International Journal of Latest Engineering Research and Applications (IJLERA) ISSN: 2455-7137

Volume – 02, Issue – 05, May – 2017, PP – 01-04

The Effect of Electric Current and Wire Feed Rate onWEDM towards The Spur Gear Surface Roughness

HastonoWijaya, FemianaGapsari
Mechanical Engineering Department. Faculty of Engineering, Brawijaya University
MT Haryono 167 Malang, Indonesia

Abstract: Wire Electrical Discharge Machining (WEDM) is one of machines which has high precision. This machine is used to build highly precision and complex engine components. WEDM parameter process gives effect to the dimension of working object. Electric current and wire feed rate is one of the parameters affecting the WEDM process. This research was conducted to know the effect of electric current and wire feed ratetoward surface roughness of spur gear making using WEDM.This research used experimental method and free variables used were varied electric currents 2,4,6, and 8 Aand varied wire feed rate 3, 4, and 5 mm/s. variable tied to this research was surface roughness of spur gear. The findings showed that the higher the wire feed rate value, the higher the spur gearsurface roughness. The lowest surface roughnessvalue was 1.91µm happened on combination of variant of wire feed rate 4 mm/son variable current 2 A. The highest surface roughness value was 2.94 µm happened on variant of wire feed rate 5 mm/s on variable current 8 A.
Keywords:W EDM, electric current, wire feed rate, surface roughness

Introduction

The advantage of WEDM use is that it is able to do a workpiece with a level of complexityand high precision and produce good quality of a workpiece's surface and it is able to do a workpiece with high level of hardness. (Meena et al, 2013;Rao,2010).EDM machine is able to create sharp edge on a workpiece because it uses electrode. High specification force is needed for EDM process.This makes WEDM needs high cost for its operation and the expense is worth paying compared to the high precision of a workpiece (Danial et al,2013; Dauw et al,1994).

A WEDM parameter process gives effect on a workpiece's dimension. Electric current and wire feed rate (WF) are ones of the parameters which affect the process of WEDM **(**Carl &Sommer, 2000; Mahapatra&Patanaik, 2006**)**. The amount of electric current correlates with the energy produced. Big energy triggerssparking. Sparkingis a process of electrical sparks which appears periodically and regularly in a dielectric liquid medium which functions as isolator. Eachsparkingrelates to the ability to erodea workpiece's surface. (Carl & Sommer, 2000; Jain et al, 2005; CunShan,2012**)**

A machining parameter which affect the production time is wire feed rate (WF). If the wire feed rate gets higher, the production time gets shorter (Mahapatra&Patanaik, 2006; Kuriakose&Shunmugam,2004**)**.If the feed rate gets higher, the deviation of workpiece precision and its surface roughness value gets higher. This is because the bigger the feed rate value, the more the amount of sparking in a certain unit of length and this causes metal release rate value increase and the workpiece surface gets rougher (Sarkar et al,2005). In this study, WEDM was cut with current variants to produce smooth surface on compound steel.

Method

Free variables used in this study were electric current variances with variance of 2, 4, 6and 8Aandwire feed ratewith variance of 3, 4 and 5 mm/s.

Tools

The method used in this study was true experimental research which was directly applied to the researched object. Surface roughness was measured by Mitutoyo Surftest SJ – 301 andWEDM Mitsubishi BA-8 machine.

Material

Workpiece used was compound steel AISI 4340. Chemical compound of the workpiece was0,36%C, 0,25%Si, 0,70% Mn,0,70%Cr, 1,40%Ni, 0,25%Mo. *TensileStrength*800N/mm^{2}and*Yield Strength*700 N/mm^2.

