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Experimental Investigation of Material Removal Rate, Surface Roughness and Machining Time in CNC Turning of Aluminium Alloy 7075

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ABSTRACT

In recent manufacturing industry, one of the trends is to manufacture low cost and produce high quality products 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, feed rate, depth of cut etc. This work focuses on CNC turning of aluminium alloy 7075 using carbide tool for varying feed rate. The results show that feed rate is the most important parameter that affects the material removal rate, surface roughness and machine time in CNC turning process.

Keywords: CNC turning, material removal rate, surface roughness, machining time, aluminium, feed rate, cutting parameter.

1. INTRODUCTION

Today every manufacturing industries try to improve their quality and fulfill the customer requirement. Turning is one of the machining processes which involve removal of unwanted material from the surface of a rotating work piece. 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. In a CNC machine, functions like program storage, tool offset and tool compensation, program-editing capability, various degree of computation, and the ability to send and receive data from a variety of sources, including remote locations can be easily realized through on board computer. The computer can store multiple-part programs, recalling them as needed for different parts.

Aluminium alloys are popularly used in most of the modern day applications due to its low cost, light weight and other attractive mechanical and thermal properties. Machinability of this material possesses relative easiness compared to other metals. 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. These carbide and coated carbide tools cut about 3 to 5 times faster than high-speed steels. 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. Cutting fluid (coolant) 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. Cutting fluids are used in metal machining for a variety of reasons such as improving tool life, reducing workpiece thermal deformation, improving surface finish and flushing away chips from the cutting zone. 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.

2. LITERATURE SURVEY

Maske K.V and Sawale J.K. [1] 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.

Arjun Pridhvijit et. al [2] had optimized cutting parameters for the surface roughness in CNC turning machining with Aluminium alloy-2014. Taguchi method is used to find optimum result. The result shows that better surface finish is achieve at low feed rate (0.05mm/rev), high cutting speed (314m/min) and at high depth of cut.

M. Sree Praveen Chowdary et. al [3] have optimized the cutting parameters like spindle speed, feed rate, and depth of cut for minimization of surface roughness and maximization of material removal rate in CNC turning of mild steel. The results showed that feed rate, depth of cut and cutting speed are the most important parameter influencing the surface roughness and material removal rate. 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.

Ali Abdallah et al. [4] have conducted and experimental investigation on turning of aluminum alloy 6061 material. The cutting parameters focused in this work are speed, depth of cut, feed rate and the response are surface roughness, material removal rate. It is predicted that feed rate, cutting speed, and depth of cut affect the material removal rate and surface roughness.

Mahendra Korat et al [5] investigated the effect of cutting parameters on En24 alloy steel using Taguchi technique. Five parameters were chosen as process variables: speed, feed, depth of cut, nose radius, cutting environment (wet and dry). Their Experimental results shows that nose radius, depth of cut ,feed rate, cutting speed and coolant condition affects the material removal rate and surface roughness.

3. METHODOLOGY

The material and tool selected was aluminium 7075 and carbide tool respectively. The specimen is prepared with the dimensions of 90mm length and 25mm diameter for turning. This alloy is part of the 7000 series of alloys. As such, its major alloying element is zinc. Zinc is added to increase strength. It also contains chromium and copper. The chemical composition of AA 7075 is depicted in table-1.

Table-1: Chemical composition of AA 7075

Chemical composition	
Element	**Content (%)**
Silicon	0.40 max
Iron	0.50 max
Copper	1.20-2.00
Manganese	0.30 max
Magnesium	2.10-2.90
Chromium	0.18-2.8
Zinc	5.10-6.10
Titanium	0.20 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.

