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Effect of Current and Wire Speed on Surface Roughness in the manufacturing of Straight Gear using Wire-cut EDM Process

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Abstract. The gears are an important part of a mechanism. Making gears requires high precision to avoid backlash. The machining process that can produce high precision is the process of Wire cut EDM. This study aims to determine the roughness of the workpiece surface and investigate the effect of current and wire speed on the roughness of the straight gear surface through wire cut machine EMS 45. The wire cut machining parameters used are 3, 5, and 7 amperes for current, and wire speed of 8, 10, and 12 mm/min. While the Wire material is a type of brass with 0.25 mm in diameter. The results presented that the increased use of current and wire speed will result in lower surface roughness, and vice versa. Therefore, it can be concluded that use low machine parameters to produce a smooth workpiece surface.

Keywords. Current, Wire Speed, Surface Roughness, Wire-cut EDM, Straight Gear.

1. Introduction

Wire-cut Electric Discharge Machining (EDM) is one of the greatest innovations in the tooling and machining industry. This process has brought about dramatic improvements in accuracy, quality, productivity, and earnings. Before wire EDM, costly processes were often used to produce finished parts. Now with the aid of computer and wire EDM machines, extremely complicated shapes can be cut automatically, precisely and economically even in materials as hard as carbide. As more design engineers incorporate new designs into the drawings, therefore it becomes important for contract shops to understand wire EDM as today's drawings are calling for tighter tolerances and shapes that can be efficiently machined only with wire EDM. Hence WEDM plays a significant role in the industries to attain better surface finish of the components. Wire cut machine is one of the CNC machines that can work automatically through a computer control system. The wire cut machine has the ability to produce high precision products with varying levels of desired roughness [1]. Surface roughness, especially on some high precision products, is a parameter to note. Products produced with a certain



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surface roughness value will determine the functionality of the product. The accuracy of the surface roughness value of a product will determine whether the product is working properly or not.

Gears are precision products that are commonly found in a variety of propulsion mechanism systems, which in practice sometimes require low surface roughness (smooth). The straight gear is a type of gear that has a simple shape. Consistent gear contours result in a straight gear machining process relatively easier to perform than any other type of gear machining process [2].

A wire cut machine is a conventional machine that is often used in various research objects. Research on setting cutting parameters on straight gears has been done before. Tosun et al. [3] were conducted a study on the effect of cutting parameters on surface roughness on wire cut with steel workpiece SAE 4140. From this research concluded that pulse duration, open circuit voltage, and wire speed greatly affect the surface roughness. The increase of dielectric fluid pressure can be obtained by a finer cutting surface. Sarkar et al. [4] were optimized for the parameter machining on cutting speed, surface finish and dimensional deviation when wire-cut EDM of titanium aluminide alloy. Sivaraman et al. [5] also were investigated the control parameters of wire-cut EDM for titanium on material removal rate and surface finish using the Taguchi approach. While Mahapatra and Patnaik [6] have also conducted research on the optimization of process parameters on the wire cut by using Taguchi method. The result of this research stated that the amount of current, frequency, and velocity of electric fluid flow and its interaction give a significant influence on cutting in increasing MRR, minimizing roughness of cutting result, and narrow cut width. This research also produces setting parameters of cutting wire cut process.

Based on the above study, this paper investigates the effect of cutting parameters on surface roughness through the wire cut process of EMS 45 steel to manufacture of straight gear.

2. Wire Cut Process

The wire cut process can only cut a workpiece that is conductive, whose base uses electricity. The hot wire is caused by an electrical pulse of DC generated between the wire and the workpiece. This is similar to other EDM processes, the wire becomes a negative pole and the workpiece becomes a positive pole so it can lead to spark jumps. Wire cut is a cutting process that uses a wire cutter that moves through the workpiece.

In the wire-cut process, there is deionized water called a dielectric. The deionization process will make pure water that serves as an insulator. In addition, the fixed water contains minerals, so it makes the wire very conductive. Meanwhile, to set the conductivity of water, they made the process of water circulation on the wire cut system. Schematic of the wire-cut process was shown in the Fig. 1.

