velocity on Surface Roughness

Effect of Feed Rate : The effect of varying the feed rate on Ra is shown in Figure -4 with constant cutting velocity (20mm/min) and depth of cut (0.5mm) and different values of depth of cut .It was observed that Ra increased with feed rate per revolution .An increase in feed rate significant an increase of the chip thickness .As a result , there was an increase in the reputed cutting force because the cutting force was directly proportional to the cutting chip thickness .Consequently a greater amount of heat was generated at the tool tip –workpiece interface . This caused the cutting edge of the cutting tool to become softer and lose its hot hardness strength and therefore its cutting ability .This phenomena resulted in higher roughness values corresponding to higher feed rates during turning operation.

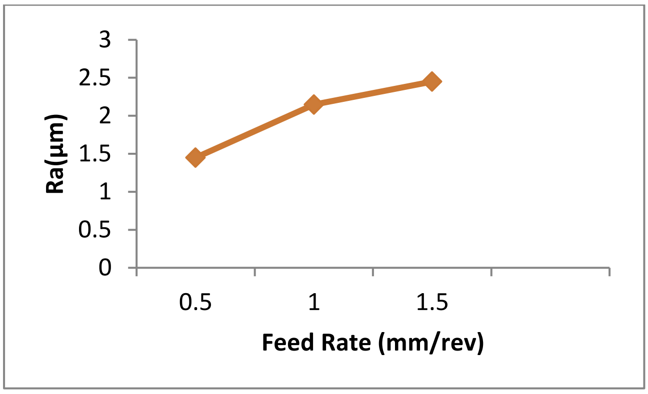

Figure-4 Effect of Feed rate (mm/rev) on Surface Roughness

Effect of Depth of Cut (mm) : The effect of the varying depth of cut on Ra is shown in Figure -5 with constant cutting velocity (20m/min) , Feed Rate (0.25mm/rev) and depth of cut (0.5mm) .It can be seen in Figure-5 that Ra increase with depth of cut and constant cutting velocity . This was owing to the fact that increasing the depth of cut in turn increased the width of the chip thickness. Consequentially, the cutting force also increased .This resulted in thermal softening of the cutting tool wear and ultimately an adequate surface finish.

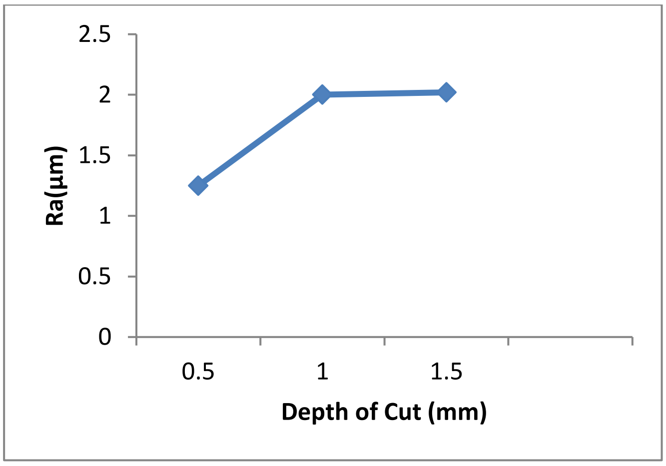

Figure-5 Effect of Depth of cut (mm) on Surface Roughness

B Data Collection: For the analysis of experiment data 9- number of experiment are conducted at the centre lathe machine. The data obtained in this experiment as input control parameters cutting speed, feed rate, depth of cut to produce output Ra surface roughness. Data summarised in Table-4

S. No	Cutting Speed(mm/min)	Feed rate(mm/ rev)	Depth of cut(mm)	Average Ra
1	20	0.25	0.5	2.2
2	20	0.5	1	2.01
3	20	0.75	1.5	1.75
4	30	0.25	1	2.1
5	30	0.5	1.5	2.71
6	30	0.75	0.5	1.97
7	40	0.25	0.5	2.06
8	40	0.5	1.5	2.5
9	40	0.75	1	2.44

C Percentage of contribution: To find the present of experimentation and analysis of variance (ANOVA) technique applied. Generally ANOVA is a statistical technique used to analyse the experimental observation data collect by the experimenter using standard experimental techniques .This is widely use to separate the total variability established between the random and systematic parameters . It is also used to determine the impact of independent variables on the dependent variable on the dependent variables during analysis of the regression models. There are many test used to know the adequacy of the data such as values as Sum of square (SS) ,Mean sum of Square ,Degree of freedom (DF), Mean Square Error (MSE) , F-value , P-value , F -critical value determined and summarised in Table-5.

Factor	SS	DF	MSS	F-value	P-value	F-Critical	PC (%)
v	77.04	2	38.52	1.44	1.84E-10	2.816708	90
F	1711.5	2	855.7	32.08			5
D	77.04	2	38.52				5
Error	53.34	2	26.67				
Total	1918.92	8	959.41				

It has been observed that the cutting velocity highly influencing parameter on the average surface roughness during turning of the alloy steel within range of the selected input parameters .The percentage of contribution of each factor for the Ra as cutting velocity =90%, feed rate =5%, depth of cut =5% has been obtained by ANOVA analysis as show in Figure-6.

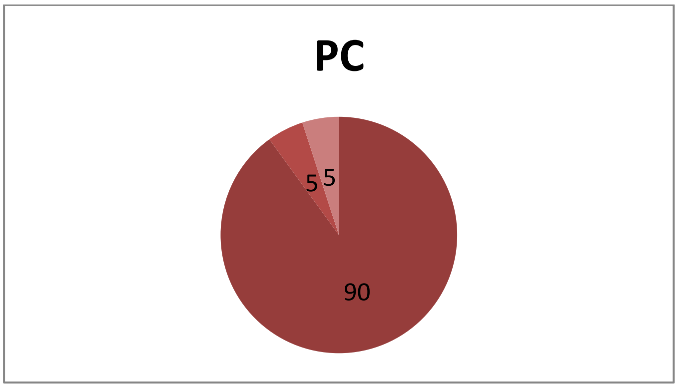

Figure-6 Percentage of Contribution of each Parameter

V. CONCLUSION

In present study made an effort has made to parametric Study of AISI1040 Alloy steel .The graphically represent the effect of the controlled parameter such as cutting speed , feed rate ,depth of cut has analysed the average surface roughness (Ra) .From the result analysis following conclusion were down. This experimental study result show the effect of control parameter cutting speed , feed rate ,depth of cut on surface roughness Ra. This paper aim is what is effect on control parameters cutting speed , feed rate ,depth of cut on surface roughness Ra The increase and decrease control parameters directly effect on surface finish during turning of AISI1040 alloy steel. The data is obtained as percentage of contribution by using ANOVA technique.

1- A Higher cutting Velocity is more suitable for achieving a better surface finish with finish or semi finish cut turning, owing to the thermal softening of the workpiece material. Despite this the combination of higher cutting velocity with rough cut turning does not produce a better surface finish.

2-Surface Roughness deteriorates with higher feed rate is used owing to the non –over lapping nature of the turning cycle during each revolution.

3-The first depth of cut does not affect the surface quality or surface finish significantly the surface quality and finish totally depend upon secondary depth of cut .

4-The combination of of lower feed rate and a smaller depth of cut result in better surface quality during turning of alloy steel 1040.

5-The turning process optimum condition better (approximate 1.44 times) initial condition surface finish compared to turning of alloy steel.

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