Surface Roughness Performance during Machining Aluminium Alloy using Automated Coolant System

Farizan Md Nor, Fairul Azni Jafar, Mohd Hadzley Abu Bakar, Wan Nur 'Izzati Wan Md Hatta

Abstract: ***Surface completion is a significant proportion of item quality since it extraordinarily impacts the presentation of mechanical parts. In CNC machining, wet cooling technique is normally applied to provide lubrication at the cutting zone to obtain good surface finish. In this system, a lot of cutting liquid is provided ceaselessly at the slicing zone to decrease the temperature between cutting instrument and work piece. Despite the fact that the cutting liquids are useful in ventures, their harmfulness can give negative effect to condition, human wellbeing and increment creation cost. Moreover, it is discovered that, solitary a limited quantity of coolant assumes their job in the cooling framework application. Therefore, an Arduino time base computerized coolant supply is created as another framework to diminish the utilization of cutting liquids. In this examination, an Aluminum Alloy was machined with CNC processing and the surface harshness is seen by utilizing this framework. As per the trial results, it is seen that the best time interim for providing and quit providing the coolant is 30 seconds with the surface harshness estimation of 1.0470 µm utilizing the shaft speed of 1200 RPM, feed pace of 100mm/min and profundity of cut of 0.4mm.This technique can reduce the cutting fluid consumption during machining operation and the improvement of the surface roughness is also obtained.***

Keywords : Cutting Fluid, Arduino Time Base, Surface Roughness

I. INTRODUCTION

In machining activity, cutting liquid assumes a significant job for cooling, greasing up and expelling chips from the cutting zone. Also, slicing liquids are provided to the machining zone so as to improve machining execution and secure machined segments and machine device parts from consumption. Gariani et al. [1]. According to Shihab et al.[2], heat generation during machining improves the cutting area temperature and can influence strength, hardness, wear resistance and life of the cutting tool. Moreover, Özbek et al.[3] express that over the top temperatures and powers may bring about quick apparatus wear and disappointment of the cutting instrument. In this way, by applying cutting liquid in the slicing territory to upgrade item surface quality and limit instrument wear, the raised temperature created at the chip-apparatus interface can be diminished. Be that as it may, the utilization of cutting liquid can antagonistically influence the human wellbeing, natural and increment creation cost. Makers are getting progressively worried about the issue of manageability in light of the fact that their monetary, ecological and social performance is enhanced by adopting sustainability in processes of metal machining, Muhammad & Ibrahim. [4].

According to Sankar & Choudhury [5], by releasing unwanted emissions and remaining material, cutting fluid adversely affects the shop floor environment. In addition, it also causes soil, water and air pollution during disposal. Valaki et al. [6] additionally referenced that cutting liquid can cause aggravation or sensitivity and microbial poisons are created by microorganisms and organisms especially in water-dissolvable slicing liquids are destructive to administrators. In addition, Priarone et al. [7] expressed that regular dissolvable oils are incredibly weakened in water, however 5% (by volume) of the cutting liquid is a mix of oil, emulsifiers, (for instance, sodium sulfonate, nonylphenol ethoxylates, PEG esters) and included substances, (for instance, calcium sulfonate, alkanoamides and blown waxes).Furthermore, the expenses of reducing the availability and storage of cutting fluid are not negligible with regard to the general manufacturing expenses. Jagadish & Ray [8] stated that cutting fluid reduction puts a great deal of economic stress on manufacturing businesses because fluid reduction is a major contributing to safety and economic hazards. This will have a strong effect on the safety of the worker, which in turn affects the full production scheme.

Moreover, Deiab et al. [9] mentioned that in machining processes, the function of lubricant consumption in the sustainability evaluation is of excellent significance. Costs associated with cutting fluid are often greater than those associated with cutting tools. Based on Sartori et al. [10] which expressed that cutting liquid transfer, cleaning of segments, contamination and harm to human wellbeing are a portion of the issues that affect stricter guideline so as to support the utilization of creative and ecologically

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benevolent advancements. Consequently, eliminating the use of cutting fluid, where necessary, may be a major financial motivation. Given the elevated price connected with the use of cutting fluid and the predicted escalation expenses when enforcing more stringent economic legislation, the option seems apparent, Khan et al. [11]. Some alternatives have been explored by researchers to minimize or eliminate the use of cutting fluid in machining operations. Padmini et al. [12] express that a portion of the choices being researched in the endeavor to supplant customary cutting liquid are dry machining, cryogenic cooling, strong ointment based machining, least amount grease (MQL) system pursued by the utilization of vegetable oils and nanofluids. According to Gatade et al. [13], MQL is a decent trade for flood coolant, which diminishes the natural effect and the expense of creation as improved device life. Those cooling techniques are developed through investigation regarding to the surface roughness, tool wear, temperature deviation and amount of coolant used.