Workpiece

The workpiece produced in the study was spur gear with specification as follows:

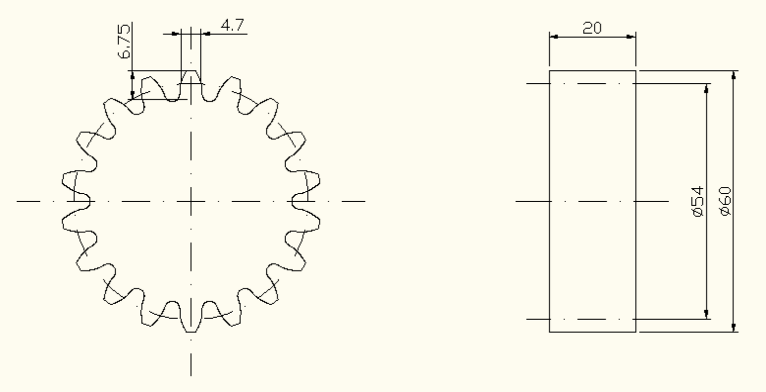

Figure 1. Specification of workpiece

Result and Discussion

Based the data of the surface roughness measurement, analysis of two ways variants was conducted to investigate the effect of electric current variance and wire feed rate and their interaction towards the surface roughness of cut result on *WEDM*. The level of confidence used in statistical analysis calculation was 95%.

Table 1. Analysis of variance of electric current variant and feed rate towards the surface roughness.

Source	SS	DF	MS	F Calculation	FTable
Electric Current (A)	0.9421	3	0.4711	7.2163	3,01
Wire feed rate (B)	1.1966	2	0.3989	8.5225	3,40
Interaction of A and B	0.3322	6	0.0554	1.0018	2,51
Error	1.3265	24	0.0553		
Total	3.7975	35	0.9806		

From Table 1, it can be concluded that the electric current variance and wire feed rate affect the surface roughness of WEDM cut result. However, interaction between electric current and wire feed rate does not correlate towards the surface roughness of WEDM cut result.

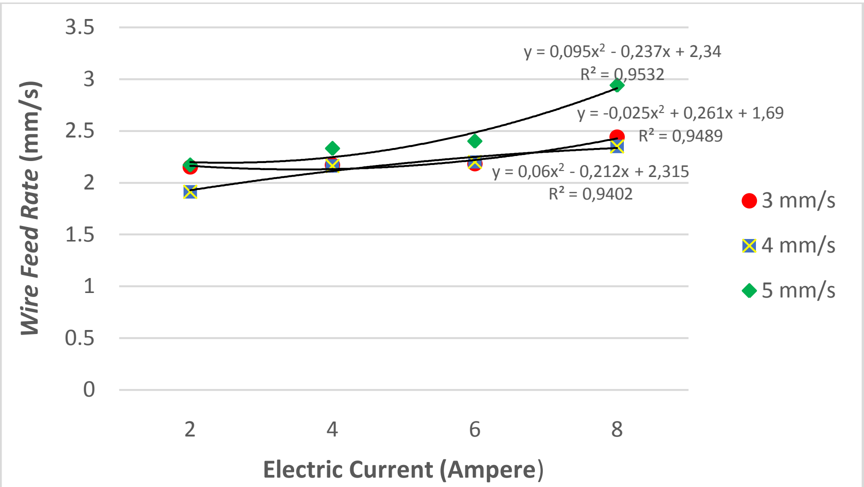

Figure 2. The graph on the correlation between electric current towards the surface roughness at some variances of wire feed rate.

From the regression analysis in Figure 2, it can be seen that the correlation between electric currents towards the surface roughness at some wire feed rate variances affects the surface roughness. The value of $R^2$is

1-100%. If the value is closer to 100%, it indicates that the correlation between electric current and surface roughness is higher. At variance of *wire feed rate* 3 mm/s, the coefficient of determination is R^2=0,940. It means that 94% of variance happened at the surface roughness variable is caused by electric current variable. This indicates that the correlation between electric current surface roughness is very significant.This is affected by other parameters such as wire lag, temperature, etc. Wire lag triggered by highly electric sparks, low wire pulling voltage, highly flushing pressure and feed rate.This may change surface roughness. Temperature during the research cannot be controlled at feeding or not feeding time. Machining temperature increases at the feeding time and it makes the current increase. This provokes electric pulses in form of more sparking and it makes surface roughness changes.

At variance of wire feed rate of 4 mm/s, coefficient of determination of R^2=0,948 is obtained. This indicates that 94.8% of the variance appears at the surface roughness variable which is caused by electric current variable. This shows that correlation between electric current and surface roughness is very significant. At variance of 5 mm/s wire feed rate,coefficient of determination R^2=0,953 is obtained. This means that 94.3% of the variance on the surface roughness variable is provoked by electric current variable. This indicates that correlation between electric current and surface roughness is very significant.

