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THE EFFECT OF SINKING PARAMETERS TO OPTIMIZE RESPONSE AT EDM OF AISI H13 USING TAGUCHI – FUZZY METHOD

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ABSTRACT

The development technology in today's manufacturing is very fast, the desire of the market will need products and components with complex shapes and a high level of accuracy as well as hardness material which has high strength. High degree of hardness and precision widely used non-conventional sinking of EDM. End cutting depth (CDE), the maximum rate of erosion material(REM) and rate of electrode wear (RWE) as well as minimal surface roughness (SR) is the performance of the process of machine sinking EDM to be achieved. Aims of a study conducted to determine the contribution of the process parameters in order to reduce the variation of response parameters simultaneously and determine the value of setting the appropriate parameter process. The parameters were varied current, on time, off time and machining voltage. This research used experimental design of Taguchi method with orthogonal matrix L_{16} 4^4. Combination of Taguchi-Fuzzy is used as a method of optimization by experimenting as much as two times. Optimization results show the contribution of each parameter on all responses simultaneously is current at 41.35%, energy on time amounted to 37.90%, off time amounting to 10,11%and machining voltage by 5%. End cutting depth (CDE) with a specific target, the maximum rate of erosion material (REM),), the rate of wear of the electrode (RWE) and the surface roughness (SR) are both derived parameter value of at least current, 15A the energy on time 300⌠s, off time 5⌠s and machining voltage of 12V.

Keywords: EDM sinking, cutting depth end (CDE), the rate of wear of the electrode (RWE), the rate of erosion material (REM), the surface roughness (SR), the Taguchi-Fuzzy method

1. INTRODUCTION

In the current technological developments in manufacturing highly la fast, thus the market demand was more diverse will need products and components with various forms of simple forms to forms that are so complex and precision is high and the level of violence material that has higher strength, and therefore the world manufacturing industry sued would their increasing the effectiveness and efficiency that is able to cut process. For now conventional machines cannot work on components of complex and high levels of violence with a high level of accuracy. It can be processed using non-conventional engines such as sinking EDM (Electrical Discharge Machine).

In 1770 the British scientist named Joseph Priestly discovered spark erosion effects of electric current. Then the discovery was developed by a Russian scientist named B. Larzarenko 1943 that is by utilizing spark electric current to create a controlled process for machining electrically in a conductive material that became known as EDM process

The process EDM is a thermal process used for metal working with complex contours, involving the formation of a plasma channel due to a spark jumps between the electrode and the workpiece occurring not continuous but periodically the time. The heat from the spark jumps will cause local melting of the workpiece material and electrodes. Thus the magnitude of the speed of processing the workpiece is strongly influenced by the melting temperature of the workpiece itself. In general, the working principle of process the EDM sinking illustrated in Fig. (Lin et al. 2002).

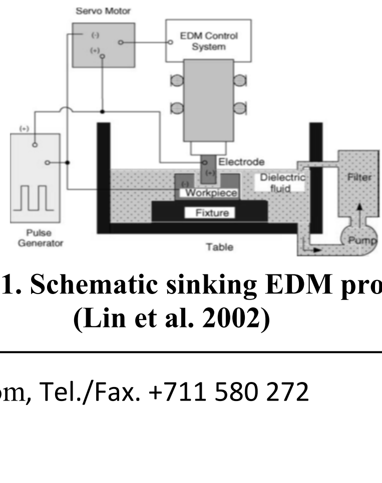

Figure 1. Schematic sinking EDM process (Lin et al. 2002)

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The rate of erosion material (REM) is the process of formation of fine craters on the surface of the workpiece. The parameters affecting the REM is the frequency of discharge, the amount of electric current and voltage of each discharge, the electrode material, workpiece material and conditions the fluid flushing dielectric(Krar, SF & Check 1997).

$$\text{REM} = \frac{\text{volume of wasted}}{\text{time processes}} \quad (1)$$

The rate of wear of the electrode material is defined as the amount of volume produced per unit time (mm^3/ min). RWE can be estimated based on the change in mass or volume change on the electrode.

$$\text{RWE} = \frac{\text{volume of wasted}}{\text{time processing}} \quad (2)$$

Surface roughness is defined as the configuration of surface irregularities on an object or area. The resulting surface configuration of machining process the EDM is a surface contour shaped in the form of small craters on the surface. The condition of the crater produced on machining process EDM sinking depend on electrical energy contained in each spark jumps electricity. Profiles in the surface roughness can be seen in Figure (Rochim 2007)

2. METHODOLOGY

The material used in the study was AISI H13 steel material with dimensions of Ø 25 x 19. Materials for electrodes or chisel used is copper. EDM machine Sinking used is a machine Hitachi the Series H-DS02-S.

