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EVALUATION OF SOLID CARBIDE END MILL WITH WIPER GEOMETRY

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ABSTRACT

In this work, we studied the difference in the surface finish using two types of end mill tools bit with wiper and no-wiper coated using the DMU 50 5-axis Computer Numerical Control (CNC) machine. One of the primary goals of the manufacturing business is to optimize the efficiency of producing high-quality, well-finished products. Our aim is to get the surface finish by 0.035 µm. This value of surface roughness is targeted by the standard of toolmaker in the industry. The workpiece will undergo roughing process first before the finishing process is performed. Simulation of both roughing and finishing processes was conducted using the Fusion 360 CAD software. The spindle speed and the feed rate during the machining process have been standardised for all lengths of the overhangs tested. The surface finish of the machining workpiece was verified using the finishing milling process. In this process, the overhang of the tool bits has been varied to 40,50, and 60 mm in lengths. The roundness test of the tool bit has also been performed before the machining process in order to make sure the result that we get in this experiment is reliable. Optical imaging and surface roughness tests were done to obtain the differences between the wiper and no-wiper finishing. The result shows a very huge differences gap between the wiper and no-wiper finishing percentage of the machining surface roughness. The wiper end mills have obtained the targeted value of the finished surface. We also found that the higher the overhang length tested, the higher the rate at which the tool bits vibrate during the machining processes. Because of its potential to enhance the production finishing result, the tool bit that includes a wiper should be utilised more frequently in industrial settings.

Keywords: *surface roughness, tool bit, wiper, no wiper*

1. INTRODUCTION

One of the main objectives of the manufacturing industry is to optimize the efficiency in manufacturing products with high quality and good surface finish. This leads to the study of various factors affecting the cutting process, such as the study of cutting tools with wiper geometry (Arias, 1983). This is because conventional non-wiper cutting tools usually display an asymmetrical surface finish of materials caused by the geometry of the cutting tool used in the cutting process. A cutting tool with wiper geometry is a tool where the nose of the edge consists of the main radius with a few smaller radiuses as opposed to the conventional cutting tool with only one radius (Vignesh, 2022).

Wiper geometry in cutting tools has been proven in various academic research to produce a better surface finish in metal cutting machining. Throughout the cutting process, the nose radius is subjected to a particular grind, resulting in a geometry that wipes away the minuscule peaks and valleys present on the material's surface. There are multiple factors which contribute to the surface finish of a material, such as the geometry of the cutting tool, the type of material of the workpiece, and the cutting parameters used in the cutting process (Schall, 2016; Nishida, 2018).

Apart from the wiper geometry, the cutting parameters such as the feed rate, spindle speed, depth of cut, tool diameter, tool stepover, and tool overhang have also been determined before running the experiment. The experiment aims to test the capability of two different solid carbide end mills with wiper geometry and without wiper geometry in achieving a surface roughness value of material, Ra of 0.035μm. Both solid carbide end mill tools have also been tested with different feed rates and the surface roughness of the materials have been measured, collected and analysed.

2. METHODOLOGY

2.1 Sample preparation

Three aluminum blocks were prepared for experimentation. The squaring process was carried out on the workpiece to obtain an even surface and an exact dimension of 99 x 101 x 20mm using a 5 axis CNC milling machine.

2.2 Machining

The aluminium block underwent two machining processes which were the roughing and finishing process. DMU 50 -5 axis CNC milling machine by DMG MORI was used to machine all the parts. Fixed cutting parameter, depth of cut, tool overhang and tool size were used for the roughing process. Meanwhile, two types of end milling cutters were used for the finishing process: a tool with wiper geometry and a tool without a wiper. Both tools used the same cutting parameter, depth cut, and stepped over but various in the overhang. The flute numbers for wiper and no wiper tool bits used in this experiment were four flutes and three flutes, respectively. Overhangs 40mm, 50mm, and 60mm for the finishing process were tested. Workpiece design and cutting programs were generated using Fusion 360 software. Table 1 describes the parameter used for the roughing and finishing process. A spindle run out check for each tool overhang was carried out before running each experiment using a dial gauge to measure how much wobble the spindle produced.

Parameters	Roughing	Finishing
Tool Diameter (mm)	20	10
Spindle Speed (rpm)	8000	8000
Feed Rate (mm/min)	600	600
Stepover	10%	30%
Depth of Cut (mm)	9.9	0.1
Tool Overhang (mm)	50	40, 50, and 60

Table 1 The Roughing and Finishing Parameters.

2.3 Image Acquisition

The surface roughness optical images of the machined workpiece were captured using an image measuring machine. The machined workpiece was set up under the camera, and the image was adjusted with various magnifications to enhance the image of the surface roughness. The image with 29.2x magnification resulted in a clearer and good-quality image. The surfaces of all machined workpieces were captured with constant magnification. The captured images were processed and saved in a folder.