In this study, a computerized coolant supply framework with the assistance of Arduino microcontroller to control the measure of cutting liquid and the planning interim time required during machining material is created so as to deliver an ideal surface unpleasantness and longer apparatus life. By using this technique, it is expected that the surface roughness of the cutting area is able to achieve the similar or better compared to the one under current conventional flood cooling technique. Furthermore, tool wear is also expected to be reduced and the system is more environmental friendly to user.

II. METHODOLOGY

Experiments have been carried out on Aluminium workpiece with 200mm width, 120mm long and 30mm height and were conducted on a CNC Milling machine with spindle speed of 1200 RPM, feed rate of 100mm/min and depth of cut of 0.4mm. The applied cutting fluid is known as AI Soluble Extra to reduce the temperature at the cutting zone and the material was cut in 10mm cutting length.

In this research work, a CNC milling machine was installed with a new developed automated coolant supply system as shown in Fig. 1. The coolant is supply directly through part A and flow into a valve to the fabricated nozzle and the coolant will be ON and OFF according to time setting in the Arduino microcontroller.

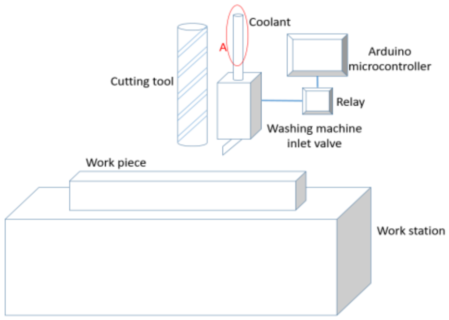

Fig. 1.Overall concept of automated coolant supply

This system consists of hardware development and software development. Hardware development is divided into two parts which are mechanical and electrical part. Fig. 2 shows the tree diagram of design and development for software and hardware for this system.

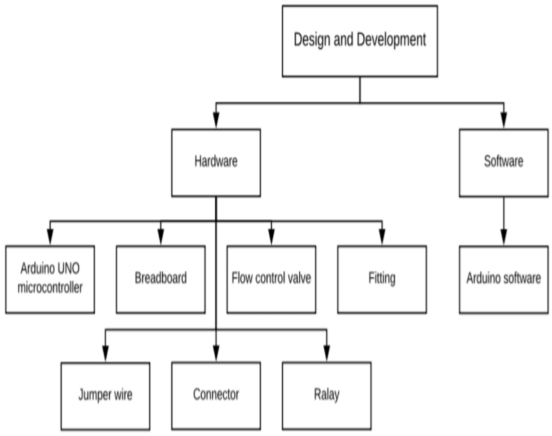

Fig. 2.Tree diagram of design and development of hardware and software

In mechanical part, a connector is developed before it is assembled with all components in the automated coolant supply system. After the part is printed, the mechanical part is roughly done and constituted of the connection between fitting and valve to the connector. Fig. 3 shows sample of the connector for the hardware mechanical parts and Fig. 4 shows the mechanical part that is installed in the CNC machine.

Fig. 3.Connection of the mechanical parts

Fig. 4.Mechanical part installed on CNC machine

Whiles in the electrical part, all the electrical components are linked together and located near to the CNC machine. An alternating current of 240V power supply is linked to the valve and controlled by normally opened circuit with a switch. When the switch is switched on, it allowed the coolant supply from the reservoir to flow to the cutting tool and workpiece.

In software development, Arduino software is used to program the timing system in the automatic coolant supply system. Generally, Arduino is a small microcontroller board connect to the computer by USB plug. Arduino can be controlled through computer or programming using computer and then disconnected and able to work independently. The Arduino UNO Rev3 is selected as one of the components used in this research as shown in Fig. 5. This Arduino board having its own library which allows the user to download and use all the coding from that library. The Arduino board is a device which can received the pre-programming from the personal computer with the aid of Arduino 1.6.12 software.

Fig. 5.Arduino UNO Rev3

In this new development system, the coolant is supplied in the condition ON and OFF at the cutting area according to time setting in Arduino microcontroller. A relay is used to control the time of supply and stop of the coolant on the cutting tool with time interval 1 s, 5 s, 10 s, 15 s, 20 s, 25 s, 30 s, 35 s, 40 s, 45 s, 50 s, 55 s and 60 s in this experiment. After the program is done, it is uploaded to the Arduino UNO R3 Compatible. For example, if the set time is 1s, then the coolant will be supplied for 1s and stop for 1s before supply again for 1s. This cycle is repeated continuously until the material is completely been machined.