4. 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: Experimental results

S.No	Spindle speed (rpm)	Feed rate (mm/rev)	Depth of cut (mm)	Material removal rate (mm^3/min)	Surface roughness (µm)	Machining time (min)
1	720	0.05	0.3	826.2	0.436	1.407
2	720	0.10	0.3	1647.6	0.912	0.706
3	720	0.15	0.3	2458.7	1.761	0.472
4	720	0.20	0.3	3265.0	3.169	0.356
5	720	0.25	0.3	4072.8	3.613	0.285

Material removal rate

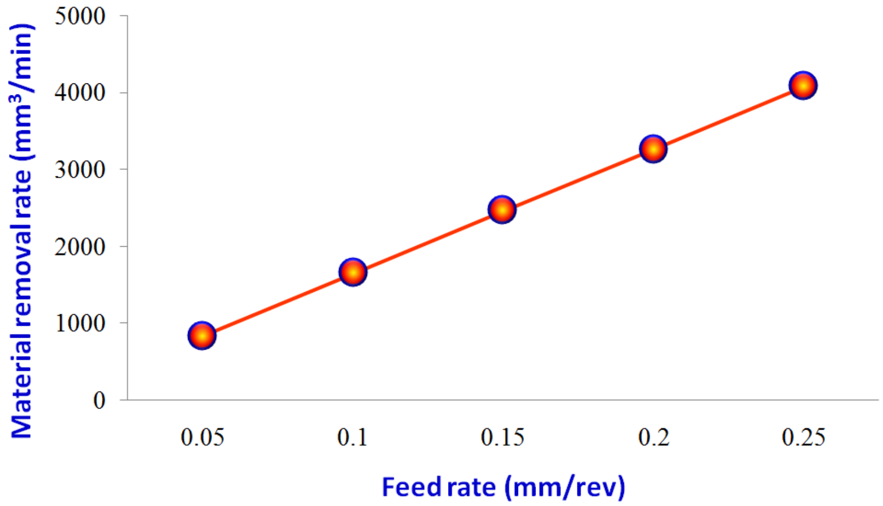

Figure-1: Effect of feed rate on material removal rate

The analysis diagram for the material removal rate during machining of the CNC turning of AA7075 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 4072.8mm^3/min which is obtained at feet rate of 0.25mm/rev. Swaraj Samanta et al [6] they determined the influence of cutting fluids on MRR and surface roughness during turning of Al 6061 alloy. They used water, coconut oil and mustard oil as cutting fluids. Their experimental results show that the cutting fluid has a influence on the material removal rate. S. Dhanalakshmi et al [7] reported that the fluid flow rate is the most significant factor that influences the material removal rate. Deepak D et al [8] investigated the effect of operating parameters such as cutting speed, feed rate and depth of cut on MRR. Also, the effect of using coolant on MRR while turning is also determined. Results concluded that 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. Girish Tilak et al [9] In this study used EN1A steel and investigated the effect of machining parameters on material removal rate, surface roughness and machining time. They conclude that theoretical value of material removal rate is more compared to actual values of material removal rate. They also conclude that material removal rate increases with increase in feed rate. T. K Durga Bhavani et al [10] studied the effect of spindle speed, feed rate and depth of cut on material removal rate and Surface roughness, in turning of aluminium, copper and gunmetal using tungsten carbide tip on CNC Lathe machine. The results revealed that the feed rate increases material removal rate increases for aluminum, copper and gunmetal.