The process parameters are parameters that can be controlled and the value can be determined. There are four parameters of the process used in this experiment are:

1. Current, electric current produced by EDM machine is between 0-28 A. Pulse current use are: 10A, 15, 20 and 25A.
2. On time, On-time generated by the EDM machine is between 50-300 µs, but the chosen are on time of 100 µs, 150, 200 and 300 µs.
3. Off time, this engine produces off-time between 3 ~ 25 µs, but in this study were selected two-level off-time is 5, 10, 15 and 20µs.
4. Machining voltage at this EDM machine between 8 ~ 12 V, but in this study were selected two-level EV is 6, 8, 10, and 12 V.

Parameter is a variable that the magnitude of the response cannot be determined and its value is affected by the treatment given, as well as the results known after conducting experiments. Response parameters used in this study are as follows:

1. End Cutting Depth (nominal the best).
2. The rate of wear of electrodes (smaller is better).
3. The rate of erosion of Material (larger is better).
4. Surface Roughness (smaller is better).

Degrees of freedom and level of process variables are presented in Table 1.

Table 1. Total degrees of freedom

No	Parameter Proses	Jumlah Level (k)	v_f (k-1)
1	*Current* (A)	4	3
2	*On time* (B)	4	3
3	*Off time* (C)	4	3
4	*Energy voltage* (D)	4	3
Total derajat kebebasan			12

Total degrees of freedom parameters and level used is 12, so the orthogonal matrix are eligible to be used as the experimental design is the 4L16^4 orthogonal experimental design L16 4^4 has four columns and 16 rows can be seen in table 2.

Table 2.Orthogonal matrix L_{16} 4^4

Eksperimen	A	B	C	D
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	1	4	4	4
5	2	1	2	3
6	2	2	1	4
7	2	3	4	1
8	2	4	3	2
9	3	1	3	4
10	3	2	4	3
11	3	3	1	2
12	3	4	2	1
13	4	1	4	2
14	4	2	3	1
15	4	3	2	4
16	4	4	1	3

3. RESULTS AND DISCUSSION

The result can be seen in table 3.

Table 3 .The test results

Ke-	Parameter proses				Respon							
	Current	On time	Off time	Machining voltage	KPA		LKE		LPM		KP	
					1	2	1	2	1	2	1	2
1	1	1	1	1	1,576	1,451	0,041	0,024	5,561	5,350	6,850	6,849
2	1	2	2	2	1,548	1,495	0,040	0,033	9,677	10,104	8,692	8,660
3	1	3	3	3	1,461	1,452	0,026	0,033	12,028	15,043	6,399	6,395
4	1	4	4	4	1,517	1,459	0,011	0,035	12,848	15,864	5,268	5,586
5	2	1	2	3	1,435	1,461	0,272	0,233	23,046	21,444	7,003	7,169
6	2	2	1	4	1,417	1,417	0,130	0,066	12,755	14,931	8,315	8,158
7	2	3	4	1	1,388	1,417	0,070	0,062	27,601	27,282	6,131	6,179
8	2	4	3	2	1,512	1,418	0,033	0,051	26,752	23,104	5,470	7,541
9	3	1	3	4	1,393	1,394	1,169	0,879	34,804	35,623	7,685	7,640
10	3	2	4	3	1,545	1,509	0,391	0,407	42,430	48,292	9,261	9,042
11	3	3	1	2	1,403	1,327	0,086	0,233	19,402	21,895	9,175	9,257
12	3	4	2	1	1,466	1,281	0,056	0,066	32,882	34,582	9,727	9,530
13	4	1	4	2	1,401	1,484	2,610	2,361	61,465	58,245	8,694	8,604
14	4	2	3	1	1,478	1,501	0,973	1,119	52,357	40,421	9,832	9,767
15	4	3	2	4	1,468	1,426	0,712	1,585	40,617	41,826	9,538	9,817
16	4	4	1	3	1,514	1,374	0,224	0,235	45,966	27,556	11,09	11,122

Ratio S / N is the design that is used to transform data into a repetition of the value of size variation arising. The value of S / N ratio depends on the type of quality characteristics of each response parameter (Soejanto 2009). The calculation of the value of the ratio S / N in this study conducted in the following manner:

