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PARAMETERS ANALYSIS OF THE FCAW WELDING PROCESS AGAINST DEFORMATION WITH EXPERIMENT USING THE TAGUCHI METHOD

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Abstrac t- *With the existence of competitive competition, the welding process can be carried out by changing the method of welding work by using a new method, namely the SMAW electric arc welding method with FCAW (Flux Core Arc Welding) welding. In this study, various parameters of the FCAW welding machine used, namely amperage, voltage, and welding lag time, will be investigated. The purpose of this research is to get the best welding quality results by combining these parameters by looking for a comparison of the three parameters to minimize one of the welding defects, namely deformation. From the results of data processing and analysis, it was found that the voltage parameter is the one that has the most influence on the deformation. The combination of levels for the parameters that have been determined are the amperage at level 1 with the number 150 A, the voltage at level 1 with the number 22 V, and the pause time at 10 minutes. The experimental data model has been tested with regression analysis to obtain an R-squared of 79.43%, and the residual plot analysis is a straight line, so that the model is normally distributed and the coefficient is significant, meaning that the observation data represents real data.*

Keywords: FCAW Welding, Welding Parameters, and the Taguchi Method

INTRODUCTION

The welding process will be carried out effectively and efficiently with using the FCAW welding process, let alone a company looking to improve production by evaluating in terms of human resources (HR) as well as supporting tools and methods that will be applied in its implementation. The method to be applied is to use the FCAW welding method both in the on board area and in the workshop area.

The use of this FCAW welding method or process allows for applied in on board or on block areas, with a lot of work volume compared to when using the SMAW welding method or process. For further optimize the use of this FCAW welding method, A welder required to be able to get a variant of a technique or a better way of working. Because in the FCAW welding process there are welding parameters that will be used include amperage (current), voltage (voltage), and the pause time before the process Welding aims to minimize one of the welding defects, namely deformation. Wrong one suitable method to solve this problem is by apply the Taguchi method. The Taguchi method is commonly used because can simplify the number of experiments so as to minimize time and costs and be able to find out optimal factors and levels for quality improvement (Belavendram, 1995). The result of the Taguchi Method is a combination of factors along with a solid level (robust) against disturbing factors (noise). Therefore, the author provides a discussion in this research and parameters to be analyzed is the determination of amperage, voltage, and processing time Welding Against Deformation Using the Taguchi Method.

As for some of the formulation of the problem in this study are as follows: (1) What are the predetermined welding parameters that affect deformation significantly using the Taguchi method? (2) What is the combined amperage, voltage and welding interval number? has been determined to minimize deformation in the FCAW weld using the Taguchi method?

RESEARCH METHODS

There are several methods for carrying out welding on this trial material, among them are:.(1) In this trial material, there are three variants of the amperage value: 150A, 160A and 180A and voltage as well as three variants, namely: 22V, 26V and 28V and the welding time also varies, there are 3 (three) minutes, 10 (ten) minutes and 5 (fifteen) minutes. For each *root pass* in welding, use *a backing ceramic*

Each material in this trial will be treated the same within the scope of; (1) Plate Thickness = 8mm; (2) Bevel spacing (gaps) = 4 mm; (3) Plate Width = 150mm; (4) Plate Length = 300mm; (5) Placement of Stoppers = 50mm.

Using the same type of welding machine in each trial. Namely the machine las semi otomatis *Flax core arc welding* (FCAW). The type of welding wire used is A5.20: E71T-1M H. The welding process is carried out with the 3G welding position and is carried out by a professional welder. The welding machine used has been calibrated by the Quality Control (QC) team. Measuring tool used in calculating the speed of each process welding is the start time (Start) of welding to the end (Stop) of welding only with a matter of seconds / seconds

