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Effect of damping parameters on part quality during turning process

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ABSTRACT: The development in production engineering is accompanied by increasing quality requirements of the workpieces produced. Three damping parameters were investigated in this research: damping angle, mass, and pressure from the spring. As shown by the results, at a value of 30°, the damping angle has the best influence. With this angle, the mass was changed from 18 to 26g and the spring pressure was adjusted from 2.24 to 8.96N to observe the change in part quality. With the mass of 24 g and the spring pressure of 5.6 N, the best result was obtained. Moreover, the part roughness shows that oil is an important element that helps to enhance the part quality.

KEY WORDS: turning process, toolholder, vibration, damping system, surface roughness.

I.INTRODUCTION

The vibration of the toolholderhas a significant influence on the surface roughness during turning process. Process damping can be an important source of increased machining stability particularly at low cutting speeds [1, 2]. In chatter analysis, however, it is usually overlooked, because there is no model available to estimate process damping coefficients. As a result of the quality characteristics of turning product, the vibration phenomenon, among cutting tool, chuck, and workpiece, plays an important role in machining performance. Particularly, toolholder vibrations are the main reason for the instability of cutting insert [3-5], which reduces the quality of machined surface roughness [6] and poor dimensional accuracy of the product [7].Many studies have proven that toolholder vibrations during turning process are one of the main factors that have the most influence on the surface roughness and can destroy the surface quality [8, 9].

Generally, toolholder vibration is a dynamic instability of cutting process that results fromthe interaction between metal cutting process and machine tool dynamics and leads to poor surface finish, cutting tool damage, and irritating, unacceptable production noise [10]. Excessive tool vibrations during machining will increase the tool wear and cause poor surface finish [11]. In the field of vibration for metal cutting, under the resonance during the cutting process, the amplitude and natural frequency of cutting tool vibrations are related to the dynamic cutting force and the chip thickness variation acting on the cutting tool. The change of cutting tool vibrations in the cutting process was observed by detecting the surface roughness of the machined surface [12]. For controlling the cutting tool vibrations, an excellent solution is to properly setup the cutting parameters;to reduce the length of the toolholder is another solution. Another course of research is the addition of a damping system on the toolholder.

This paper aims to observe the toolholder vibration amplitude and the surface quality with different parameters of the damping system. The damping system has been designed to combine the object mass and two springs to test the effect of damping on vibration reduction. For each parameter, the selected object mass and spring pressure will be changed with five types. Moreover, the angle ofdamping system was also changedto observe the influence. To visualize the effect of toolholder vibration on the surface roughness performance,a cutting test was carried out.

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II. EXPERIMENT METHOD

The experiment was performed, in this research, with the CNC Turning center machine with the machine specifications as shown in Table 1 to observe the effect of damping system on the toolholder vibration and the part quality. The cutting process was conducted with the toolholder supported by the damping system. The toolholder and the damping system were designed and assembled with different angles (α) as shown in Figure 1 and operated as in Figure 2. In this research, the parameters of damping system include the damping angle (α), the object mass (g), and the spring pressure (N). Figure 3 shows the assembly of damping system. In this research, the damping system was operated with the damping angle (α) from 0° to 360°. The object mass varied from 18 to 26 g, and the spring pressure also increased from 2.24 to 8.96 N. With the turning process, the position of the workpiece and the toolholder are shown in Figures 2 and 4. In this research, to observe the toolholder vibration, a sensor was designed and assembled on the toolholder. Figure 5 also shows the sensor position. The sensor shows the history of vibration magnitude.

Table 1. The specific of CNC Turning machine

Powerful standard equipment– Main spindle	7.5 kW
Spindle speed	5800 rpm
Machine dimension	1490mm × 890mm × 890mm
Max workpiece	Ø200 mm
Controller	Mazatrol T35-2
Turret	Six tools