Figure 2 shows the effect of electric current towards surface roughness. From the figure it can be seen that the graph tends to increase along with the increase of electric current. It is because if the electric current used increases, the energy which is produced during the sparking gets bigger which leads to the erosion process creating craters appeared on the surface of the workpiece.

The craters are formedcaused by the process of pulse release which appears at gaps between electrode and workpiece. In this pulse release process, energy which is triggered by electric current will produce electric pulses in form of sparkingflowing through dielectric medium to erodeworkpiece surface and the electrode (Rao et al, 2011). The process oferosion is caused by the electron concentrationflowing in high speed and in short time and makes the electric sparks hit the workpiece surface and cause the surface to melt (Rao et al, 2011; Tosun et al, 2003).

Figure 2 shows that the lowest level of roughness is obtained at the use of 2 Ampere electric current because at the current, the produced sparking caused by the current between the gaps is not as big as the use of 8 ampere. This is because less particles have been eroded from the workpiece during the machining. This causes the working rate to be longer along with less current use.Besides, the amount of metal volume that should be omitted is equal and it means that the energy of each big sparking needs shorter time of erosion. This indicates that the bigger craters are formed(Mahapatra&Patanaik, 2006). At little sparking energy, shorter time is needed for the machining and it will form smaller craters. In this case, the particles which are passedoff from the workpiece surface will left marks in form of soft craters on the workpiece surface. The process of taking out the eroded material is helped by flushing process with dielectric fluid which circulates during the machining process. Flushingis dielectric fluid circulation between workpiece and electrode wire.

Figure 2 shows the graph of correlation between the electric current towards the surface roughness. It illustrates the correlation between electric current and surface roughness where little electric current will produce low surface roughness and big electric current will produce rougher surface.

The variance of wire feed rateaffects the surface roughness of thecut result. This can be seen in Figure 2. At biggest wire feed rate, which is 5 mm/s, the average of surface roughness value is also big.Wire feed rate 3 mm/s has surface roughness averagevalue which is bigger than the average value at wire feed rate 4 mm/s. This happens because the value of wire feed rate 5 mm/s and 3 mm/s is higher because the gap between wire electrode and workpiece is closer.The closer gap between wire electrode and workpiece makes sparking easy to appear and the sparking energy gets higher. If the sparking energy gets higher, the workpiece erosion caused by wire sparking will get higher (Hasçalýk&Çaydas,2004 ; Kumar et al, 2012) Surface roughness on lowest variable wire feed rate4 mm/s caused by the low energy of sparking causes the workpiece erosion which is triggered by wire sparking become lower(Liao et al, 2004 ; Han et al ,2007a and b ; Bamberga and Rakwal,2008 ; Aspinwall et al 2008).

Conclusion

From the study, it can be concluded that:

1. Electric current affects the surface roughness of gear surface. The surface roughness value on the ordinate axiswill increase in line with the increase of electric current value on abscissa. This indicates that the higher the value of electric current, the higher the value of gear surface roughness.
2. Wire feed rateaffects gear surface roughness. The value of wire feed rate of 5 mm/s is too big. It means that the bigger the wire feed rate,the smaller the gap between wire electrode and workpiece. If the gap between wire electrode and workpiece is closer, sparking can easily appear and the energy gets higher. If

the sparking energy gets higher, the workpiece erosion can easily happen. Wire feed rate 3 mm/s is too small. This is caused by the big gap between wire electrode and workpiece. This leads to less sparking because the gap between workpiece and wire electrode is bigger and it makes the workpiece surface roughness increase. Exact wire feed rate is needed for the spur gear which is made of AISI 4340 material.

3. The lowest value of surface roughness, which is 1.91 µm, is obtained at the combination of variance of wire feed ratefor 4 mm/s at current variable of 2 A. The highest surface roughness value of 2.94 µm is obtained at the variance of wire feed rateof 5 mm/s at variable of current of 8 Awhich is the highest variable variance used.