For CDE response that has the quality characteristics with values or the target is not zero and limited. Or in other words a value close to a value determined is the best (nominal is the best) equation 3.

$$\text{S/N} = -\log\left[\sum_{i=1}^{n}\frac{(y_i-\bar{y})^2}{n}\right] \quad (3)$$

For REM response that has the quality characteristics of the smaller the better (smaller is better),use equation 4.

$$\text{S/N} = -\log\left[\sum_{i=1}^{n}\frac{y_i^{\,2}}{n}\right] \quad (4)$$

for the RWE response that has the quality characteristics of the bigger the better (larger is better), use the equation 5.

$$\text{S/N} = -\log\left[\sum_{i=1}^{n}\frac{(1/y_i^{\,2})}{n}\right] \quad (5)$$

for the response of SR which has the quality characteristics of the smaller the better (smaller is better),use equation 5.

$$\text{S/N} = -\log\left[\sum_{i=1}^{n}\frac{y_i^{\,2}}{n}\right] \quad (6)$$

The value of S / N ratio is obtained for each response were observed at each combination of settings parameter shown in table 4.

Table 4. Ratio S / N for each response

Ke-	Parameter proses				Rasio S/N respon			
	Current	On time	Off time	Machining voltage	KPA	LKE	LPM	KP
1	1	1	1	1	31,598	30,710	11,818	-15,785
2	1	2	2	2	36,698	30,425	14,449	-16,713
3	1	3	3	3	47,194	29,085	18,852	-16,120
4	1	4	4	4	31,294	19,703	20,741	-14,695
5	2	1	2	3	38,037	11,065	22,343	-17,009
6	2	2	1	4	295,024	18,306	18,459	-17,905
7	2	3	4	1	24,694	13,688	23,907	-18,766
8	2	4	3	2	28,924	28,716	23,844	-17,604
9	3	1	3	4	69,415	-1,763	27,199	-17,687
10	3	2	4	3	35,641	8,352	29,096	-19,231
11	3	3	1	2	28,021	19,879	22,409	-19,291
12	3	4	2	1	20,421	23,430	25,463	-19,672
13	4	1	4	2	27,811	-8,294	30,310	-18,740
14	4	2	3	1	39,364	0,422	27,536	-19,824
15	4	3	2	4	33,618	3,201	27,794	-19,716
16	4	4	1	3	23,301	13,853	25,362	-20,911
Sumber: Hasil hitungan			Maksimal		295,024	30,710	30,310	-14,695
			Minimal		20,421	-8,294	11,818	-20,911

Table 5.Results FRG

No	Respon				FRG
	KPA	LKE	LPM	KP	
1	31,598	30,710	11,818	-16,713	0,428
2	36,698	30,425	14,449	-18,766	0,386
3	47,194	29,085	18,852	-16,120	0,542
4	31,294	19,703	20,741	-14,695	0,564
5	38,037	11,065	22,343	-17,009	0,470
6	295,024	18,306	18,459	-18,443	0,602
7	24,694	13,688	23,907	-15,785	0,547
8	28,924	28,716	21,853	-14,816	0,628
9	69,415	-1,763	27,199	-17,687	0,435
10	35,641	8,352	29,096	-19,231	0,438
11	28,021	19,879	22,409	-19,291	0,474
12	20,421	23,430	25,463	-19,672	0,490
13	25,270	-7,567	29,447	-18,407	0,342
14	39,364	0,422	27,536	-19,824	0,380
15	33,618	3,201	27,794	-19,716	0,407
16	23,301	13,853	25,362	-20,911	0,536

Determining the best parameter combination begins with a table of process parameters of

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FRG. The calculation of the value of the FRG at each level of the process parameters shown in Table 6.

Table 6. Average FRG at each level of the process parameters

Parameter proses	Level 1	Level 2	Level 3	Level 4
Current	0,480	0,562	0,459	0,416
On Time	0,419	0,452	0,474	0,555
Off time	0,510	0,438	0,496	0,473
Machining Voltage / gap voltage	0,461	0,458	0,497	0,502
Rata-rata:	0,478			