III. RESULT AND DISCUSSION

Observation made during the 1s to 60 s interval times is on the surface roughness of the workpiece and summarized in Table I. The surface roughness results were analyzed using surface roughness tester. The result is plotted in graph form as shown in Fig. 6.

TABLE- I. Result of interval time vs surface roughness

Intervals time (s)	Surface roughness (µm)
1	1.5395
5	1.4770
10	1.2940
15	1.2605
20	1.2490
25	1.1135
30	1.0470
35	1.0635
40	1.0745
45	1.3945
50	1.3800
55	1.3315
60	1.3555

According to Fig. 6, It is obviously seen that the surface roughness value decreased from interval 1s until 30 s and increased back from 30s to 60s. It is summarized that the lowest surface roughness is achieved at the time interval of 30s with the value of 1.0470µm. In this condition, the coolant is sufficient to reduce the temperature and remove the chips at the cutting zone. Moreover, it is believe that there is excessive coolant from 30s coolant on to provide good lubrication at the cutting area although the coolant is off for 30s. This is in conjunction with the results of Jessy et al. [14], where they indicated that the development of chips during machining tends to arise through coolant. When the coolant is delivered to the machining area and the amount of coolant is too large, the chips cannot emerge from the cutting zone. Therefore, a big quantity of coolant that is commonly used in industry may not be of great importance in machining. However, in this automated coolant supply system, during the time interval below than 25s, the time is too little to even think about removing the chips from the cutting zone and chips became deter between the cutting apparatus and the workpiece. The modest quantity of coolant is inadequate to decrease the temperature at the cutting zone and may cause for the expanding of surface harshness.

It is observed that starting from interval time 30s, the surface roughness values increased until 60s interval time. This is because during the interval time above 30s, the condition is more trending towards dry machining compare to the condition before 30s which is more trending to minimal quality lubrication technique**.** Based on Sun et al. [15], MQL has demonstrated the potential of empowering for higher machining conditions, which can swap conventional flooded method cooling and dry cutting. It is accomplished a sufficient cooling impact with the limited coolant flow rate. When the feed rate is above 0.08mm/tooth, MQL accomplishes the best cutting fluid impact which essentially and outspread cutting powers.

The surface roughness is increase after 30s time interval because the coolant is insufficient to lessen the temperature at the cutting zone. It is additionally seen that the estimation of surface unpleasantness is more than 1 µm. This is on the grounds that equivalent cutting device is utilized for all interim time and may be as of now wear off or obtuse. Besides that, the cutting parameter is not considered during the experiments. This condition may affect the result of surface roughness obtained.

Further investigation is needed to verify this problem, as the present study work was not considered to change milling tool and cleaning of the material after each interval time. It is believing that with the changing of milling tool and cleaning the material for each interval time, minimum surface roughness will be obtained.

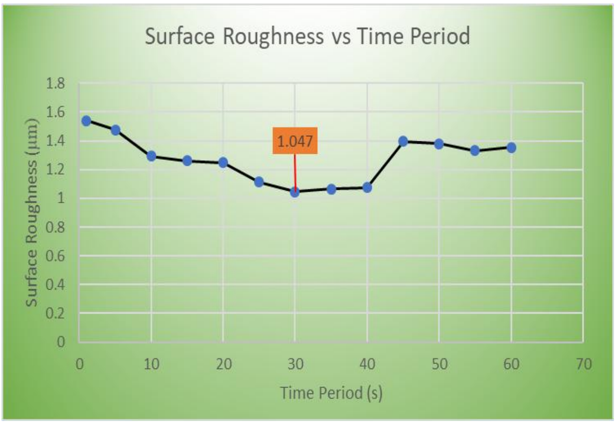

Fig. 6.Graph of surface roughness vs interval time

IV. CONCLUSION

Experimental findings in this research stated that the newly lubricating approach can produce economic advantages for producers owing to the reduction in cutting fluid consumption. In addition, the issue of adverse impacts on the environment and human beings was subsidized. Although this system is not fully a MQL based machining, this system produces good surface roughness which is align to the result of MQL. This is because a small amount of cutting fluid can penetrate effectively to the cutting area and adequate for lubrication with the reduction in temperature to provide good surface roughness on machining material. It can be concluded that this new development of automated coolant supply is one of the alternatives for environmentally lubrication strategies and can be practically use in manufacturing industry.

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