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SURFACE FINISH ANALYSIS OF EN-8 STEEL FOR DIFFERENT COOLANT

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Abstract:

Coolant plays very important role in improvement of surface roughness during machining. Variety of coolants are being used according to material and surface roughness requirements. Recently researchers are imposing questions on the use of coolants because of their hazardous effects on human health but still there is no other alternative have been identified for the coolants during machining. This paper presents investigation on use of two different coolants while turning EN 8 Steel components. Oil based and Water based coolants have been analyzed for surface finish requirements of a lot of 110 components. The results indicate that water-based coolants are more suitable and gives good surface finish during turning of EN 8Steel for a longer period of machining.

Index Terms: ***Coolant, Surface Roughness, Machining, EN 8 Steel.***

1. INTRODUCTION

Rapid prototyping is an advanced manufacturing practice that consists of various technologies and methodologies for developing components for a variety of end implementations. Fused Deposition Modelling (FDM) is a rapid prototyping methodology for 3-D printing of thermoplastics [1]. The quality of the product produced which use Fused Deposition Modeling (FDM) method is much more reliant on the process parameters chosen [2]. Geometric tolerance is a vital criterion for determining the functionality of products manufactured for industry applications which include shafts, bearings, pulleys. Therefore, selection of particular set of process parameters is essential for better geometric properties and applicability.

Boschetto and Bottini [3, 4] discussed how the orientation of pieces has a significant effect on geometrical errors. Vertical walls had the smallest deviations, according to the findings. A smaller or larger angle than 90° results in increase in deviations. Using Design of Experiment (DoE) methodologies, Sood et al. investigated the effect of various factors on geometrical accuracy and discovered significant factors and effective parameter configurations to reduce geometrical deviations [5, 6]. Mahesh et al. [7] presented a geometry defined by flexible form surfaces that exhibit variations from nominal dimensions ranging from 5% to 15%. In one case the shape distortion caused a 2.5 mm divergence. So far, the effect of process parameters on geometrical precision has only been examined briefly. Dimensional tolerances are studied with two aims: methodical establishment of dimensional tolerances for additive manufacturing processes and optimization of machine parameters and manufacturing impacts to reduce dimensional deviations [8]. The dimensional correctness of a component part is measured by its size (size tolerance) and shape (geometric tolerance, including form, orientation, and location), as per present dimensioning and tolerance standards [9,10]. We solely addressed size variation in roundness of component and diameter for the convenience. Size variation is very vital when fitting component parts together since size has a direct impact on clearance conditions. Ollison and Berisso [11] investigated cylindricity errors and the impacts of build direction, printhead life, and feature size on cylindricity. They made two components with diameters of 0.75 and 1 inch and with three different orientation angles of 0, 45, and 90 degrees. They performed an ANOVA study on the components and discovered that the cylindricity error was lowest at a build angle of 0 degrees and highest at a build angle of 90 degrees.

From literature review, it can be seen that very few research has been carried out on geometrical tolerances of cylindrical parts. The current work is based on effect of various process parameters on geometrical tolerance particularly on roundness of cylindrical component of PLA printed by Fused Deposition Modelling technology. From previous research, for current analysis the three process parameters are selected named as Layer Thickness, Infill Percentage and Print speed. We solely addressed size variation in roundness of component for the convenience. Size variation is very vital when fitting component parts together since size has a direct impact on clearance conditions.

2. EXPERIMENT DETAILS:

. Experiment have been carried out by turning a hexagonal bar of EN8 steel (Ø27mm x 55mm) on a CNC machine by uncoated inserts (DNMG) with different types of coolants at same cutting speeds (V) and feeds (f). All these parameters have been selected as per tool manufacturer's recommendation as well as industrial practices for machining steel. The depth of cut (d), being less significant parameter, was kept fixed. The experimental set-up used for the present purpose has been shown in figure

Fig. 1: Photographic View of the Experimental Set-Up

The machinability characteristics of EN8 material by keeping fixed parameters like Work material, Machining method, Tool, Tool Material, Cutting Conditions (speed, feed, depth of cut), Flow rate of coolant, Pressure of coolant and variables parameters like types of coolants; the effect of different coolants on surface finish of workpiece and tool wear have been investigated.

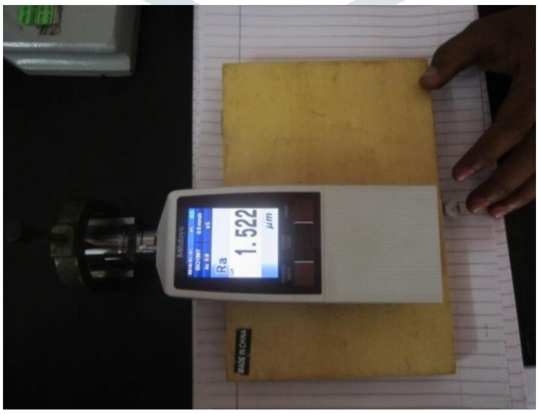

Fig. 2: Photographic View of the Calibration of Roughness Testing Set-Up

3. The experimental conditions are as follows:

- Machine Tool:
- CNC machine
- Make - ACE

- Control - Siemens
- Work Specimen:
- Material: EN8 Steel
- Hardness (BHN):
- Size: Ø 27mm x 55mm
- Cutting Tool:
- Type of Tool: Single point cutting tool
- Tool Material: DNMG110204330NF (IC907)
- Tool Insert: DNMG (IC320)
- Machining method: Turning
- Process Parameters:
- Cutting Velocity: 2000 rpm
- Feed rate: 0.1 mm/rev
- Depth of cut: 0.2 mm
- Cutting conditions:
- Coolant Pressure: 10 bar
- Flow rate of coolant: 15 litre/min
- Type of Coolants:
- Water-based: Ashoka LD-700
- Oil-based: Servocut-S

Machining was interrupted at regular interval and the insert was unclamped to measure the width of wear land. Tool wear was monitored under Scanning Electron Microscope. Surface roughness was measured at every interruption along longitudinal direction of turned workpiece with the help of a Mitutoyo Surface Roughness Tester. As per ISO standard tool rejection criteria was selected as the growth of wear V_B= 300 µm on its principal flank. When the tool wear reaches to its limiting value or unexpectedly wear out rapidly, it was inspected under scanning electron microscope to study the wear mechanism.