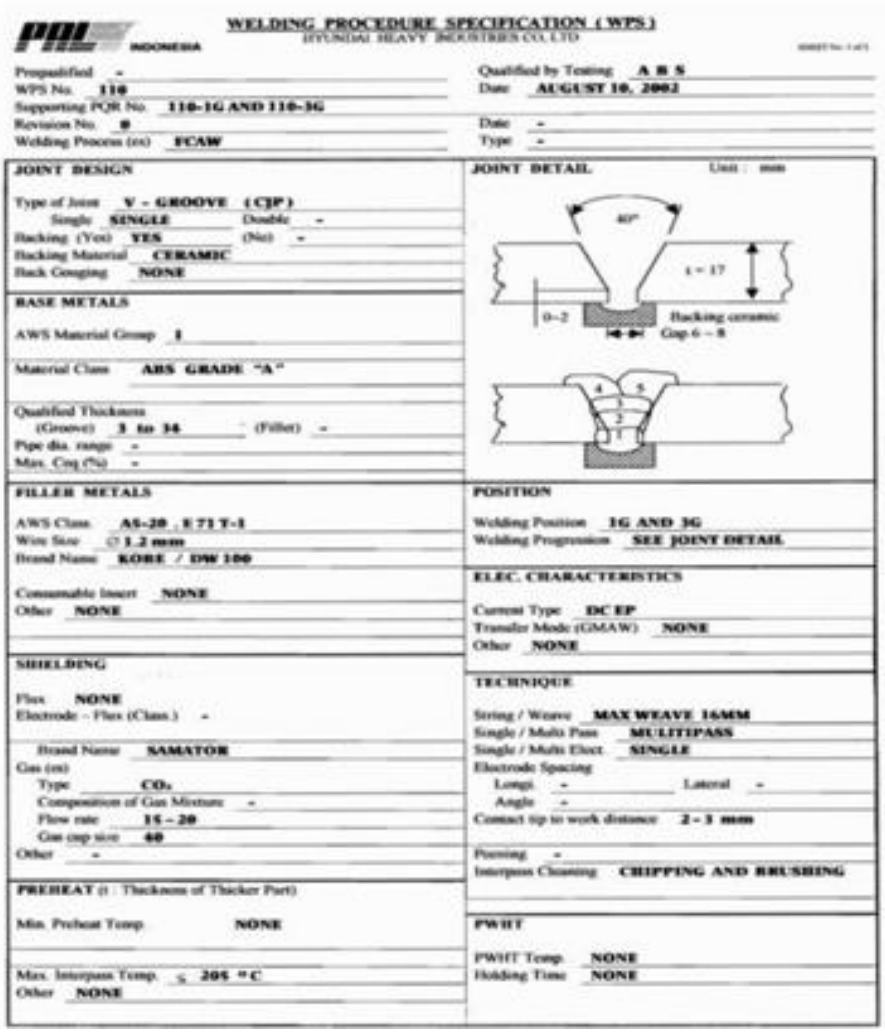
The welding process only uses two layers, just a root pass and finishing. (1) After the root pass is complete , it will always be cleaned with using a steel brush grenda on the weld groove. (2) Time measurement in welding will be

summed up from the root pass process and finishing with a matter of seconds / seconds (3) Deformation measuring tool using thread and welding gauge with millimeter count.

Table 1. Meanwhile, the WPS can be seen in Figure 1

Parameters	Level	2
Ampere	150A	160A
Voltage	22V	26V
Pausetime	3 Minute	10 Minute

In this study, several parameters of the FCAW welding machine were used used are Ampere, Voltage, and welding interval time. The following is Detailed parameters and levels used in this study can be seen in table 1.



WELDING PROCEDURE SPECIFICATION (WPS)

(HYUNDAI HEAVY INDUSTRIES CO.,LTD)

INDONESIA

Prequalified : -
WPS No. : 110
Supporting PQR No. : 110-1G AND 110-3G
Revision No. : 0
Welding Process (es) : FCAW

Qualified by Testing : A B S
Date : AUGUST 10, 2002

Date : -
Type : -

JOINT DESIGN

Type of Joint : V - GROOVE (CJP)
Single : SINGLE Double : -
Backing (Yes) : YES (No) : -
Backing Material : CERAMIC
Back Gouging : NONE

JOINT DETAIL Unit : mm

BASE METALS

AWS Material Group : 1
Material Class : ABS GRADE "A"
Qualified Thickness
(Groove) : 3 to 34 (Fillet) : -
Pipe dia. range : -
Max. Cnq (%) : -

FILLER METALS

AWS Class : A5-20 , E 71 T-1
Wire Size : Ø 1.2 mm
Brand Name : KOBE / DW 100
Consumable Insert : NONE
Other : NONE

POSITION

Welding Position : 1G AND 3G
Welding Progression : SEE JOINT DETAIL

ELEC. CHARACTERISTICS

Current Type : DC EP
Transfer Mode (GMAW) : NONE
Other : NONE

SHIELDING

Flux : NONE
Electrode - Flux (Class.) : -
Brand Name : SAMATOR
Gas (es)
Type : CO_2
Composition of Gas Mixture : -
Flow rate : 15 - 20
Gas cup size : 40
Other : -