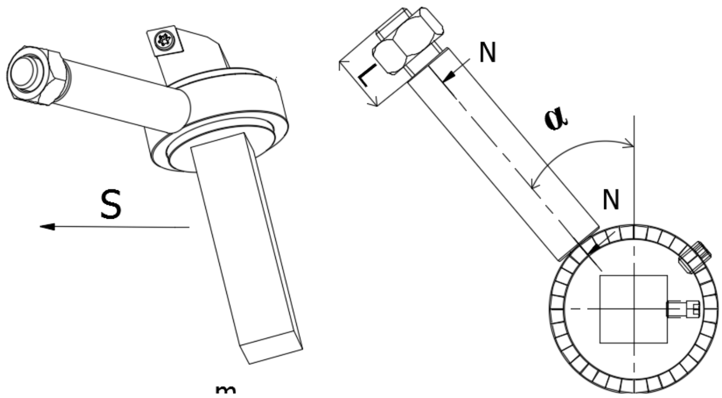

Figure 1: The toolholder designs

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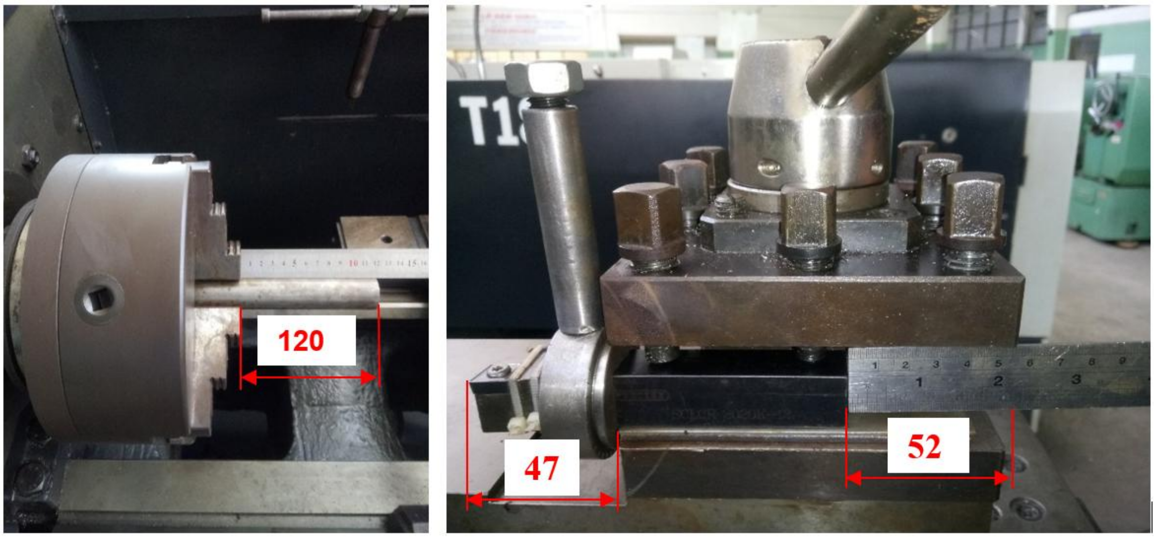

Figure 2: The toolholder with the damping system for turning process

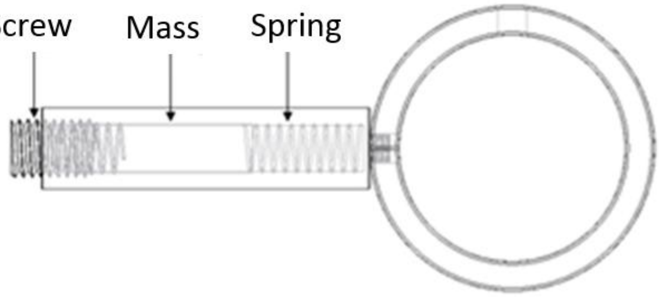

Figure 3: The damping system

To detect the effect of vibration as well as the damping system on the part surface quality, the workpiece was prepared with a diameter of 28 mm and a length of 100 mm. This workpiece was hanged on the machine with the position shown in Figure 6. To measure the surface roughness, the cutting process was operated with a cutting length of 60 mm. This surface was used for the roughness measurement. Each case of damping parameter was used for 10 workpieces. After the turning process was finished, the roughness was measured five times for each part. After that, the roughness average was calculated. This result was compared with the angle vibration for detecting the damping effect. Furthermore, to observe the effect of damping system on the turning process, the common toolholder was used. Then, the vibration and surface roughness result was collected and compared. In all cases, the cutting was operated with a cutting depth of 0.5 mm, a velocity of 0.05 mm/rev, and a spindle speed of 1000 rpm.

