

# Fluctuations in Chip Formation with Alterations in Cutting Conditions during Turning Operation using Aluminium 6061

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## Abstract:-

Turning process is conducted on cylindrical job of material Aluminum 6061 for the extraction of chip in different cutting conditions. Cutting conditions variation is limited to alteration in feed rate and cutting speed. Macroscopic evaluation involved direct measurement of chip thickness via instrument of minimum precision 0.01mm. Chip thickness obtained implemented direct relation between with feed rate and partially direct relation at lower cutting speeds. This can be provided by shear forces involved along the shear plane angle.

**Keywords:** Turning process; Aluminum 6061 ; Chip thickness.

## 1. INTRODUCTION

Chip formation in machining processes beside the measure of the rate of removal of material, provides intricate information regarding cutting conditions implemented during the process. The type of chip produced (continuous, discontinuous, serrated etc.) accounts for the direct correlation with the cutting speed, feed rate, and material and tool combination[1][2]. The process leading to chip formation has a direct bearing with plasticity and cracking of material[3]. However continuity of chip during turning will be excessively increased if the material is annealed before operation as compared to quenched material resulting in the formation of serrated and discontinued chips especially at moderate speeds[4].

More over the overall opposing frictional energies are much higher during hard turning (as compared to that of annealed work piece) resulting in high temperatures at tool-work interface[5]. The research in the field generally imposes that the chip formation is enormously dependent on feed rate and cutting speed especially in turning of hard materials[6]. In machining process white layers are imprinted on the work and chips which are actually due to microscopic structural change in the material by application of tool[7]. This interstitial change makes this zone vulnerable to failure[4]. In this specified research however a more particular study of nature of chip formed as a result of variation in cutting conditions in turning is covered.

## 2. TOOL AND WORK PIECE SPECIFICATION

## 2.1 WORK PIECE SPECIFICATION

The work piece under consideration is cylindrical in shape and composed of Aluminum 6061. This aluminum alloy has prominent alloying elements Mg and Si. The specified grade is the most extensively used Al alloy possessing excellent corrosion resistance and machinability when moderately heat treated.

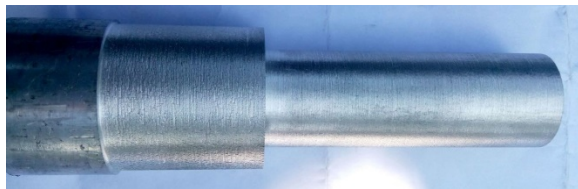


Figure 1: Cylindrical Work piece after chip removal

## 2.2 CUTTING TOOL MATERIAL

Hi speed steel typical roughing turning tool was utilized in the machining of Aluminum 6061.



Figure 2 : HSS Tool geometry with positive rake angle

The tool specifications are provided as under:

Side Rake angle =  $\gamma = -5^\circ$

Back Rake angle =  $\alpha = -5^\circ$

Nose Radius =  $r = 0.2\text{mm}$

Tool Material = Hi Speed Steel (HSS)

Side Cutting Edge Angle (SCEA) =  $-5^\circ$

## 3. EXPERIMENTAL INITIALIZATION

Hitachi Seiki 4NE 600 CNC Lathe used as primary machine tool allowed variation in cutting speed and feed by adoption of different CNC programs. Each CNC program covered one

of the specified configuration for cutting conditions.



Figure 3 : Hitachi Seiki 4NE 600 (Used for Turning)

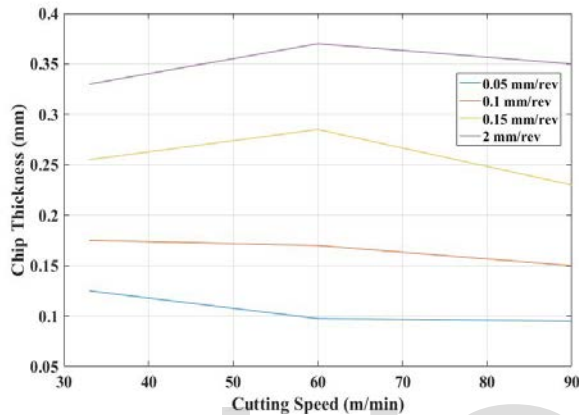
Al 6061 work piece was mounted ensuring concision between centers of spindle and work piece. Rotating speeds of spindle were adjusted to a lower scale to inhibit most of vibrations. Increment in vibration can lead to elevation in magnitude of errors. Moreover initially a cut of small depth was allowed that did not cover any provided configuration. This was done to prevent the recording of external impression of the work piece in the micrographs. Hence chip produced was free of external contaminations. Micrographs were formed by virtue of electron microscopy. Micrographs of formed chip were effectively utilized in the deduction of the nature of chip as well as surface roughness of chip due to variation in cutting speed and feed rate.

## 3.1 EFFECT OF CUTTING CONDITIONS ON CHIP THICKNESS

Chip thickness obtained from turning with different cutting configurations was observed via screw gauge with 0.01 mm precision (least count). For accuracy of measurement and removal of random errors, average thickness was considered obtained from different segments of chip for a unique condition.

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The thicknesses were plotted against their respective cutting speeds and feeds. The general trends for comparatively higher feed rate i.e. 0.15 and 2 mm/rev proposed increment of chip thickness as a result of increment in cutting speed; however as the graphs progress an inverse relation is experienced between the two above specified range of cutting speed.



In the case of comparatively less feed i.e. 0.05 and 0.1mm/rev gradual decrease in thickness of chip is experienced with increment in cutting speed which is quite in contrast with higher feeds.

The thickness is highly exaggerated though by the increment in feed rate from 0.05 to 0.2 mm/rev. Elevated feed (comparatively) results in increased shear plane forces along the shear plane which not only results in the increased thickness but induces discontinuity in chip leading from continuous to saw tooth and eventually to discontinuous chip.

#### 4. MICROGRAPHS OF SURFACE ROUGHNESS

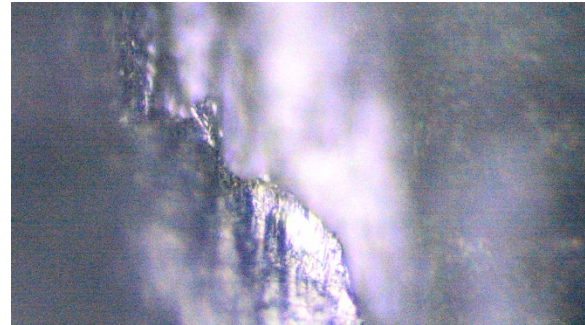


Figure 4a : Surface Roughness of chips at cutting speed (0.1mm/rev)

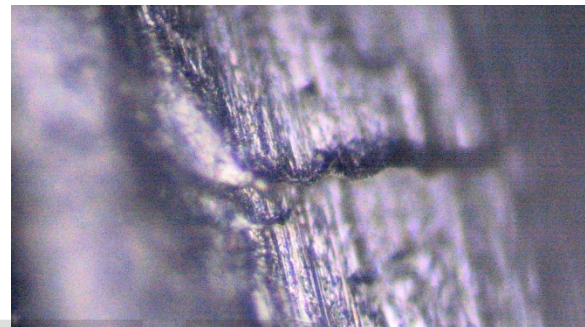


Figure 4b : Surface Roughness of chips at cutting speed (2 mm/rev)

#### 5. CONCLUSION

In general considering graphical indication chip thickness elevates as result of increment in magnitude of cutting speed though inverse effects are duly experienced at lower feeds.

The thickness is most prominently increased by increasing feed variable primarily due to high shear plane forces along the shear plane.

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