Experimental observation of turning operation using Al-6063 on single point cutting tool with different feed rate and spindle speed for different depth of cut

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Abstract- The use of engineering materials has increased to a great extent in the industries. To increase the quality of the machined parts during turning process is considered as the main challenge of industries. So it is required to find the optimum parameters in order to have easy and economical machining. Material removal rate affects the productivity and in turn the cost of manufacturing. This paper presents the optimization of material removal rate (MRR). Metal cutting processes are performed on metal cutting machines, more commonly termed as "Machine tools" by means of various types of "cutting tools". One major drawback of metal cutting or machining process is the loss of material in the form of chips. There are many machines which can perform the different operation like: boring machine to make a hole, grinding machine to sharpen the tool, milling machine to make slot, gears, but the most important machine tool is the lathe, which performs many operations. Turning constitutes the majority of lathe work. The cutting speed, resulting from feeding the tool from right to left, removes a surface layer of the work piece is in the form of chips, it will produce three cutting forces components, i.e. main cutting force, which acts in the direction of cutting speed, feed force, which acts in feed rate direction and thrust force, which acts normal to the cutting speed. The research indicate that the cutting forces are directly depends on the cutting parameters like cutting speed, feed rate, depth of cut, work piece material, tool. The present work involves the experimental investigation of MRR and using single point cutting tool for a turning operation in the orthogonal cutting. The experiments are carried on different spindle speeds for the different depth of cut on specially designed cutting tool.

1. INTRODUCTION

Due to the advancement of technology demand of the hour is increasing and maintaining operation is the economic production with the optimal use of resources is of main concern for the engineers. One of them is metal machining. During time of machining operation is to be facing many types of the challenges and engineers face challenges like to find out the optimal parameters and is to be maximize the performance of machine and production rate as well as manufacturing and the desired product quality is most important factor using the available resources. Superior attention is given to dimensional accuracy of machine and product, the hardness of material and surface finish[1]. An important parameter is surface quality. Lathe machine is a type of a machine and chuck is holding the work piece and tool is mounted on a tool post, the lathe machine is on and chuck is rotating the workpiece about an axis and the different type operations is to be performing such as turning, The turning operation is to be remove the metal from the workpiece in the form of the outer diameter of the rotating cylindrical work piece. Turning operation fundamentally reduced the diameter of the work piece usually into specified dimension and finally produced final product is in the form of finish product. The turning operation is most important type machining procedure and performing and producing the cylindrical type parts and this operation is basically defined as external surface is to be machined. The cutting tool inserted in tool holder turning operation is used in manufacturing of machine components, engine cylindrical components, shafts and other rotational components. While selecting a material, various factors must be considered such as the cost, resistance to wear, strength and machinability.

2. LITERATURE REVIEW

S.R. Daset al [1] this experiment conducted on the Tungsten AISI 4340 steel and using Coated Graphite tool inserts on tool post. Feed is most important factor in machining operation and feed is to be found and most significant parameter for the work piece surface roughness (Ra) with a percent contribution of 52.55%. Cutting speed contributed of 25.85% and considered significant parameter for Ra with Depth of cut had a negligible impact in case of Ra.

Jitendra. M. Varma et al [2] conducted experiments on AISI 4340 using solid lubricant with coated carbon tool inserts. It is start that the use of solid lubricant in dry machining has caused in a feasible alternative to cutting fluid, providing it is applied properly. There is enough improvement in surface roughness and quality of product produced.

Karanam Krishna et al [3] execute an investigation of material removal rate on Aluminum in turning by using ANN. This work researched the effect of the operating parameters like, depth of cut, feed rate, clamping length & spindle speed. Error in the dimensions of the machined component is studied by the operating parameters. Feed rate& depth of cut effected more on the accuracy than the other parameters. ANN predicted that before commencing the actual machining operation, the NC program could be corrected, hence accuracy of the components improved at less cost and time.

A.Sathyavathi et al [4]carried a study on different researches conducted. The most of researchers are interested in optimization of machining condition with corresponding surface roughness. In past reviewed found, none of researcher involved for TiBN coated cemented carbide tool. In this paper uncoated carbide tool and PVD (TiBN) coated carbide tool involved for performance of quality of surface and optimization of cutting parameter with aid of DOE and GA. **M.M.A. Khan et al [5]** carried out on study to analyze the effects of minimum quantity lubrication liquid is used in machining operation on turning AISI 9310 alloy steel using vegetable oil-based cutting fluid. They decided that the chips produced under both dry and wet condition are of ribbon type continuous chips at lower feed rates and more or less tubular type continuous chips at higher feed rates. The prime contribution of MQL jet is to reduce the flank wear by machining the low alloy steel and by the carbide insert, which improves the tool life Oenanthe productivity (MRR)provide higher cutting velocity and feed. The Surface finishes also improved mainly due to reduction of wear and damage at the tool-tip by the application of MQL.