TECHNIQUE

String / Weave : MAX WEAVE 16MM
Single / Multi Pass : MULITIPASS
Single / Multi Elect. : SINGLE
Electrode Spacing
Longi. : - Lateral : -
Angle : -
Contact tip to work distance : 2 - 3 mm
Peening : -
Interpass Cleaning : CHIPPING AND BRUSHING

PREHEAT (t : Thickness of Thicker Part)

Min. Preheat Temp. : NONE
Max. Interpass Temp. : ≤ 205 °C
Other : NONE

PWHT

PWHT Temp. : NONE
Holding Time : NONE

Figure 1. WPS FCAW

RESULTS AND DISCUSSIONS

Experiment with A = 150 A

Table 2. Deformation results with A=150 A. Experimental table difference between 150 amperes and voltage 22, 26, 28

No	A/V	G AP	Layer Weld	Temperature	Time	Welding Proses time (Second)	Deformation
1	150 A/22V	4	2	200	3	191	1,07
2	150 A/26V	4	2	60	10	163	1,05
3	150A/28V	4	2	50	15	209	2,07

Experiment with A = 160 A

Table 3. Deformation results with A=160 A. Experimental table difference between 150 amperes and voltage22, 26, 28

No	A/V	G AP	Layer Weld	Temperature	Time	Welding Proses time (Second)	Deformation
1	150 A/22V	4	2	350	3	145	1,06
2	150 A/26V	4	2	83	10	182	2,05
3	150A/28V	4	2	70	15	167	2

Experiment with A = 180 A

Table 4. Deformation results with A=180 A. Experimental table difference between 150 amperes and voltage22, 26, 28

No	A/V	G AP	Layer Weld	Temperature	Time	Welding Proses time (Second)	Deformation
1	150 A/22V	4	2	430	3	167	1,08
2	150 A/26V	4	2	90	10	145	2,02
3	150A/28V	4	2	60	15	140	3

Processing with the Taguchi Method

In this study, all data processing using the taguchi method will be done with the help of software minitab17. This is done to avoid error in manual calculation. The level of time efficiency and effectiveness The use of this software is also higher than that done manually. Plan the combination used for the taguchi method used in this study is an L9 orthogonal array. This design is in data processing so that it can saving time. From Minitab software do : (1) will get S/N ratio calculation; (2) then plot the relationship between parameters and deformations; (3) followed by selecting normal probability to generate graphs probability

Results of ANOVA, R-squared, regression formula, and probability plot will Reliability test results appear below the software calculation results:

S/N Ratio Calculation

In this S/N ratio calculation, the quality characteristics of the taguchi method are in use is the smaller-the better. It is applied because we do research on the results of welding defects, namely deformation. The purpose of this characteristic application is to get the minimum defects. S/ N Ratio for the smaller-the better. Where n is the number of observations and R is each response in data observation.

Table 5. Combination design and S/N Ratio calculation results

No. Exp.	Parameter			Deformation(mm)	Result of S/N ratio (dB)
	Ampere (A)	Voltage (V)	Pause time (minutes)		
1	150	22	3	1.07	-0.58768
2	150	26	10	1.05	-0.42379
3	150	28	15	2.07	-6.31941
4	160	22	10	1.06	-0.50612
5	160	26	15	2.05	-6.23508
6	160	28	3	2	-6.0206
7	180	22	15	1.08	-0.66848
8	180	26	3	2.02	-6.10703
9	180	28	10	3	-9.54243

In Table 5 above it has also presented the results of observations, the results of the design combination of data collection, and the results of deformation measurements after being carried out welding. From here shows no. 1 shows the best result.

Effect Plot of Weld Parameters on Deformation

After carrying out the process of calculating the S/N ratio, the next step is make an effect plot to find out what parameters or factors are the most effect on deformation. From the processing results of the software, we get the plot in Figure 3