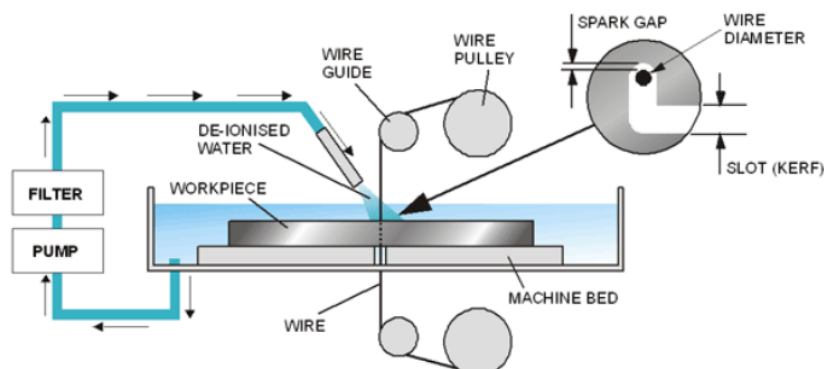


Figure 1. Schematic of wire cut process

Water will be deionized when the system is electrically powered. Furthermore, there is an electrical spark jump between the wire and the workpiece and erode a small part of the workpiece. Electric pulses occur repeatedly thousands of times per second. While pressurized dielectric fluid is flowed to assist the process of cooling the workpiece and cleaning up the scraping of wire and workpiece.

3. Experimental Setup

3.1. Materials

The material specification used in the experiment is EMS 45 steel. Meanwhile, the material used for wire cut electrode is wire brass type (brass) with a thickness of 0.25 mm.

3.2. Cutting Parameters

In this study, the experimental setup is using the cutting parameters as follow:

Table 1. Parameters for wire cut process

Parameters	Range
Current (Ampere)	3, 5, and 7
Wire Speed (mm/m)	8, 10, and 12

Surface roughness testing was performed using surface roughness tester SURFTTEST SJ-310. Data on Surface roughness was measured three times for each position.

4. Results and Discussion

The results of surface roughness on the straight gear making are shown in Table 2.

Table 2. The result of surface roughness

No	Current (Ampere)	Wire Speed (mm/min)	Surface Roughness (μm)			
			Ra ₁	Ra ₂	Ra ₃	Average
1	3	8	2.766	2.929	2.871	2.855
2	3	10	2.729	2.820	2.660	2.736
3	3	12	2.693	2.781	2.954	2.809
4	5	8	2.828	2.700	2.755	2.761
5	5	10	2.872	2.823	2.709	2.801
6	5	12	2.695	2.649	2.553	2.632
7	7	8	2.656	2.567	2.496	2.573
8	7	10	2.296	2.457	2.450	2.401
9	7	12	2.767	2.577	2.615	2.653

In order to gain a clear understanding, the test results data can be illustrated in Figs 2 and 3.

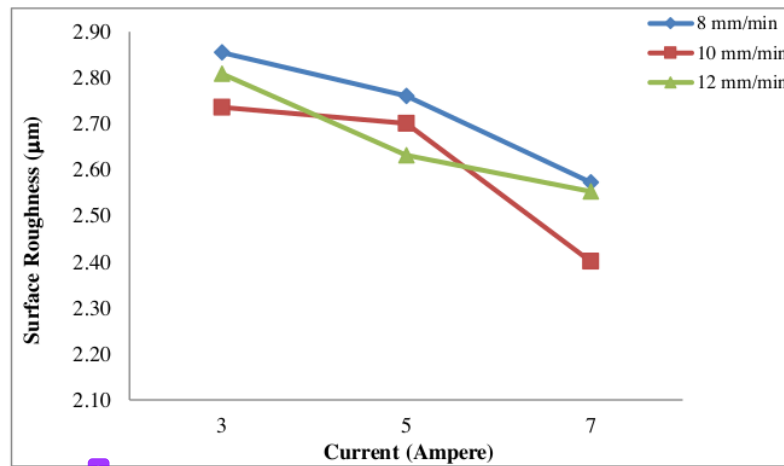


Figure 2. Data of surface roughness for different of current.

Fig. 2 shows that surface roughness is strongly influenced by currents. It is very clear that the surface roughness tends to be smoother if the current value is greater. If the current is minimized then the surface roughness will be rougher.