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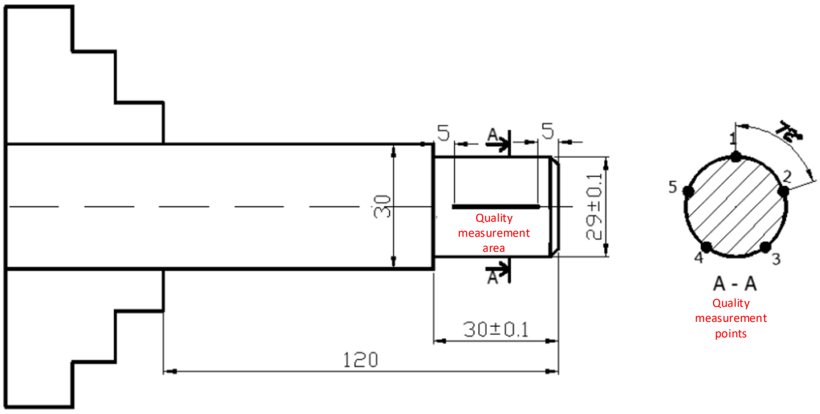

Figure 4: Workpiece dimension

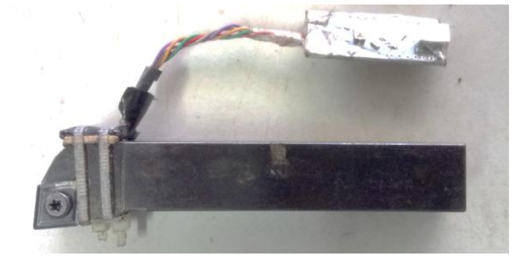

Figure 5: Sensor location for vibration collection

III. RESULTS AND DISCUSSION

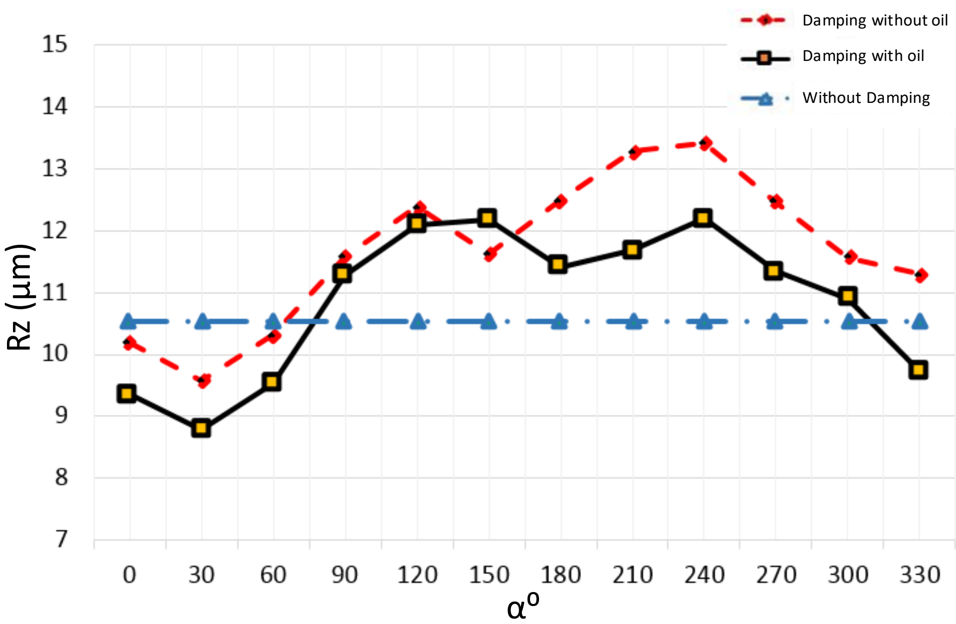

Figure 6: Effect of α on the surface quality (Rz)

ISSN: 2350-0328

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Vol. 7, Issue 3 , March 2020

