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Effect of Feed rate on Material Removal Rate, Surface Roughness and Machining Time of Aluminum Alloy 6063 in CNC Turning

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ABSTRACT

The main objective of today's manufacturing industries is to produce low cost and high quality product in short time. Turning is a very important machining process in which a single-point cutting tool removes material from the surface of a rotating cylindrical work-piece. In general, CNC lathe machine is operated with several controllable factors such as spindle speed, depth of cut, feed rate etc. This present work focuses on CNC turning of aluminum alloy 6063 using carbide tool for varying feed rate. The results revealed that the feed rate is the most important parameter that affects the material removal rate, surface finish and machine time in CNC turning process.

Keywords: Feed Rate, Material Removal Rate, Surface Roughness, Machining Time, Aluminum.

I. INTRODUCTION

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. It is done with a single point cutting tool. The three primary factors in any basic turning operation are cutting speed, feed, and depth of cut. Other factors which further influences the machining are type of material, size of work, tool geometry, lubricant etc. The accuracy, surface finish, precision which is achieved through CNC cannot be done or achieved through conventional process. Nowadays, more and more CNC machines are being used in every kind of manufacturing processes.

Aluminum alloys have been widely used in industrial applications due to its low cost, corrosion resistance, light weight and other attractive mechanical and thermal properties. The classes of cutting tool materials currently in use for machining operation are high speed tool steel, cobalt-base alloys, cemented carbides, ceramic, polycrystalline cubic boron nitride and polycrystalline diamond. Different machining applications require different cutting tool materials. In industry today, carbide tools have replaced high-speed steels in most applications. Carbide steel has more high cutting speed and is 4- 7 times higher than high – speed steel. Carbide is much harder, so it has a longer tool life and faster cutting data than conventional high speed steel. Cemented carbide is a powder metal product consisting of fine carbide particles cemented together with a binder of cobalt. The major categories of hard carbide include tungsten carbide, titanium carbide, tantalum carbide, and niobium carbide. The cutting fluid is any liquid or gas that is applied to the chip and/or cutting tool to improve cutting performance. A very few cutting operations are performed dry, i.e., without the application of cutting fluids. Generally, it is essential that cutting fluids be applied to all machining operations. The main purpose of using cutting fluid is to decrease cutting temperature, reduce friction between tool and work piece, extend tool life, and improve machining efficiency and surface quality. Metal removal rate and surface roughness are important for describing the quality of the product. Metal removal rate directly affects the cost of the product and time of manufacturing. Surface roughness is an important measure of product quality since it greatly influences the performance of mechanical parts as well as production cost. Surface roughness has an impact on the mechanical properties like fatigue behavior, corrosion resistance, creep life, etc. It also affects other functional attributes of parts like friction, wear, light reflection, heat transmission, lubrication, electrical conductivity, etc.

II. LITERATURE REVIEW

Deepak D et al [1] investigated the effect of operating parameters such as feed rate, cutting speed and depth of cut on the material removal rate. Also, the effect of using coolant on material removal rate while turning is also determined. The result show that the material removal rate increases with increase in feed rate. Machining of the work piece by the supply of coolant is found to produce higher material rate compared to machining without using coolant.

C.John Joshua et al [2] investigated the effect of cutting speed, depth of cut and feed rate on material removal rate, machine time and surface roughness for turning of aluminium alloy 6063A. Selected machining parameters are the cutting speed of 500, 1000 and 1500 rpm, feed rate of 0.1, 0.15 and 0.2 mm/rev. From the experimental results they observed that machining time in CNC turning is greatly influenced by feed rate.

M. Sree Praveen Chowdary et al [3] have studied material removal rate and surface roughness on turning operation using CNC lathe. The process parameters used in the experiment were spindle speed, feed rate, and depth of cut. The results showed that feed rate, depth of cut and spindle speed are the most important parameter influencing the material removal rate and surface roughness. The surface roughness was found at cutting speed of 150 m/min, depth of cut of 0.6 mm and feed of 0.4 mm/rev. Whereas, at cutting speed of 630 m/min, depth of cut 0.7mm and feed of 0.6 mm/rev, the maximum material removal rate was obtained.

Maske K.V et al [4] worked on the effect of insert nose radius and machining parameters including cutting speed, feed rate and depth of cut on surface roughness and material removal rate in a turning operation are investigated by using Taguchi Grey Relational Analysis. For this work they used three spindle speed range from 225 to 715rpm, three feed range from 0.1 to 0.2 mm/rev, three depth of cut range from 0.1 to 0.3mm and three nose radius range from 0.4 to 1.2 mm. The results revealed that the feed rate and nose radius are the most important parameters that affect the surface finish and material removal rate (MRR) in CNC turning process is greatly influenced by depth of cut followed by cutting speed.