References

[1]. Aspinwall, D.K., Soo, S.L., Berrisford, A.E, Walder, G. 2008. Workpiece Surface Roughness And Integrity After WEDM Of Ti–6Al–4V And Inconel 718 Using Minimum Damage Generator Technology. *CIRP Annals. Manufacturing Technology*. 57: 187–190.

[2]. Bamberga,E., Rakwal,D. 2008. Experimental Inves- Tigation Of Wire Electrical Dischargemachining Of Gallium- Doped Germanium. *Journal of materials processing technol- ogy*. 197: 419–427.

[3]. CunShan X. 2012. Working Principle and Performance of Wire Electrical Discharge Machining. *Advanced Materials Research*. 507: 180-183.

[4]. Dauw, D.F., ETHI,B. 1994. High Precission Wire EDM by Online Wire Position Control. *Annals of the CIRP*. 41:193-197.

[5]. Ghodsiyeh, D., Golshan, A., Shirvanehdeh, J.A.2013. Review on Current Research Trends in Wire Electrical Discharge Machining (WEDM). *Indian Journal of Science and Technology*. 6(2): 4128-4140.

[6]. Han,F., Jiang, J., Yu, D. 2007a. Influence of Machining Parameters on Surface Roughness in Finish Cut of WEDM. *The International Journal of Advanced Manufacturing* Technology. 34(5-6): 538-546.

[7]. Han,F., Jiang, J., Yu, D. 2007b. Influence of Discharge Current On Machined Surfaces by Thermo-Analysis In Finish Cut of WEDM. *International Journal of Machine Tools and Manufacture.* 47 (7–8): 1187 1196.

[8]. Hasçalýk, A., Çaydas, U. 2004. Experimental Study of Wire Electrical Discharge Machining of AISI D5 Tool Steel. *Journal of Materials Processing Technology*. 148: 362–367.

[9]. Jain, V.K. 2005.Advanced Machining Processes. *Allied Publishers Pvt*. Limited, New 646 Delhi.

[10]. Kumar A., Kumar V., Kumar J. 2012. Prediction of Surface Roughness in Wire Electric Discharge Machining (WEDM) Process Base on Response Surface Methodology. *International Journal of Engineering and Technology (IJET)*. 2 (4): 708-719.

[11]. Kuriakose , S., Shunmugam , M.S.2004. Characteristics of wire-electro dischargemachined Ti6Al4V surface. *Materials Letters*.58 (17): 2231– 2237.

[12]. Liao Y.S., Huang, J.T. , Chen Y.H., 2004. A Study To Achieve A Fine Surface Finish in WireEDM. *Journal of Materials Processing Technology*. 149: 165–171.

[13]. Mahapatra, S.S., Patanaik, A. 2006. Optimation Of Wire Electrical Discharge Machining (WEDM) Process Using Taguchi Method. *International Journal of Advanced Manufacturing Technology*. 34 (9):911-925.

[14]. Meena, K.L., Manna, A., Banwait, S.S., Jaswanti. 2013.Effect of Wire Feed Rate and Wire Tension During Machining Of Pr-Al-SiC-MMC,s by WEDM. *European Journal of Engineering and Technology.* 1(1): 7-13.

[15]. Rao, P.S. 2010. Parametric Study of Electrical Discharge Machining of ALSI 304 Stainless steel, *International Journal of Engineering Science and Technology*. 2(8): 3535-3550.

[16]. Rao, P.,S., Ramji,K., Satyanarayana,B. 2011. Effect of WEDM Conditions on Surface Roughness: A Prapmetric Optimisation Using Taguchi Method. *International Journal of Advanced Engineering Sciences and Technologies*. 6: 41 – 48.

[17]. Sarkar, S, S., Bhattacharyya, M.B. 2005. Parametric Analysis and Optimization of Wire Electrical Discharge Machining of Titanium Aluminide Alloy. *Journal of Materials Processing Technology*. 159: 286–294.

[18]. Sommer, C.,Sommer, S. 2000. *Complete EDM Handbook*. Texas: Advance Publishing.

[19]. Tosun, N., Cogun, C., Inan, A. 2003. The Effect of Cutting Parameters on WorkpieceSurface Roughness in Wire EDM. *MachiningScience and Technology: An International Journal*. 7 (2) :209-219.