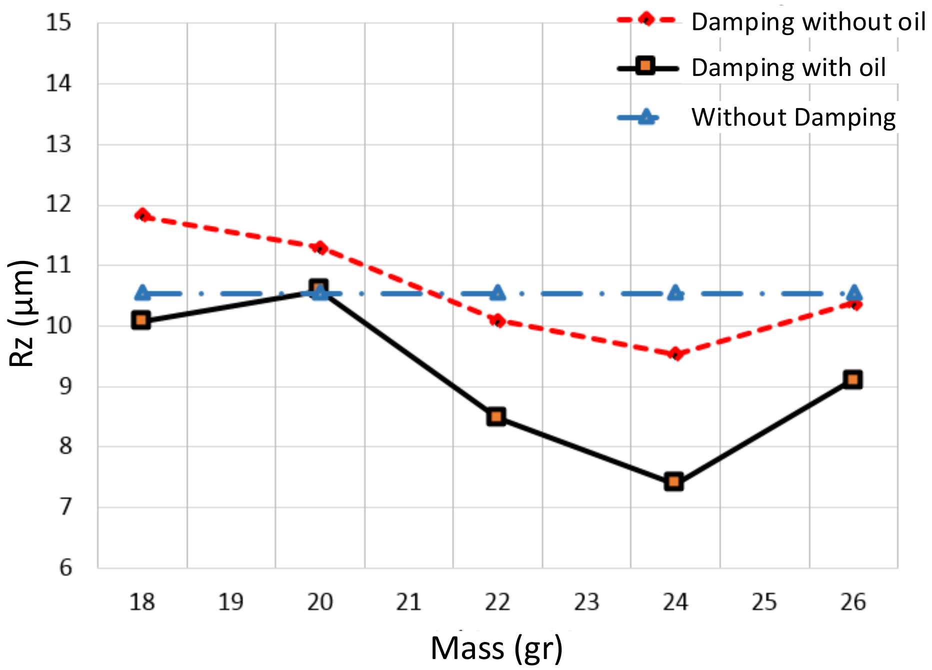

Figure 7: Effect of mass on the surface quality (Rz)

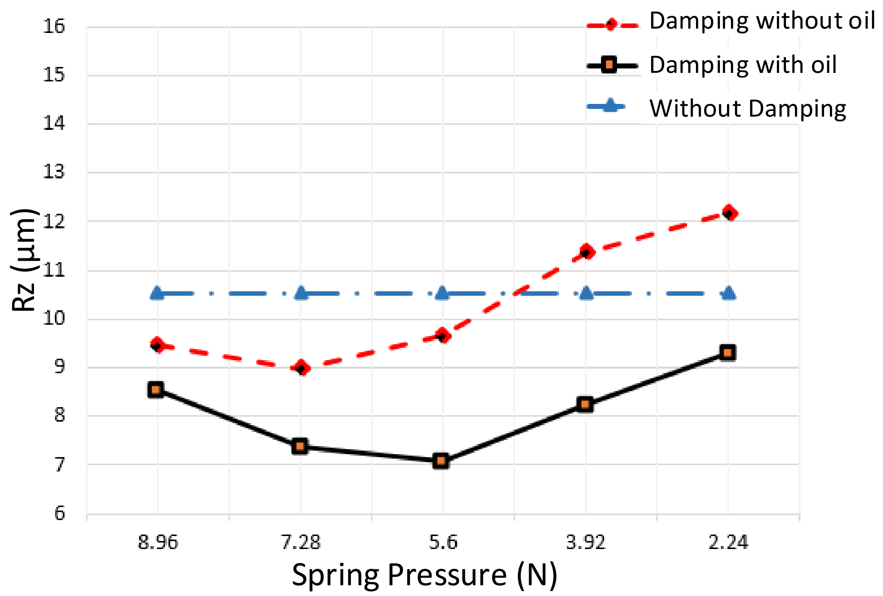

Figure 8: Effect of spring pressure (N) on the surfacequality (Rz)

Based on the sensor results (Figures 4 and 5), toolholder vibrations were collected. These results were compared as shown in Figures 6, 7, and 8 with changesin damping angle, mass, and spring pressure, respectively. Vibration results show that with the design shown in Figure 1, the damping angle has a positive influence from 0° to 60°. In this range, the part roughness is lower than without damping. This result also shows that oil has a good impact on the damping function. The best quality was acquired with a damping angle of 30°having a roughness lower than 9 µm.

To observe the change in part quality, with the damping angle of 30°, the mass was varied from 18 to 26 g, and the turning process was completed. The roughness was measured and compared as shown in Figure 7. This result shows that when the mass is more than 20 g, the positive value of mass was achieved. A mass of 24g shows the best influence. The comparison also proved that oil has a positive contribution to the damping process, which helps reduce the roughness in all cases of mass. In this group of experiments, the best roughness was achieved at 24g mass with oil for the damping system. The same with the group of massive influence, the impact of spring pressure on the part quality was also observed with the damping angle of 30°. The influence of oil was also provenin all cases of spring pressure. In addition, the spring pressure has the optimization value at 5.6N.

IV. CONCLUSION

In this research, the damping system was designed and manufactured to observe the influence of damping parameters on part quality during turning process. Three parameterswere experimented: damping angle, mass, and spring pressure. The result shows that the best damping angle was cleared at 30°. With this angle, the experiment of mass and spring pressure was completed. The result showsthe following:

- The positive value of mass was obtained when the mass is more than 20g. A mass of 24g shows the best influence.
- The spring pressure also has the optimization value at 5.6N.
- The good function of oil has been proven in all cases.

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