EXPERIMENTAL INVESTIGATION ON SURFACE ROUGHNESS AND CHIP MORPHOLOGY DURING CNC TURNING OF ALUMINUM (6063-T6)

Rajani Gadhiya, Prof. Ankit Darji, Prof. Hemant Trivedi
Research scholar, Asst. Professor, Asst. Professor,
Mechanical Engineering Department,
LDRP-ITR, (Kadi Sarva Vishwavidyalaya), Gandhinagar, India

Abstract: The surface roughness is an important measure of product quality since it greatly affects the performance of mechanical parts as well as production cost. In this research work numbers of the experiment are carried out to investigate the evolution of chip morphology and its effect on surface roughness during CNC turning of aluminum 6063-T6 using different cutting tool inserts. Further, it is also present an effect of various cutting parameters and cutting tool geometry on surface roughness. After conducting experiment various chips are examined under microscope for chip morphology and effect of various types of chips on surface finish is studied.

Keywords - CNC Turning, surface roughness, chip morphology

I. INTRODUCTION

In modern machining industry, product quality is an important factor to keep in mind in order to achieve higher productivity. The turning process on a CNC is programmed by speed, feed rate, and cutting depth according to job characteristics which are frequently determined based on the job shop experiences. However, these cutting conditions are not guaranteed to be acceptable. Therefore, the optimum turning conditions have to be accomplished. This paper investigates the cutting parameters of Aluminum alloy 6063 in CNC turning machine and optimize these cutting parameters like depth of cut, speed, and feed. The cutting inserts used are CNMG, DNMG, and TNMG with appropriate shim material. After measuring surface roughness of machined part these results are related with chip morphology study. From experimental result, an optimum cutting condition is being obtained.

1.1 Turning process

Turning is the most common machining operation carried out in any machine shop. Turning is a form of metal removal process which is used to modify the shape, dimension, and surface roughness of a workpiece by removing the unwanted material it in the form of chips. Turning is largely used to mate one part with other parts in the die, aerospace, automotive and machinery design also in manufacturing industries. To perform turning operation, relative motion is achieved between primary motion, called the cutting speed, and the secondary motion, called the cutting feed. In turning operation primary motion is provided to the workpiece while secondary motion is provided to the cutting tool. By using combination of these motions, the desired shape of the machined surface can be obtained.

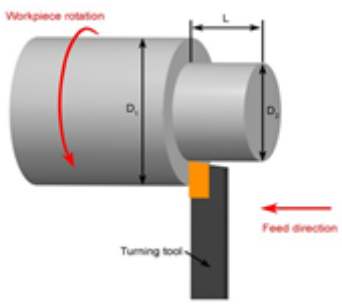


fig. 1- turning process

1.2 Single point cutting tool

Single point cutting tool has only one cutting edge. The examples of single point cutting tool are Shear tools, lathe tools, planner tools, boring tools etc.

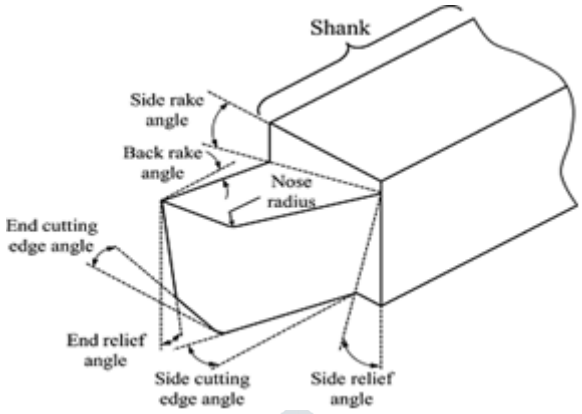


fig. 2 - single point cutting tool

1.3 What is surface roughness?

Surface roughness is a component of surface texture. It is quantified by the deviations in the direction of the normal vector of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small, the surface is smooth. Quantitatively, surface roughness is evaluated by means of one or more of the following main parameters: the arithmetical average deviation of the surface profile (Ra), the height of irregularities at ten points (Rz), the maximum height of irregularities (Rmax), the average spacing of irregularities (Sm), the average peak spacing of irregularities (S), and the sampling length of the profile (tp).