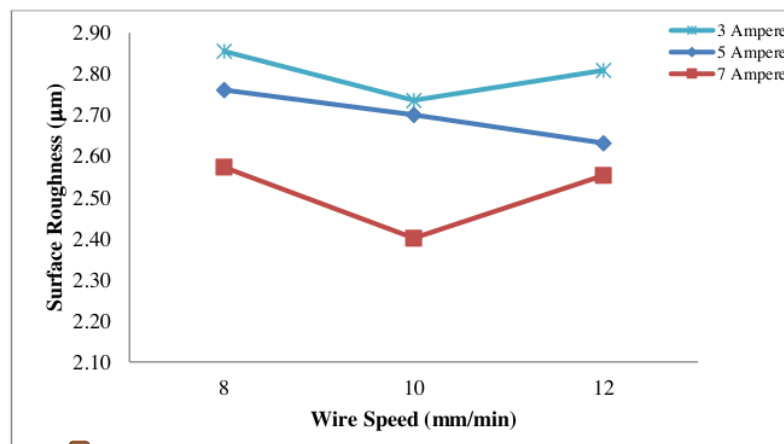


Figure 3. Data of surface roughness for different of wire speed.

Fig. 3 presents that surface roughness is influenced by wire speed, where the lower wire speed the surface roughness value will be rougher. Likewise, if the wire speed is improved then the surface roughness value will be smoother, but if wire speed added then it will make the workpiece surface rough again. It had been proven by Hasan et. al. [7], it was found that an excellent machined finish can be obtained by setting the machine parameters at low pulsed current and small pulse-on duration. This can be attributed to the fact that as the pulsed current decreases, discharges strike the surface of the sample less intensely, and the resulting better erosion effect leads to smoother surface. Furthermore, as the pulse-on duration decreases, the amount of heat energy transferred to the sample surface decreases,

and so less material melts. The fact that the surface roughness decreases with decreasing discharge energy has been described in the literature [8, 9, 10].

Displaying the results of gear made with the wire cut process can be seen in Fig. 4.



Figure 4. Display the results of making gear straight

The wire cut process using two variables (i.e. current and wire speed) has been running well. The result of surface roughness and cutting time is significantly influenced by strong variables of current and wire cut. This is in accordance with the facts proposed by Tosun et al. [3] was stated that wire speed is very influential on the roughness of the cutting surface. This phenomenon is also reported by a study conducted by Mahapatra and Patnaik [6] who examined the optimization of the parameters of wire cut EDM machining process by using the Taguchi method with the result that the magnitude of the current and the interaction gave a significant effect on cutting in increasing the MMR, minimizing roughness the result of cutting, and able to narrow the width of cutting [6].

As implied in Figs. 2 and 3, the surface roughness is dominated by variations of the two given variables, i.e. current strength and wire speed. The slower wire speed used then the surface roughness value will be rougher, and if the wire speed is increased when the surface roughness will be smoother. Likewise with the current variable, if the current value used is low then the surface roughness value will be rougher, and if the current value is added gradually will make the surface roughness value smoother. Ravi Kumar et al [11] find out on this work is aimed to optimize the parameters of Wire-cut EDM process by considering the effect of input parameters viz. Time On, Time Off, Wire Speed & Wire Feed. Experiments have been conducted with these parameters in three different levels of data related to process responses viz. Metal removal rate, surface roughness (Ra) have been measured for each of the experimental run. These data have been utilized to fit a quadratic mathematical model (RSM) for each of the responses, which can be represented as a function of the process parameters.

The experimental work by Selvam and Kumar [12], it reveals the following conclusions on Wire EDM operations on Hastelloy C-276 workpiece material. Main objective of this work is to develop the empirical model using GA. The genetic algorithm methodology is one of the best techniques to identify the effects of machining parameter on Wire EDM process. The voltage and pulse off time have the significant effect on machining time, the higher level of current produce lower machining time. The voltage, Current, Pulse on time and pulse off time are have significant effect on surface roughness. The higher level of current, voltage, pulse on time and pulse off time are produce poor surface finish.

5. Conclusion

Based on the investigation done in the process of wire cut on the straight gear making, it can be concluded that the current variable gives a significant influence on the roughness of the straight gear

surface. The greater the current use, the roughness of the straight gear surface is lower, the smaller the current is used, the higher the roughness of the straight gear surface.

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