Palash Biswas et al [5] investigated the effect of cutting speed, feed rate and depth of cut on surface roughness during turning of aluminium alloy. From this investigation they concluded that an increase in depth of cut surface roughness value also increase when the other two variables are fixed. Likely with an increase in feed rate surface roughness value also increases when the other two variables are fixed.

Mahendra Korat et al [6] have conducted and experimental investigation on turning of En24 alloy steel. Five parameters were chosen as process variables: speed, feed, depth of cut, nose radius, cutting environment (wet and dry). It is predicted that nose radius, depth of cut, feed rate, cutting speed and coolant condition affects the material removal rate and surface roughness.

T. S. Pawar et al [7] investigated the effect of spindle speed (800, 900, and 1000), feed rate (80, 100, and 120) and depth of Cut (0.5, 0.8, and 1.0) on surface roughness in CNC turning operation. The experiments were performed on 2024-T3 Aluminium material using Taguchi method. The result shows that optimum level for surface roughness is obtained as 800 m/min of spindle speed, 80 mm/min of feed and 0.8mm of depth of cut.

T. Nithyanandhan et al [8] have investigated the influence of process parameters on surface finish and material removal rate. In this work, stainless steel work pieces are turned on conventional lathe by using tungsten carbide tool. The results showed that the feed and nose radius is the most significant process parameters on work piece surface roughness. However, the depth of cut and feed are the significant factors on material removal rate.

M.V.R.D Prasad et al [9] has analyzed turning parameter of cylindrical parts. The machining parameter are selected in this work are cutting speed, feed and depth of cut. The results predicted that the surface roughness increased with increase of speed and depth of cut is not influencing much on roughness but the roughness value increasing non linearly with increasing feed.

III. METHODS AND MATERIAL

The material and tool selected was aluminum 6063 and carbide tool respectively. The specimen is prepared with the dimensions of 80mm length and 25mm diameter for turning. This alloy is part of the 6000 series of alloys. It is a medium strength alloy, which is used for applications such as railing, window frames, door frames, roofs, sign frames, shop fittings, irrigation tubing, building products, electrical, marine, piping, recreation equipment, storage tanks, truck frames & trailers. The chemical composition of aluminium alloy 6063 is depicted in table-1.

Table-1: Chemical composition of aluminium alloy 6063

Chemical composition	
Element	**Content (%)**
Silicon	0.20-0.60
Iron	0.35 max
Copper	0.1 max
Manganese	0.10 max
Magnesium	0.45-0.90
Chromium	0.1 max
Zinc	0.1 max
Titanium	0.1 max
Other elements	0.15 max
Aluminum	Bal

The experiments were conducted on a high precision CNC Turning centre. The work piece was mounted on a chuck and the CNC program for machining is entered according to the selected parameters.

IV. RESULTS AND DISCUSSION

The results of the machining experiment for material removal rate, surface roughness and machining time were as tabulated in Table-2.

Table-2 : Cutting parameters and the experimentation results.

S. No	Spindle speed (rpm)	Depth of cut (mm)	Feed (mm/rev)	Material removal rate (mm³/min)	Surface roughness (μm)	Machining time (min)
1	600	0.3	0.05	697.6	0.419	1.368
2	600	0.3	0.10	1395.3	0.871	0.684
3	600	0.3	0.15	2092.6	1.638	0.456
4	600	0.3	0.20	2790.1	3.276	0.342
5	600	0.3	0.25	3486.9	3.582	0.273

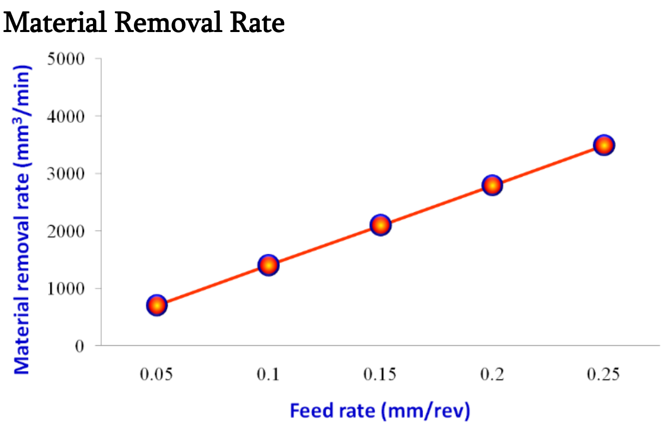

Figure-1: Effect of feed rate on material removal rate

The analysis diagram for the material removal rate during machining of the CNC turning of aluminium alloy is displayed in figure -1. It can be observed from the results that material removal rate increases with the increase in feed rate. The material removal rate required is maximum for maximum production rate so the optimum value of material removal rate is 3486.9mm³/min which is obtained at feet rate of 0.25mm/rev. The influence of cutting fluids on the material removal rate and surface roughness during turning of aluminium alloy was investigated by Swaraj Samanta et al [10]. They used water, coconut oil and mustard oil as cutting fluids. Results concluded that the cutting fluid has a influence on the material removal rate. Yakala Mani Ratnam et al [11] has experimentally investigated the effects of machining parameters such as cutting speed, feed, depth of cut on the surface roughness and material removal rate of EN8 steel. The result show that the material removal rate increases with increased feed rate.

