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Impact of the toolholder hardness on the quality of part produced during the turning process

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Abstract: This research studies cutting toolholdersthat have hardness varyingbetween 40 and 60 HRC. Workpiecescomposed of C10, C30, and C45 steel were used for the experiment. The measurement of the surface roughness shows that with soft steel such as C10, the higher the toolholder hardness, the better the surface quality. In particular, when the toolholder hardness increases from 40 to 60 HRC, the roughness reduces from 25.96 to 16.40 µm. With a harder workpiece, the influence of the damping function on the toolholder appears. The result shows that the hardness of 50 HRC is the best value for the turning process, which will reduce the roughness to 20.86 and 17.90 µm for the C30 and C45 workpieces, respectively. The main reason for this is the combination of damping parameterssuch as mass, spring, and hardness of the toolholder.

Keywords: turning process, toolholder, hardness, surface roughness, metal cutting, vibration

I. INTRODUCTION

Turning is a metal cutting process used for producing cylindrical parts. Typically, the product is rotated on a spindle and the tool is moved into it radially, axially, or both ways simultaneously to create the required surface. In recent years, the turning process for hard metalshas shownimprovedefficiency. Precision turning is animportant metal manufacturing method and is commonly used in industrial applications. The process of creation of surfaces oriented primarily perpendicular to the workpiece axis is called facing. In turning, the direction of the feeding motion is predominantly axial with respect to the machine spindle. In facing, a radial feed is dominant. Tapered and contoured surfaces require both modes of tool feed at the same time;this is often referred to as profiling.

As a result of the quality characteristics of the turning product, the vibration phenomena among cutting tool, chuck, and workpiece has an important role in machine performance [1, 2]asthe vibrations of the toolholder are the main reason for cutting-insert instability [3], which reduces the quality of machined surface roughness [4] andcauses poor dimensional accuracy of the product [5]. Numerous researches have proven that one of the main factors that has the most influence on the surface roughness and can destroy the surface quality is the toolholder vibrations during the turning process [6].

This paper aims to observe the vibration effect of a toolholder on the surface quality using different toolholder hardness. The turning toolholder was designed and manufactured under five types of hardness for the experiment. The experiment was performed with samples of C10, C30, and C45 steel. Each type of toolholder hardness was operated 10 times with the sample. Then, the surface roughness was averaged for comparison and discussion. A cutting test was conducted to visualize the effect of toolholder vibration on the performance of surface roughness. (10)

II. EXPERIMENT METHOD

In this paper, to observe the effect of toolholder hardness on quality, an experiment was conducted using the CNC Turning Center Machine with specifications shown in Table 1. The cutting process was operated with different toolholder hardness. Two types of toolholder were designed and assembled (Figure 1), and manufactured (Figure 2).

For detecting the effect of toolholder hardness on part surface quality, the workpiece was prepared with the diameter of 36 mm and cutting length of 160 mm. This workpiece was hanged on the machine in the position as shown in Fig. 3. The cutting surface was used for the roughness measurement as in Fig. 4. Each case of toolholder hardness was used for 10 workpieces. After the turning process, the roughness was measured five times for each part. Subsequently, the roughness average was calculated. In all cases, the cutting was operated with the cutting depth of 0.75 mm, velocity of 0.08 mm/rev, and spindle speed of 1200 rev/min.

Table 1. The specifics of CNC Turning Center Machine.

Powerful standard equipment – Main spindle	7.5 kW
Spindle speed	18,000 rpm
Collet size	A-32
Machine dimension	1890× 1490× 1800mm
Max workpiece	Ø280 mm
Feed (X axis Travel; Z axis Travel)	(225 mm; 150 mm)
Controller	Mazatrol T32-2
Linear tooling (number of T-slots)	Number 2
Turret	8 tools