M. Venkata Ramana et al [6]carried experiments to study the effect of process parameters on tool wear in Turning of Titanium Alloy under different machining conditions It was concluded that the advantages of MQL machining is that it reduces tool wear as well as environmental issues, which reduces the friction between the tool-chip interaction .In ANOVA ,role of cutting speed is more followed by tool material, depth of cut, feed rate and then coolant condition which help in minimizing the wear of tool.

VikasB. Magdumetal [7] carried out investigation to evaluate and enhance/optimize the machining parameters for turning of EN 8 steel using, Carbide, HSS M2 and Cermet tools.

N.Zeelan Basha et al [8]optimized turning process parameters on Aluminum 6061 using Genetic Algorithm. Optimum surface finish was obtained at maximum cutting speed, minimum feed and minimum depth of cut.

Y.B. Kumbhar et al [9] investigated tool life and surface finish optimization of PVD TiAlN/TiN multi-layer coated Carbide tool inserts in semi hard turning of hardened EN-31 alloy steel under dry cutting conditions. Maximum tool life is obtained at low cutting speed, moderate feed and depth of cut. Feed rate was found to be the most significant factor for tool life. Feed rate was also the most significant factor for surface roughness.

Gopal Krishna, P. V et al [10] studied the effect of cryogenic processing and carried out experiments on cryogenic treated tools in turning. Significant influence is seen on tool life which gets improved up to 90%. It has been concluded that the tool life enhanced by cryogenic treatment while machining both soft and hard materials. The most productive at high speeds and feeds are carried by cryogenic treated tools.

Feng and Wang [11] The considered for the experimental data and estimation of surface roughness in finish turning operation by developing an experimental data through considering machining work and using the machining parameters: work piece hardness (material), feed, cutting tool point angle, depth of cut, spindle speed, and cutting time is most important type parameter. To develop the empirical model to predict the surface roughness, techniques like Data mining, nonlinear regression analysis with logarithmic and most efficient type data transformation were employed.

3. WORK MATERIALS

Aluminum alloy is used this experimental work. This aluminum alloy is 6063 material is used and materials was obtained in the form of cylindrical type work piece. Find most widely used around the world become very popular in Asian. This aluminum alloy 6063 can be made into plates and coils and finds used in the field of architectural application and windows and door frames, pipe and tubing and also used in the field of aluminum furniture.

Table 3.1 of chemical composition

S NO	Elements	% wt
1	Aluminum	97.25
2	Chromium	0.05
3	Copper	0.05
4	ferrite	0.30
5	Magnesium	0.85
6	Manganese	0.05
7	Silicon	0.50
8	Tin	0.05
9	Zinc	0.05

Figure 3.2 Mechanical Properties of Al-6063

S. NO	Property	Value
1	Density	2.7 g/cm
2	Yield strength	195 Mpa
3	Ultimate strength	240 Mpa
4	Hardness	75 BHN
5	Shear strength	150 Mpa
6	Fatigue strength	65 Mpa
7	Poisson’s ratio	0.33

4. EXPERIMENTAL SETUP AND INITIAL PREPRATION

A center lathe machine is used in this experiment and performing the machining operation. The cutting tool is clamped into a tool holder and this is mounted on the tool post. The tool post is also mounted on all assembly of the carriage. The job is attached with the help of the chuck of the lathe. The turning operation is done and job or work piece is held by chuck. The setup is to be completed and runs have been carried out form here. This machine is as shown in the figure below. The material is to be removed from the work-piece with the help of center lathe machine by providing linear motion of tool towards work-piece in form of chips.

5. DESIGN OF EXPERIMENTS

Taguchi replaces the full factorial experiment with a lean, less expensive process, and this process is faster, partial factorial experiment. Taguchi's design is type of the partial factorial design is based on specially developed OA's. Since this partial experiment is only a sample type of the full experiment, and this analysis is the partial experiment must include an analysis of the self-confidence that can be placed in the results. Fortunately, there is a standard statistical technique called Analysis of Variance (ANOVA) which is routinely used to provide a quantity of confidence.