1.4 Factors affecting surface finish

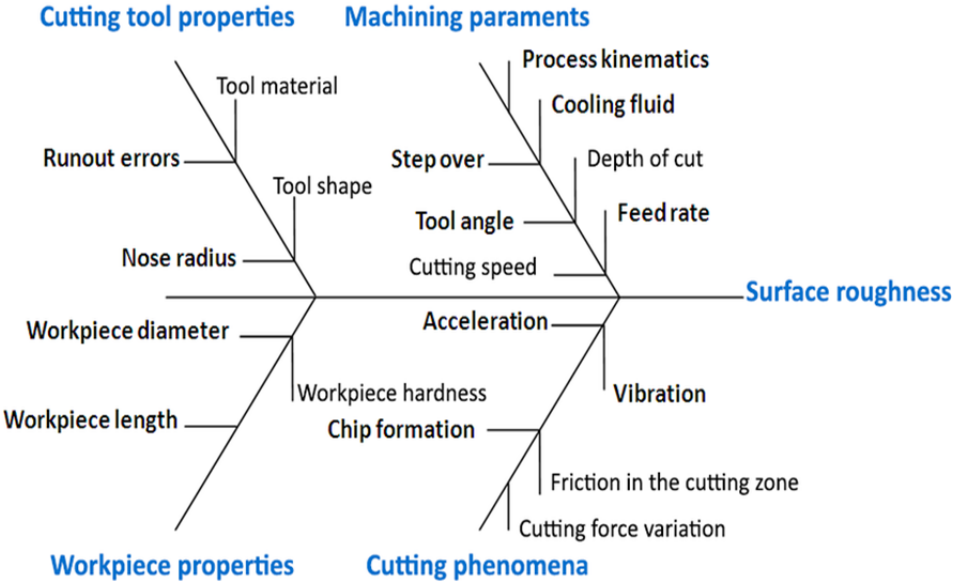


fig.3 - fishbone diagram for parameters affecting surface roughness

1.5 Chip morphology

Chip morphology is a study of chip geometry which are produced during various operation like turning, milling etc. An understanding of the theory is an important part of the development of such machines and their cutting tools. Types of chips depends on various cutting conditions like speed, feed and depth of cut, work material, tool geometry etc.

• Types of chips

1. Continuous type Without Built up edge
2. Continuous type with Built up edge
3. Discontinuous type
4. Saw-tooth or Segmented type

II. LITERATURE REVIEW

Daochun Xu et al. (2014) [1] had investigated the chip formation process of aluminum alloy 6061-T6 by performing a series of operation on a wide range of cutting speed and feed. By doing so, there are seven types of chips were obtained in the operation. In this experiment, the chips mainly appear to be a continuous chip, discontinuous chip, and curling chip. By increasing cutting speed, friction angle, chip thickness, length and width of first shear zone decreases and there are increase in shear slide distance and shear angle by increasing cutting speed. To form a curl chip feed should be high and to form ribbon chip, a high cutting speed was helpful.

Fuda Ning et al. (2014) [2] studied chip morphology and its effect on surface roughness during milling of Inconal 718 alloy. They found that when cutting speed increases from 25 to 200 m/min, the chip burrs value decreases first and then increases. Both height and pitch of chip burrs reach the lowest value at a cutting speed of 75 m/min and serrated chip begin to appears. That cutting speed is called critical cutting speed and surface roughness R_a is also minimum at that point.

Vickey Nandal et al. (2015) [3] concluded that during machining of AISI 4140 (410 HV) steel, the formation of Continuous and saw tooth chips takes place at relatively low cutting speeds and different feed rate has been examined. All cutting tests were performed by using Cubic boron nitride (CBN) tool inserts on specific cutting speeds from 75 m/min to 150 m/min. As a result of interrelated mechanisms such as adiabatic shear, localized shear in the forms of cracks, saw- tooth chip is produced. The chip samples collected during machining were observed using SEM and were measured in terms of their form, surface roughness of workpiece after all experiments, thickness and micro hardness of chips. This study investigated that both cutting speed and feed rate are found to have an influence on the chip thickness.

Basim A. Khidhir et al. (2010) [4] has done study on turning operation of nickel-based Hastelloy C-276 using different types of inserts using CNC machine at different stages of cutting speed. By using different types of inserts chip transition is take place from thick continuous chip to wider discontinuous chip. The burrs disappear for the coated insert tips when the speed changed to 150m/min and also surface roughness is improved. For the uncoated insert tips, by increasing speed above 150m/min, there are increase in the chip burr size. From the SEM examination it is found that nose radius wear is responsible for the surface roughness value. Based on performance, coated S type insert is better than uncoated S type. So, it is recommended to use coated S type insert at medium cutting speed while machining of Hastelloy C-276.