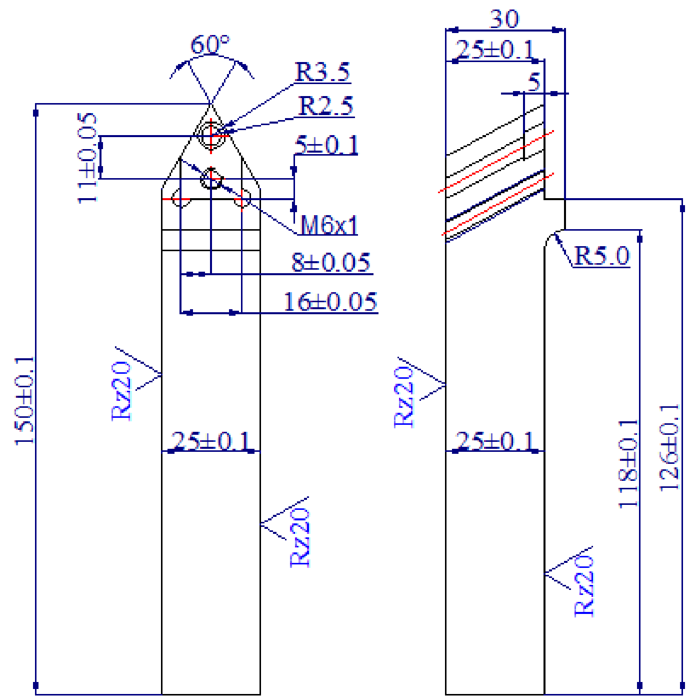

Figure 1. The toolholder designs

Figure 2. The manufactured toolholder

Figure 3. The manufactured toolholder

Figure 4. Roughness measurement

III. RESULTS AND DISCUSSION

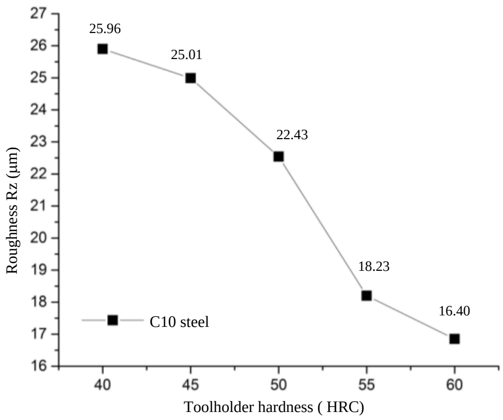

Figure 5. Effect of toolholder hardness on the part quality with the C10 steel

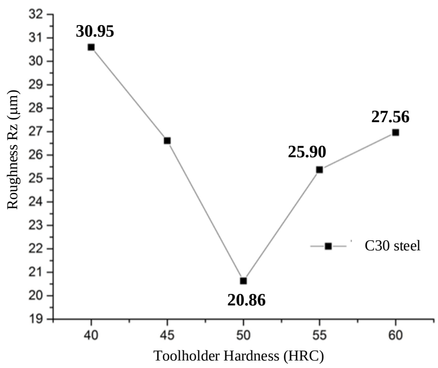

Figure 6. Effect of toolholder hardness on the part quality with the C30 steel

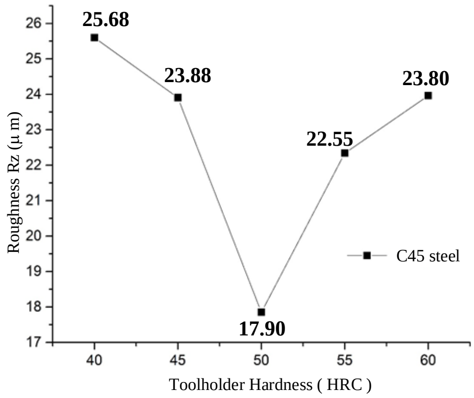

Figure 7. Effect of toolholder hardness on the part quality with the C45 steel

Based on the results of surface roughness (Figures 5, 6, and 7), the influence of workpiece hardness on the result is quite clear. With the soft steel C10, we found that the higher the toolholder hardness, the better the surface quality. This result could be explained by the rigidity of the toolholder. The harder the toolholder, the more stable the cutter; therefore, the quality is better with the harder toolholder. In particular, when the toolholder hardness is increased from 40 to 60 HRC, the roughness was reduced from 25.96 to 16.40 µm.

However, with the harder workpiece, influence of the damping function on the toolholder was observed, showing that the toolholder hardness reaches a limit in improving the part quality; if hardness is increased further, the quality of the part reduces. In particular, it was found that the hardness of 50 HRC is the best value for the turning process, which reduces the roughness to 20.86 µm and 17.90 µm for the C30 and C45 workpieces, respectively. The main reason for this is the combination of damping parameterssuch as mass, spring, and hardness of the toolholder, which was studied in other studies [3, 4].

IV. CONCLUSION

In this research, the turning process was operated with different toolholder hardness. Workpieces of C10, C30, and C45 steel with the diameter of 36 mm and cutting length of 160 mm were used. For the experiment, toolholder hardness was varied from 40 to 60 HRC. The result showedthe following:

- With the softer workpiece material,the toolholder hardness is a key parameterin deciding the stability of the cutter and can reduce the roughness to 16.4 µm.

- With the harder workpiece material, the combination of damping parameters determine the quality of the part. In both C30 and C45, the 50 HRC toolholder hardness is the best value for reducing roughness.

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