CNC turning performance under automated coolant supply system

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ABSTRACT – In the modern manufacturing industry, dry machining and wet cooling techniques are two types of cooling techniques that are commonly used. Both cooling techniques however, have their drawbacks which result in adverse effects on the workpiece, tooling, health, economy and environment. To solve the problem, an automated coolant supply system has been developed where spraying of the coolant is controlled based on the best interval time, hence reduced the amount of the coolant used. This paper presents the achievement of CNC turning machine under the automated coolant supply system. Experimental results demonstrate the effectiveness of our proposed method where the finest roughness is achieved at 15s interval time.

1. INTRODUCTION

A wet cooling method is used during the conventional CNC machine in order to reduce the heat produce and the excess chips that presence at the workpiece. However, there are 3 major problems that occur in this study where the method of wet cooling is applied. Firstly, the continuous flow of coolant in the system has cause the increase in cost of production. This causes the coolant to be recycled in a shorter time. Then a large amount of fluid is projected onto the workpiece, resulting in a lot of waste as they only need a small amount of the coolant. In addition, the use of extra coolant over a longer period of time will gives effect on health and the environment [1]. MQL method and PLC development to control the time-based supply of coolant are therefore used to minimize the problems. However, increasing heat due to friction and loss of energy can lead to the unsharpened of the cutter, affecting high power usage and poor surface finishing.

In the previous study done by Md Hatta [2], it was discovered that the best surface roughness occurs during experiment at the time interval of 20s with the average of 0.26333µm. However, the time interval studied were not detailed where only flooded, 2s, 3s, 4s, 5s, 10s, 15s, 20s and lastly 25s were recorded. Furthermore, there is a possibility that the best surface roughness may be achieved somewhere at the time interval where no records were taken. Thus, the result of the best surface roughness is yet not confirmed due to the inconsistent time interval. So to investigate the possibility, this project is proposed where the interval time will be detailed for every 5 second and the whole experiment is to be conducted between 1 second to 60 second. Although it is also important to determine the temperature of the workpiece during machining in order to identify the best time interval for the automated coolant supply system, this paper is focusing only on the best surface roughness.

2. METHODOLOGY

A CNC turning machine was equipped with a newly developed automated coolant supply equipment as shown in Figure 1. The coolant from the CNC machine should flow through a valve and a specially fabricated nozzle to provide the on-off coolant supply. The on-off coolant supply is controlled by using an PLC controller system (Figure 2).

Figure 1 CNC turning attached with nozzle and valve.

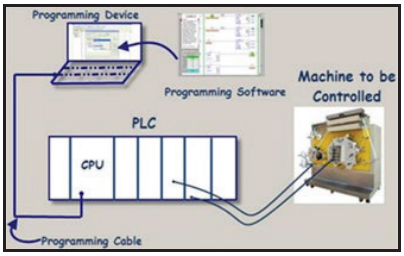

Figure 2 Diagram of the system.

When the switch is triggered, it allowed the coolant to be supplied from reservoir to the cutting tool and workpiece following the time setting. The coolant supply is in the condition of supply-stop based on the

time setting. For example, if the setting is for 10s, then the coolant is supplied for 10s and stop for 10s before continue the supply back for 10s. This cycle will be repeated until the machining process is completed.

The experiment was conducted using aluminium alloy as the workpiece together with Haas SL-20 CNC Turning Machine with spindle speed of 1575 RPM, feed rate of 0.04mm/min and depth of cut of 1mm. Workpieces with a diameter of 31.5 mm with a cutting length between 100 mm and 200 mm are used to obtain the best time interval in terms of surface roughness. The parameter combination is used to obtain the exact data required in this experiment. The applied cutting fluid is known as AI Soluble Extra to cool down the workpiece.

3. RESULT AND DISCUSSION

The focus of this experiment is to use PLC program to manage time-based coolant supply with a time interval of every 5 seconds. The arrangement of the time interval is designed to increase starting from 1s to 60s. From this experiment, the smallest value of surface roughness is chosen as the best surface roughness. The trend can be seen through the graph of Figure 3 and average value calculated in Table 1. Figure 4 shows the results of the aluminium workpiece after the turning process operation.

Table 1 Interval time vs surface roughness.

Time (s)	**1**	**5**	**10**	**15**	**20**
Ra (µm)	0.3990	0.5490	0.4830	0.3930	0.4110
Time (s)	**25**	**30**	**35**	**40**	**45**
Ra (µm)	0.4250	0.5200	0.4920	0.4030	0.4230
Time (s)	**50**	**55**	**60**		
Ra (µm)	0.5260	0.4480	0.6480		

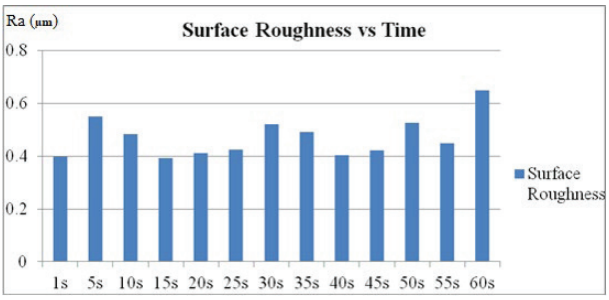

Figure 3 The surface roughness result of cutting process.

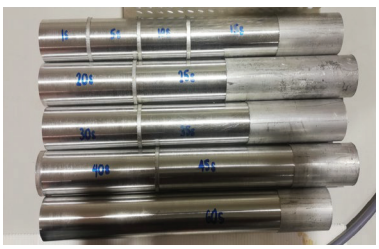
Figure 4 The worpiece.

Through Figure 3, it can be seen that the surface roughness value is increased from 1s to 5s before decreasing from time interval 5s until 15s before it increased back until 60s. The best surface roughness is determined using the lowest value of surface roughness where from the data shown in Table 1, the lowest average surface roughness reading, which is calculated from data taken 10 times, is at the 15s interval time, and the average value obtained is 0.3930µm.

After the time interval 20s, the surface roughness value increase back in fluctuating condition until the time interval of 60s. Perhaps that the condition after 30s is more trending towards dry machining technique because nearly half or more than half of the time taken to complete the cutting process is without any coolant supply. And the condition before 30s can be said to be more on minimal quality lubrication technique**.** As stated by Sun et al. [3], MQL has shown the potential of empowering for higher machining conditions, which can swap conventional flood method cooling and dry cutting. It accomplishes a sufficient cooling impact with the limited coolant flow rate.

This method offers favourable effects through reduction of cutting temperature. This situation probably provides impressive cooling to the machining zone. Therefore, it can be said there is a close relationship between the coolant volume and interval time that give minimum value for the surface roughness.

4. CONCLUSIONS

The results of the experiment proved the theoretically prediction where the coolants is not required to be supplied in bulk amount as to obtain the best surface roughness. Although the proposed method is not fully a MQL based machining, but the concept is similar, which is to reduce the amount of coolant supply to the machining operation, and the result of experiment proves that the surface roughness is much better when the coolant is supplied based on certain interval time rather than continuously supply or no supply at all . Overall, it can be determined that the proposed automated coolant supply has potential for an alternative green machining concept in industry.

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