Mohamed Baccar Mhamdi et al. (2013) [5] has performed operation on AISI-D2 steel at different cutting conditions and observed their chip formation mechanism to obtain optimum cutting condition. During machining process chips are collected for microscope examination and from study of chip morphology it is found that chip formation mechanism is affected by cutting conditions. ANOVA method is used for experimental process and at the end of process, microhardness test was carried out. Due to high temperature and mechanical stress, microstructure of chip is changes.

Walid Mahmoud Shewakh (2013) [6] investigated influence of shim materials on the surface quality during hard turning of bearing steel. Using shims made of natural and composite materials to enhance the damping properties of the ceramic inserts holding systems, surface roughness is being evaluated. The experimental results show that the chlorites and sandstones have the minimal acoustic activity, the sandstones shim has the minimal vibration within high frequencies: within the low frequencies the chlorites shims has shown advanced priority against the other shims, the experiment also shows that shims consisting of minerals and composite materials have advanced machining conditions and high vibration absorption, and effectively fixing the cutting inserts results in increase in the quality of machined surface.

Basil M. Eldhose et al. (2014) [7] investigates the effects of various parameters such as depth of cut, speed and feed on the material removal rate and surface roughness of the SS304 in a CNC turning machine. There are three factors cutting speed, feed, and depth of cut at three different level are taken for experiment and their degree of influence is studied. Taguchi method is adopted in design of experiment to reduce numbers of experiment. After conducting experiment, their results are transformed into signal to noise ratio and deviation are being measured. For S/N ratio lower is better is selected for desired characteristics and from signal to noise plot effect of input parameters are examined. In this analysis they concluded that speed is most influencing parameter followed by depth of cut and feed.

Nachimuthu A. K. (2013) [8] taguchi method for minimization of surface roughness in turning operation. During operation we have to select various cutting parameter combinations of speed, feed, and depth of cut which is always not acceptable. So, by using taguchi method these parameters combination can be predicted and according to control level numbers of experiments are carried out. At a speed of 4000rpm, feed of 0.2m/min, and using aluminium shim material, surface roughness reduced to its minimum value. ANOVA analysis is used to find cutting parameters effect on surface roughness.

III. EXPERIMENTAL SETUP

3.1 Material

The material studied here is aluminium 6063-T6. The length and diameter of workpiece is 100mm and 50mm respectively.

Table 1- chemical composition of aluminum 6063-t6

Component	Wt. %
Al	Max 97.5
Cr	0.0-0.10
Cu	0.0-0.10
Fe	0.0-0.35
Mg	0.45-0.90
Mn	0.0-0.10
Si	0.20-0.60
Ti	0.0-0.10
Zn	0.0-0.10
Other	0.0-0.05

1.1 Test conditions

1) CNC Machine
The turn master GF 165-A CNC lathe machine is used for performing experiments.

fig. 4 – CNC machine

Table 2: Machine Specifications

Sr. No.	***Specifications***	***Units***
1	Maximum Turning Diameter	200mm
2	Maximum Turning length	300mm
3	Distance between center	550mm
4	Spindle motor	5HP
5	Chuck Size	165mm
6	Positioning Accuracy	0.008mm
7	Motor power	0.18KW

2) Surface roughness tester

The Mitutoyo Sj-210 surface roughness tester used for measuring surface roughness of workpiece after machining

Fig.4 - Surface roughness tester [12]

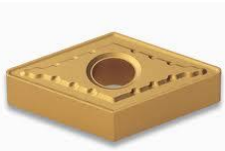
3) Tool material

Tool Holder: DCLNR 20412CQ

CUTTING INSERT: (Nose radius=0.81, Grade = CA 225)

a) CNMG-12 04 08

b) DNMG-15 04 08



c) TNMG -22 04 08

IV. EXPECTED CONCLUSION

- surface roughness is principally affected by the cutting speed and then followed by depth of cut and feed. As increase in cutting speed leads to better surface finish.
- By studying chip formation characteristics, we can get information about cutting condition which is helpful in improving product quality
- Effect of cutting tool geometry on surface finish is investigated using different cutting tool inserts.

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