Surface roughness

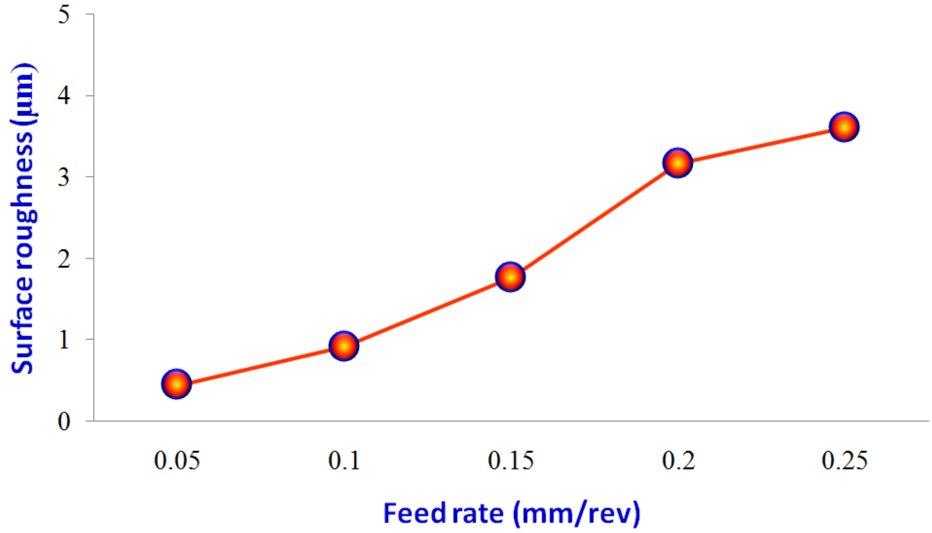

Figure-2: Effect of feed rate on surface roughness

The effects of feet rate on the surface roughness as 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 (coolants and lubricants). Tadiparthi Chaitanya et al [11] reported that the cutting fluid has a major influence on the surface finish. S. Dhanalakshmi et al [7] reported that the fluid flow rate is the most significant factor that influences the surface roughness. J. Kouam et al [12] had optimized cutting parameters for the surface roughness in CNC turning machining with aluminum alloy 6061-T6 material. For this work they use three cutting speed range from 79.40 to 661.54 m/min and three feed range from 0.0508-0.2845 mm/rev with constant depth of cut 1mm. From this investigation they concluded that surface roughness increases as feed rate increases. N. Satheesh Kumar et al [13] 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. The study reveals that the surface roughness is directly influenced by the spindle speed and feed rate. It is observed that the surface roughness increases with increased feed rate. T. K Durga Bhavani et al [10] reported that the surface roughness increases with increase in material removal rate. This statement can clearly be seen from table-2.

Machining time

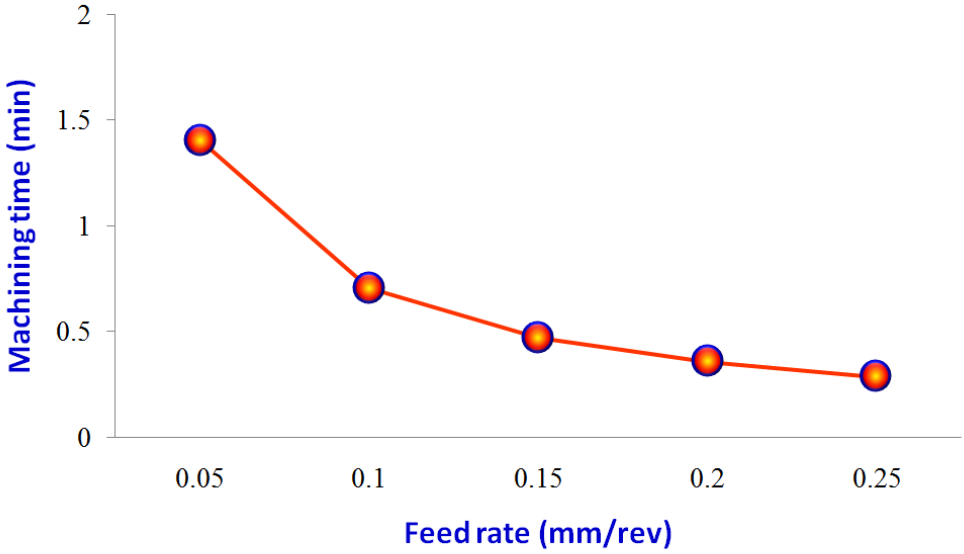

Figure-3: Effect of feed rate on machining time

The analysis graph for machining time during machining of the CNC turning of AA7075 is 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. Girish Tilak et. al [9] carried out optimization of surface roughness parameters in turning EN1A steel on a CNC lathe with coolant. Their experimental results show that actual values of machining time is more compared to theoretical value of machining time and machining time decreases with increase in feed rate. M.Dhanenthiran et al [14] have studied 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. Based on this study they concluded that machining time decreases as feed rate increases. C.John Joshua et.al [15] 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. The result show that machining time decreases as feed rate increases.

CONCLUSIONS

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 is found to increase almost linearly with increase in feed rate.
- Surface roughness was found to increase with increase in feed rate. So it concludes that for achieve good surface quality, feed rate must be required less.
- The machining time in turning decreases with increase in feed rate.

REFERENCES

[1]. Maske K.V. and Sawale J.K., "Study of Influence of Tool Nose Radius on Surface Roughness and Material Removal Rate in Turning of Inconel 718 by using Taguchi Grey Relational Analysis," *International Research Journal of Engineering and Technology*, Vol: 04 Issue: 09, pp. 1148-1153, 2017.