2.4 Surface roughness testing

The surface roughness of the machined workpiece was measured using a surface roughness tester. A Mitutoyo surface roughness SJ-410 machine was used in the experiment to measure the surface roughness produced by two types of tools with various tool overhangs. The surface roughness value from the X-axis and Y-axis of the machined workpiece were taken. The distance travelled by the end of the tip to the endpoint was around 22.5 mm to generate the Ra value in micrometers (µm). Three readings of surface roughness from the X and Y axes were taken and averaged into one reading for each axis. The result of surface roughness obtained has been analyzed and presented in a graph of tool overhang (mm) versus surface roughness value (Ra).

3. FINDINGS

Figure 1 shows the percentage difference in surface roughness between wiper and no-wiper tool bits. As the tool overhang increased, the percentage difference for the X-axis decreased while the Y-axis increased. The histogram graph plotted in Figure 1 showed that the percentage reading of the surface roughness value was almost 91.2%. This was a huge difference in surface roughness finishing for wiper and no-wiper. Thus, the higher the percentage difference, the lower the surface roughness, significantly reducing the machining cost and increasing the mechanical performance (Bouzakis, 2003). This is in good agreement with the previous study in Sulaiman (2022); Bouzakis (2003); and CERİTBİNMEZ (2021) that mentioned their experiment gets a lower surface roughness and can be proved by the result obtained in this experiment.

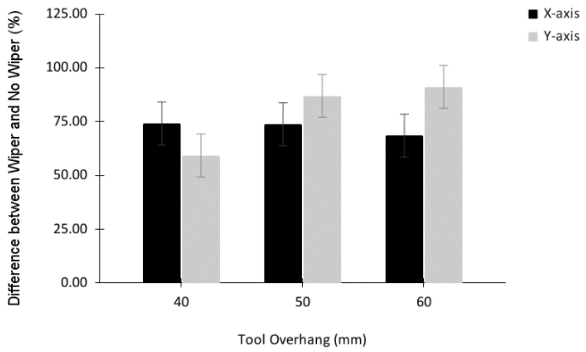

Figure 1 Percentage Difference of Surface Roughness between Wiper and No Wiper.

Figure 2 shows the surface roughness value obtained using the wiper and no wiper tool bits during the machining process. The surface roughness value for X-axis and Y-axis with 40, 50 and 60mm tool overhang with wiper lower compared with no wiper tool bit. For comparison, in the reading of the surface roughness value for wiper and no wiper, only the task on the Y-axis achieved the surface roughness value 0.035 µm. It shows that when machined, using a wiper tool bit can decrease and improve the surface roughness value instead of using no wiper tool bit, as the surface roughness value from the previous studies was also lower when using coated tool bit rather than an uncoated tool bit CERİTBİNMEZ (2021). The surface roughness value that we obtained in this study for both X-axis and Y-axis for the no-wiper tool bit shows that during the machining process, the higher the overhang, the more the tool bit vibrates.

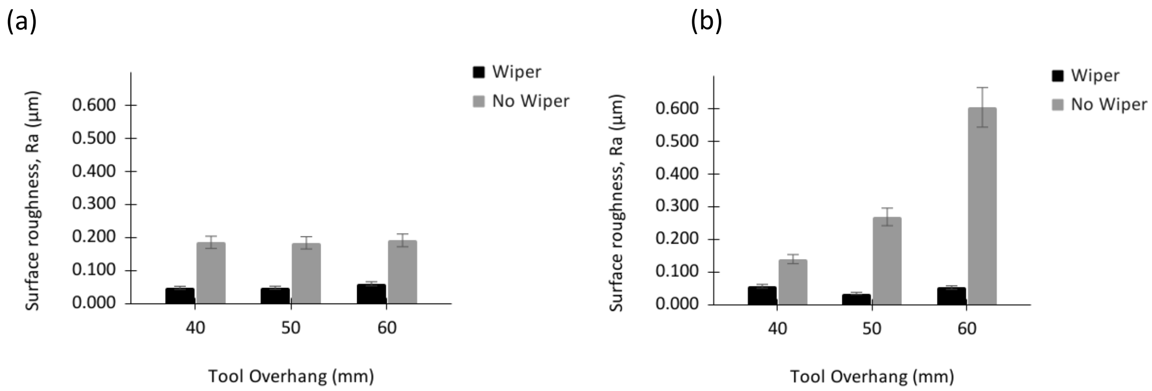

Figure 2 Surface Roughness Value for Wiper and No-Wiper (a) X-axis (b) Y-axis

4. CONCLUSION

From the comparison that has been made, we can see the improvement when machined with a wiper tool bit as the surface roughness is lower with 40, 50 and 60mm overhang. Therefore, the tool bit with the wiper is the best option to use when machined, as it can enhance the finishing process. By using the wiper tool bit we achieved 0.035µm of surface roughness compared to no wiper tool bit that has a higher value. Therefore, the tool bit with wiper is best to be implemented in the industries.

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