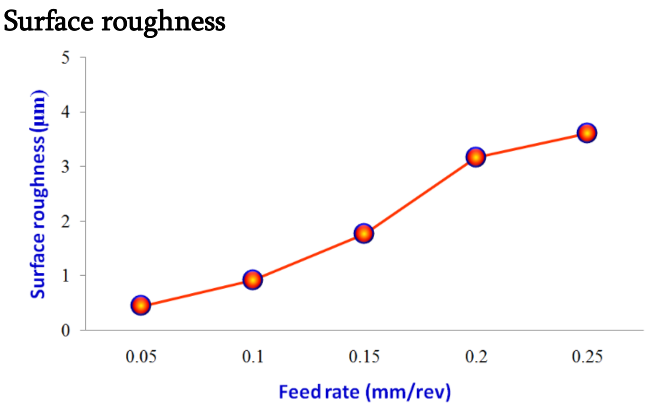

Figure-2: Effect of feed rate on surface roughness

The analysis graph for surface roughness during machining of the CNC turning of aluminium alloy 6063 is shown in figure-2. The depth of cut was kept at 0.3mm throughout, but feed rate was varied from 0.05mm/rev to 0.25mm/rev in steps of 0.05mm/rev. Increase in feed rate results in an upsurge in values of roughness. The surface roughness is influenced by the most important factors such as: cutting parameters, tool geometry, build-up edge, process time, work piece and tool material, tool wear, machine condition appliance of cutting fluids. N. Satheesh kumar et al [12] investigated the effect of process parameters in turning of carbon alloy steels in a CNC lathe. The parameters namely the spindle speed and feed rate are varied to study their effect on surface roughness. The five different carbon alloy steels used for turning are SAE8620, EN8, EN19, EN24 and EN47. Based on this study they concluded that the surface roughness increases with increased feed rate. J. Kouam et al [13] have conducted and experimental investigation on turning of aluminum alloy 6061-T6 material. For this work they use three cutting speed range and three feed range (0.0508-0.2845 mm/rev) with constant depth of cut. The result shows that the surface roughness increases as feed rate increases.

Machining time

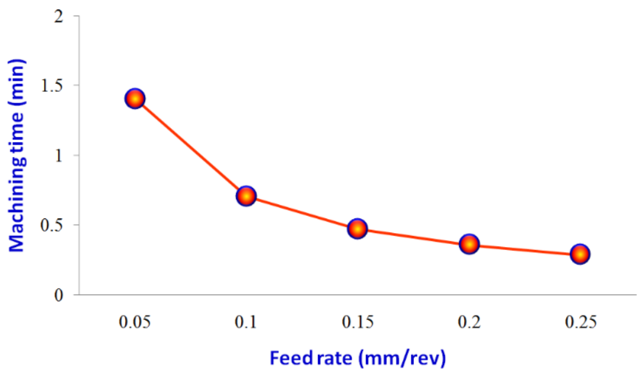

Figure-3: Effect of feed rate on machining time

The effects of feet rate on the machining time as shown in figure-3. It was increased from 0.05mm/rev to 0.25mm/rev in steps of 0.05mm/rev, by keeping the depth of cut constant at 0.3mm throughout. It is seen from these figures that the machining time decreases with increase in the feed rate. M. Dhanenthiran et al [14] investigated the effect of various cutting parameters on the surface roughness, material removal rate and machining time of Al 6063 aluminium alloy. They selected speed 800, 1200, 1600 rpm. Feed (mm/rev) 0.1, 0.2, 0.3 and depth of cut (mm) as 0.04, 0.06, 0.08. From this investigation they concluded that machining time decreases as feed rate increases. Alagarsamy.S.V et al [15] has analyzed the effect of cutting parameters on the material removal rate and machining time of aluminum alloy 7075. The machining parameter are selected in this work are cutting speed, feed, depth of cut. The results predicted that the machining time decreased with an increase of feed rate.

V. CONCLUSION

Following conclusions are drawn from the present experimental work

- It is observed that the feed rate is most influential process parameters that influence material removal rate, surface roughness and machining time.
- Material removal rate and surface roughness are found to increase with increase in feed rate.
- The machining time in turning decreases with increase in feed rate.

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