Proceedings of Symposium on Electrical, Mechatronics and Applied Science 2018 (SEMA'18), pp. 23-24, 8 November 2018

Arduino Based Automated Coolant Supply System for CNC Machining

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Keywords: Arduino; Coolant Supply; Machining

ABSTRACT – Cutting fluid in CNC machining brings negative impact to the environment and human as well as creates high maintenance cost. Furthermore, it is found that only small amount of coolant play role in the cooling system application Thus, an Arduino based time-control automated coolant supply system for CNC machining is developed to reduce the amount of coolant used. Result of experiment proves that a better surface roughness is achievable and furthermore, reduction in consumption of coolant in this new development system is also obtainable.

1. INTRODUCTION

Cutting fluids plays an important role in CNC machining process. Cutting fluid is a type of coolant and lubricant designed specifically for machining processes, such as milling and turning.

However, those cutting fluids have very strong negative impacts to environment and health. Shashidhara and Jayaram [1] stated that frequent use of petroleum based oils will create a lot of negative effects on the environment. Cetin et al. [2] also stated that during machining, cutting fluids vaporize and spread into micro particles. Dermatological as well as inherent diseases, lung cancer, genetic diseases and respiratory infections might become a serious issue and health problems to the operator. Debnath et al. [3] also mentioned that the cost of cutting fluids cannot be removed from the budget, but the usage of cutting fluids can be reduced and indirectly reduce the cost.

Since health issues, environmental issues and economic issues had been discussed among the manufacturer, various methods of cutting fluids application in CNC machine have been investigated and developed in order to minimize or replacement of cutting fluids such as dry machining and minimal quantity lubrication (MQL). Those cooling techniques are developed through investigation regarding to the surface roughness, tool wear, temperature deviation and amount of coolant used.

2. METHODOLOGY

In this research work, a CNC milling machine was installed with a new developed coolant supply system (see Figure 1). The coolant from the CNC machine should flow from the part A through a valve and a specially fabricated nozzle to provide the on-off coolant supply. The supply is controlled by using an Arduino controller system as shown in Figure 2.

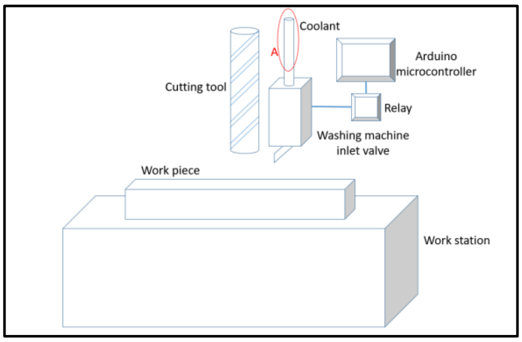

Figure 1 The overall concept of the automated coolant supply system.

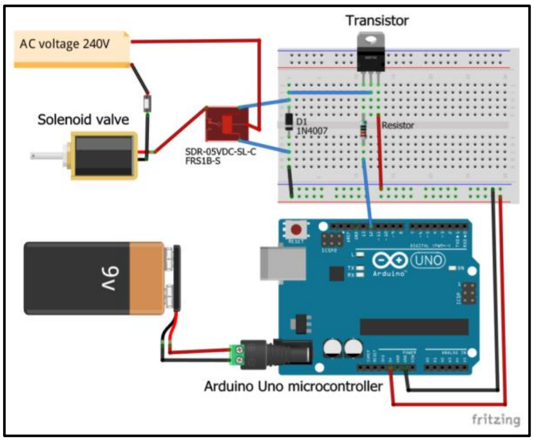

Figure 2 The Arduino controller circuit system.

When the switch is switched on, it allowed the coolant to be supplied from reservoir to the cutting tool and workpiece following the time setting. On the other side, a direct current of 9V adapter was inserted into the Arduino microcontroller board. The pin number 12 is linked to the relay (SDR-05VDC-SL-C) and the relay controlled the circuit of solenoid valve to become on/off by the coding.

The coolant supply is in the condition of supply-stop based on the time setting. For example, if the set time is 5s, then the coolant will be supplied for 5s and stop for 5s before supply again for 5s. This cycle will be repeated until the machining process is completed.

An AISI 304L workpiece was used with 200mm width, 120mm long and 30mm height to cut by the 10 mm of high speed steel cutting tool. The applied cutting fluid is known as AI Soluble Extra to cool down the workpiece. The experiment was conducted on a CNC Milling machine with spindle speed of 1200 RPM, feed rate of 100mm/min and depth of cut of 0.4mm.

3. RESULTS AND DISCUSSION

Figure 3 shows the result of the milling process operated on the aluminium block. Each interval time period is running for one cutting and labelled with a black marker pen. After all cuttings were done, the surface roughness of the cutting surface was measured by using a roughness tester and the result is shown in Table 1 as well as in the graph of Figure 4.

Figure 3 The result of cutting process on the workpiece.

Table 1 Result of interval time vs surface roughness.

Time (s)	1	5	10	15	20
Ra (µm)	0.6650	0.6585	0.5520	0.5015	0.5010
Time (s)	25	30	35	40	45
Ra (µm)	0.4975	0.4990	0.5965	0.5920	0.5815
Time (s)	50	55	60		
Ra (µm)	0.6050	0.6315	0.7420		

According to Figure 4, it is clearly seen that the results of the surface roughness value are decreasing from time interval 1s until 25s before it increased back until 60s. It can be summarized that the best surface roughness is during time interval of 25s with the value of 0.4975µm as can be notified in Table 1. Based on Jessy el al. [4], the chips formation during machining are tended to emerge from the cutting zone to machining zone through coolant. When the coolant is supplied to the cutting zone, the chips cannot emerge from the cutting zone if the amount of coolant is too big. Hence, drilling with external coolant which is widely practiced may not be a good significance in machining. In our proposed method, the amount of coolant during the time interval is too small (below than 15s), the chips cannot escape from the cutting zone and became obstruct. This may cause a bad surface roughness on the cutting zone. As the time interval increased, the coolant amount become lesser and this allows the chips away from the cutting zone more easily and cause an improvement in the surface roughness.

After the time interval 30s, the surface roughness value increase back 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 is more trending towards minimal quality lubrication technique**.** Based on Sun et al. [5], MQL has demonstrated 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.

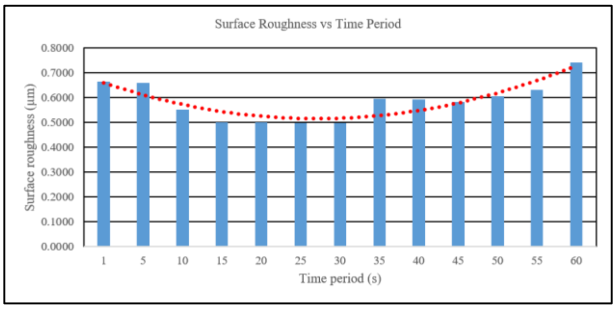

Figure 4 Graph plotted based on the data obtained.

4. CONCLUSION

Based on the experiment, the results obtained is basically follows the theoretically prediction which is the longer the time intervals of the coolants supply, the better the surface roughness obtained. 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 which is align to the result of MQL based machining. Overall, it can be concluded that the development of automated coolant supply is practical and can be an alternative for green machining in industry.

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