[2]. Arjun Pridhvijit and Dr. Binu C Yeldose, "Experimental Study and Parameter Optimization of Turning Operation of Aluminium Alloy-2014", *International Journal of Engineering Research and General Science*, Vol.3, Issue.5, pp.525-530, 2015.

[3]. M. Sree Praveen Chowdary, SK. Waseem Sohail , SK. Sajidh and K. Sai Krishna, "Optimisation of surface roughness and material removal rate in turning operation of mild steel using Taguchi method", *International Journal of Engineering Sciences & Research Technology*, 7(2), pp.477-484, 2018.

[4]. Ali Abdallah, Bhuvenesh Rajamony and Abdulnasser Embark, "Optimization of cutting parameters for surface roughness in CNC turning machining with aluminum alloy 6061 material," *International organization of Scientific Research*, Vol. 04, Issue 10, pp.01-10, 2014.

[5]. Mahendra Korat and Neeraj Agarwal, "Optimization of Different Machining Parameters of En24 Alloy Steel In CNC Turning by Use of Taguchi Method", International Journal of Engineering Research and Applications, Vol. 2, Issue 5, pp.160-164, 2012.

[6]. Swaraj Samanta, Sumit Kumar, Souram Guha and Sonal Kr. Singh, "Process parameters optimization of CNC turning on Al 6061 using multiple cutting fluids," *International Research Journal of Engineering and Technology*, Vol: 05 Issue: 07, pp.1751-1757, 2018.

[7]. S. Dhanalakshmi and T. Rameshbabu, "Multi-Aspects Optimization of Process Parameters in CNC Turning of LM 25 Alloy Using the Taguchi-Grey Approach", *Metals*, 10, 453, pp. 01-17, 2020.

[8]. Deepak D and Rajendra B, "Studies on material removal rate of Al 6061 while turning with coolant and without coolant using Taguchi method", *International Journal of Research in Engineering and Technology*, Vol: 04 Issue: 09, pp.75-78, 2015.

[9]. Girish Tilak, Pavan P Kadole, and N.Lakshmana Swamy, "optimization of surface roughness parameters in turning EN1A steel on a CNC lathe with coolant," International Research Journal of Engineering and Technology, Vol: 04 Issue: 06, pp. 2469-2474, 2017.

[10]. T. K Durga Bhavani, G. S .V Seshu Kumar, Prof. K Satyanarayana and I. Ajit Kumar, "Optimization of Material Removal Rate and Surface Roughness in Turning of Aluminum, Copper and Gunmetal Materials using RSM", International Journal of Engineering Research & Technology, Vol. 6, Issue.02, pp.585-590, 2017.

[11]. Tadiparthi Chaitanya, Namburi Harsha and V S N Venkata Ramana, "Effect of Nano Vegetable Cutting Fluids on Surface roughness and Material removal rate in Turning of AISI 1040 steel", *International Journal of Scientific Development and Research*, Vol:3, Issue: 8, pp:30-36, 2018.

[12]. J. Kouam, V. Songmene, M. Balazinski and P. Hendrick, "Dry, Semi-Dry and Wet Machining of 6061-T6 Aluminium Alloy", *Aluminium Alloys - New Trends in Fabrication and Applications*, http://dx.doi.org/10.5772/51351

[13]. N. Satheesh Kumar, Ajay Shetty, Ashay Shetty, Ananth K, Harsha Shettya, "Effect of spindle speed and feed rate on surface roughness of Carbon Steels in CNC turning", *Procedia Engineering*, 38, pp.691 – 697, 2012.

[14]. M.Dhanenthiran , P. Naveenkumar, M. Mohamedsameer, A. Romario richard, and K. Ranjith Kumar, "Parameters of micro turning of aluminium rod Al 6063 using CNC machine", International Journal of Engineering, Science and Mathematics, Vol. 7, Issue.4, pp. 231-241, 2018.

[15]. C. John Joshua and N. Rajakumar, "Effect of Spindle Speed and Feed Rate on Surface Roughness and Material Removal Rate of AA6063A in CNC Turning Using Response Surface Methodology", International Journal of Research in Mechanical Engineering & Technology, Vol.5, Issue.2, pp.7-11, 2015.