The surface roughness of the machined surface after each cut was measured by Mitutoyo Surface Roughness Tester using sampling length of 0.8 mm.

4. Experimental Results

Surface roughness is one of the important factors in all areas of tribology and in evaluating the quality of a machining operation. Surface roughness is formed as a result of the repetition of the cutting tool tip moving along the work-piece at the desired feed rate during machining processes.

The nature and extent of surface roughness in turning is mainly caused by the feed marks in the longitudinal direction of the turned job depend mainly upon the value of feed, tool geometry, nose radius and condition of the auxiliary cutting edge. The level of feed So directly and almost proportionately governs the surface roughness in machining by single point tools but the value of cutting velocity also affect the nature, pattern and extent of surface finish, though indirectly through deformation of the tool nose profile, BUE formation and vibration.

The effect of water-based coolant and oil-based coolant on surface finish of component can be investigated from following Figures

4.1 Reading for surface finish measurements:

a. Sampling Length: 0.8 mm
b. Speed of Probe: 0.5 mm/sec

The following reading were taken from

Table No. 1: Experimental Readings

Component Number	Ra (µm) (Water Based Coolant)	Ra (µm) (Oil Based Coolant)
1	1.459	2.437
5	1.466	2.490
10	1.472	2.508
15	1.492	2.524
20	1.523	2.545
25	1.558	2.618
30	1.605	2.671
35	1.651	2.727
40	1.687	2.741
50	1.693	2.779
60	1.708	2.816
70	1.719	2.832
80	1.723	2.827
90	1.727	2.842
100	1.743	2.859
110	1.768	2.871

5. Results and Discussion:

On basis of above obtained values, the following graphs were drawn. The interpretation is as follows:

Ra is the arithmetic mean of the absolute values of the evaluation profile deviations (Y_i) from the mean line. The components which are separated for the experimental purpose at the time of machining.

Job Number

From the above graph, it can be found that the Ra values of water-based coolant are lower than the Ra values of oil-based coolants. For, all the workpieces machined with water-based coolants (Ashoka LD-700) have better surface finish than workpieces machined with oil-based coolant (Servocut-S).

The water-based coolants are tending to improve surface roughness significantly because this cutting fluid is able to reduce the contact area between the chip and rake face, resulting in a reduction of frictional forces at the chip-tool interface. Water based cutting fluid possesses great cooling properties while oil-based coolants possess better lubricating properties. Therefore, the reduction of friction between the chip-tool and work-tool interface is less in cutting operation with the use of water-based coolant. As reduction in kinetic coefficient of friction not only decreases frictional work, but also decreases the shear work. This cannot be possible by the use of oil-based coolants.

Also, for effective cooling it is necessary to penetrate the fluid as much as possible to the chip-tool interface where the temperature is maximum. The water based cutting fluids application causes to cool the tool quickly. This affects the surface finish of the component. This is mainly because the water based cutting fluids contains some additives which helps to increase the cooling properties of the fluid.

Heat generation while machining has significant influence on machining indices. It can increase tool wear and thereby reducing tool life. It gives rise to thermal softening of cutting tool. It is commonly accepted that both the wear and failure mechanisms which develop in cutting tools are predominantly influenced by temperature and it also results in modification to the properties of workpiece and tool material such as hardness. In order to predict the wear and failure characteristics of a tool, it is necessary to quantify the temperatures which develop during the cutting operation. In machining operations, mechanical work is converted to heat through the plastic deformation involved in chip formation and through friction between the tool and workpiece or flowing chips. Three regions of heat generation in turning are the shear zone, the chip-tool interface and the tool-workpiece interface zone. During machining heat is generated at the primary deformation zone due to shearing of metal, secondary deformation zone and the flank (clearance) surfaces due to rubbing, but the temperature becomes maximum at the chip-tool interface. The cutting temperature measured in the present work refers mainly to the average chip-tool interface temperature. Any cutting fluid applied conventionally cannot reduce this chip-tool interface temperature effectively because the fluid can hardly penetrate into that interface where the chip-tool contact is mostly plastic in nature particularly at higher cutting speed and feed. High energy jet impinging beneath the flowing chip acts as a wedge that lifts up the chip facilitating chip breakage by reducing curl radius as well as plastic contact and coolant reach to the interface. Coolant having high cooling capacity cools the interface expectedly, effectively and lubricate between the chip-tool and work-tool contact thus reduce frictional heat generation. From above results, we conclude that use of water based cutting fluids is more economical as well as beneficial than the oil-based fluids. This is because; it improves the surface quality of component.

6. CONCLUSION: -

Current investigation is concern with use of two different coolant while turning of EN-8 steel components. The result indicates that surface roughness obtained using water-based coolant is superior than that of oil based coolants. So, while machining En-8 steel for condition under investigation one can use water-based coolant for good quality machined surface which can reduce the cost of coolant also.

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