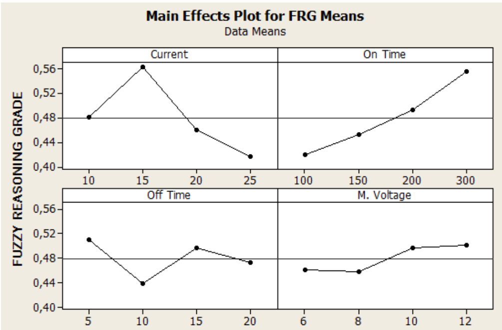

Figure 2. Plot the value of the FRG at each level of the process parameters

Table 7 Combination of process parameters for optimum response

Parameter proses	Level	Nilai level
Current (A)	Level 2	15 Ampere
On time (µs)	Level 4	300 µs
Off time (µs)	Level 1	5 µs
Machining Voltage/gap voltage (V)	Level 4	12 Volt

analysis of variance (ANOVA) was used to determine the process parameters that have contributed in reducing variations in response to end (CDE), the rate of wear of the electrode (RWE), the rate of erosion material (REM), the surface roughness (SR) workpiece simultaneously. In this study, ANOVA was performed on the FRG is a response parameter that represents the overall response as shown in table 8.

Table 8. ANOVA on FRG

Source	DF	SS	MS	F	SS'	% Kontribusi (ρ)
Current	3	0,044703	0,014901	37,67	0,043515	41,35
On time	3	0,041074	0,013691	34,61	0,039886	37,90
Off time	3	0,011831	0,003944	9,97	0,010643	10,11
Machining Voltage	3	0,006449	0,002150	5,43	0,005261	5,00
Error	3	0,001187	0,000396			5,64
Total	15	0,105243				100

Table 9. Data observations tensile carbon steel

No	Ø (mm)	L0 (mm)	L1 (mm)	Pu (kgf)
1	109,5	76	99	3610
2	109	76	97	3620
3	109	76	99	3710
4	109	76	99	3750
5	109	76	99	3450

The test results show that a medium carbon steel immersed with sea water during the 192 -hour weight loss of 0.005 g of initial weight and then immersed for 360 hours turned out to lose weight by 0.17 g of initial weight of 174.74 g minus 174.574, then the longer soaked is getting larger corrosion rate. Corrosion occurred on any additional time or are in mm / year is 0.725 mm /year

4. CONCLUSION

Based on the research that has been done on the effect parameters machine EDM sinking to optimize the response on the material AISI using the method H13-fuzzyTaguchi can be concluded that:

1. Contributions of the process parameters that significantly to maximize the KPA targets, maximize and minimize LPM simultaneously LKE and KP are:
   - Current has a contribution of 41.35%.
   - Energy, on time contributing has amounted to 37.90%.
   - Energy off time has contributed 10.11%.
   - Machining voltage (gap voltage) contributed only 5%.
2. The combination of process parameters appropriate level on sinking EDM significantly against KPA, LKE, LPM and KP simultaneously is the process parameters:
   - Current 15A.
   - Energy on time 300∫s.
   - Energy off time of 5∫s.
   - Machining voltage (gap voltage) of 12V.

REFERENCES

[1] Lin, C.L., Lin, J.L. & Ko, T.C., 2002. Optimisation of the EDM Process Based on the Orthogonal Array with Fuzzy Logic and Grey Relational Analysis Method. *journal of Advance Manufacturing Technology*, pp.271–277.

[2] Rochim, T., 2007. *Klasifikasi Proses, Gaya dan Daya Pemesinan. Lab.Teknik Produksi dan Metrologi Industri ITB, Penerbit ITB, Bandung.* Bandung: Institut Teknologi Bandung.

[3] Soejanto, I., 2009. *Desain Eksperimen dengan Metode Taguchi* Pertama., Yogyakarta: Graha Ilmu.

[4] Krar, S. F.& Check, A., 1997. *Technology of Machine Tools* fifth edit., Mc-Graw Hill: International Editions.

[5] Kusumadewi, S. & Purnomo, H., 2010. *Aplikasi Logika Fuzzy untuk Pendukung Keputusan* kedua ed., Yogyakarta: Graha Ilmu.

[6] Lin, J.L. & Lin, C.L., 2002. The use of the orthogonal array with grey relational analysis to optimize the electrical discharge machining process with multiple performance characteristics. *International Journal of Machine Tools & Manufacture*, 42, pp.237–244.

[7] Bagiasna, K., 1979. *Proses-proses Non Konvensional* Diktat Kul., Bandung: Departemen Mesin ITB.Ramesh, S., Karunamoorthy, L. & K. Palanikumar, 2008. Surface Roughness Analysis in Machining of] Guitrau,

[8] E.B., 1997. *The EDM Handbook*, Cincinnati: Hanser Gardner Publications.