Table 5.1: L9 Orthogonal Array

Exp. No	Speed (Rpm)	Feed Rate	Depth of cut
1	150	0.1	0.5
2	150	0.2	0.7
3	150	0.3	0.9
4	250	0.1	0.7
5	250	0.2	0.9
6	250	0.3	0.5
7	350	0.1	0.9
8	350	0.2	0.5
9	350	0.3	0.7

6. Calculation of MRR

Table 6.1 Calculation of MRR

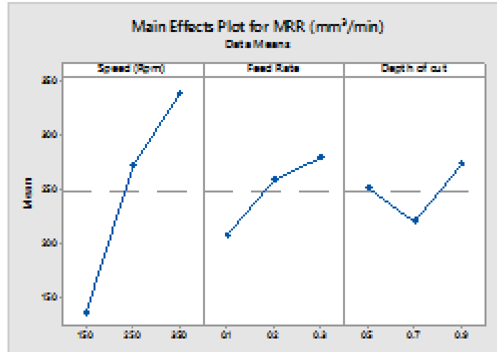
Exp. No	Speed (Rpm)	Feed Rate	Depth of cut	MRR (mm^3/min)
1	150	0.1	0.5	111.256
2	150	0.2	0.7	121.666
3	150	0.3	0.9	174.886
4	250	0.1	0.7	185.353
5	250	0.2	0.9	318.642
6	250	0.3	0.5	309.252
7	350	0.1	0.9	325.271
8	350	0.2	0.5	334.572
9	350	0.3	0.7	353.159

In this thesis work, the output for the given input data has been obtained in the form of general regression model. This technique is to be used with the help of MINITAB 18. It is possible to obtain the output value in this equation. The whole method is to be used with the help of analysis of variance is used in this work and provide the MINITAB 18.

Table: 6.2 ANOVA for MRR

Source	**DF**	**Adj SS**	**Adj MS**	**F-Value**	**P-Value**	**Contribution (%)**
Speed (Rpm)	2	63394	31696.8	46.47	0.021	82.121
Feed Rate	2	8190	4095.0	6.00	0.143	10.609
Depth of Cut	2	4247	2123.7	3.11	0.243	5.505
Error	2	1364	682.0	-	-	1.765
Total	8	77195	-	-	-	100%

The above ANOVA table 6.2 showing that the data feed rate and speed and depth of cut are most important factor and the most dominating parameters for material removal rate and has major influence on machining parameter. The contribution of speed towards material removal rate is 82.121% while that of feed rate is 10.609% Depth of cut also has some influence on material removal rate and contributes only 5.505% towards it.



The graph on previous page presents the main effect plot for mean of MRR. It is clear that as we increase the process parameters, the MRR tends to increase. MRR increases with increase in all the parameters of turning. As depth of cut increases, MRR increases because higher material is cut as the thickness of material that is to be removed from the work piece has been increased. On the other hand, feed rate is the most influential parameter for MRR and has a contribution of 10.609%. Moreover, the cutting speed is found to be the second most dominating factor for material removal rate and observed to have a contribution of 82.121%. As the cutting speed increases, the material is removed at a faster rate and hence MRR increases.

Optimal Levels of Parameters for MRR

For MRR the optimal level of parameters are as follows

Table 6.3 Optimal level of parameter for MRR

Process variables of factors		**Optimum level**
Depth of Cut	**mm**	0.9
Feed	**mm/rev**	0.3
Speed	**RPM**	350

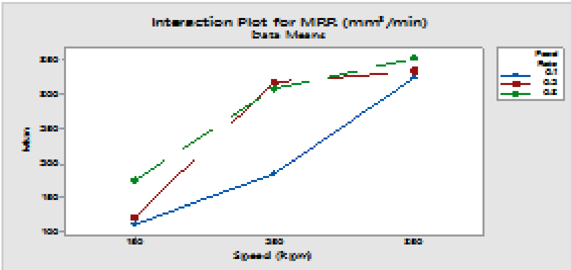


Figure 6.2: Interaction Plot between MRR and Plain turning parameters

The above Figure 6.2 illustrates the interaction of MRR with plain turning parameters. It is seen from the plot that at lower feed rate, the MRR increases almost linearly with increase in the level of cutting speed. At highest level of feed i.e. 0.2 mm/rev, the MRR initially decreases with increase in cutting speed, but with further increase in value of cutting speed the MRR tends to increase. At highest level of feed rate, the MRR initially increases with cutting speed but get reduced with further level of spindle speed.

7. CONCLUSIONS

Material removal rate is increases with increases spindle speed and feed rate, depth of cut.
Optimal condition of speed is obtained at 350 rpm and MRR is increases.
Feed rate increases and MRR is also increases slowly increases. But optimal condition of feed rate is 0.3 obtained.
Depth of cut is increases with MRR increases and depth of cut rapidly increases. The optimal condition of MRR is obtained at 0.9.
MRR is increases at 350 rpm spindle speed, feed rate 0.3 mm/rev and depth of cut 0.9 mm.

6. REFERENCES

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