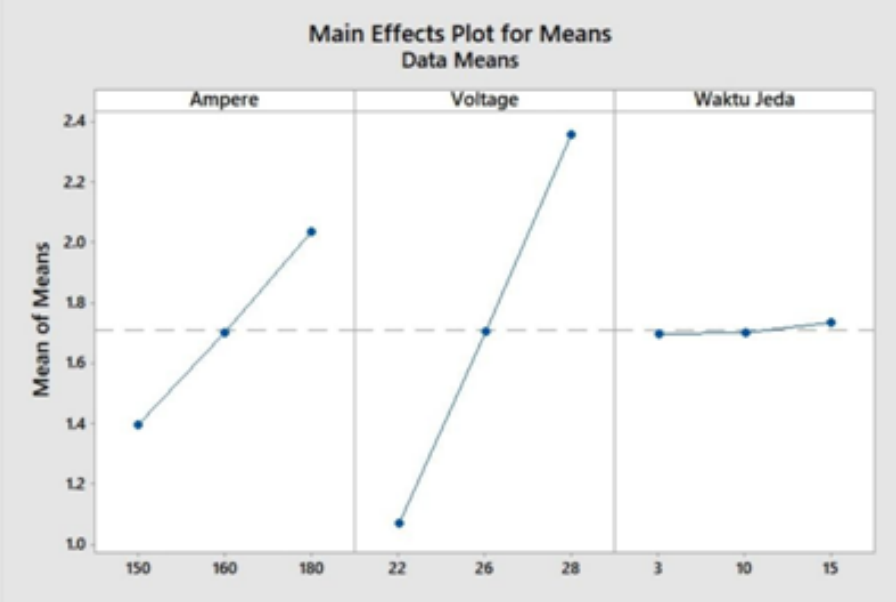


Figure 2 Effect Plot of Welding Parameters on Deformation

Nb: Amperes (A), Voltage (V) and pause time (minutes)

From the average value of each deformation that is calculated and can be seen in the picture above that each parameter with a high value is the parameters that have a large impact on deformation.

Optimum Parameter Selection Of Each Level To Minimize Deformation

This step will be carried out by looking at the plot and the response calculation results table on the S/N ratio. Optimum selection of each parameter is by choosing the largest value of each parameter value in the response table. Based

on the taguchi method, a higher S/N ratio reflects the smallest possible deviation between desired and measurable output. For more clear results which parameters. The optimal one can be seen in Figure 4 in the S/N ratio plot below.

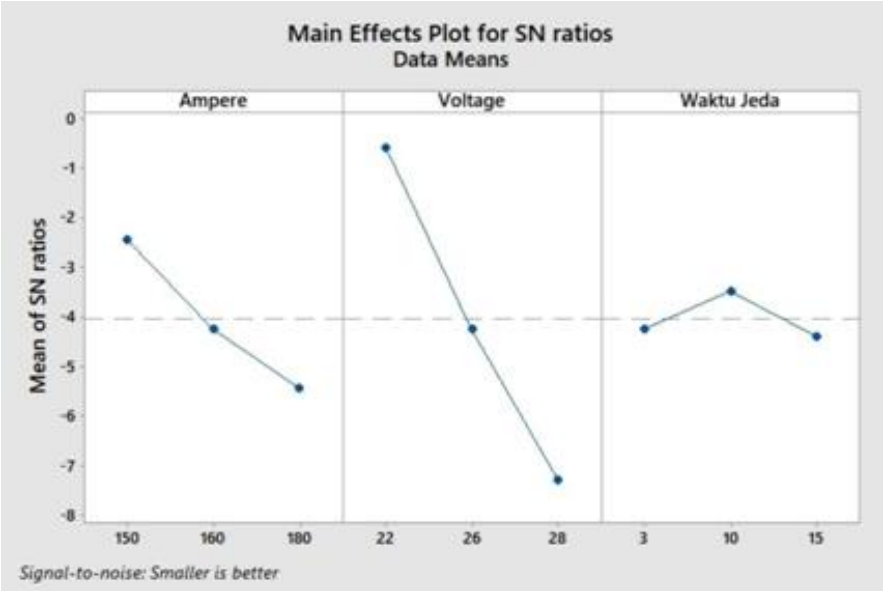


Figure 3 Plot S/N Ratio

Nb: Amperes (A), Voltage (V), and Pause time (minutes)

And you can detail the value of each S/N ratio response calculation result for each parameter seen in table 5.

Table 6 Response Table untuk S/N Ratio (Smaller is better)

Level	Parameter The	
	Ampere	Voltage
1	-2.4436	-0.5874
2	-4.2539	-4.2553
3	-5.4393	-7.2941
Delta	2.9957	6.7067
Rank	2	1

From the table above we can conclude that the amperage parameter is on level 1 which is at 150 A is optimal to get the deformation the smallest. For the voltage parameter at level 1, namely at 22 V, it is optimal to get the smallest deformation. for parameters pause time at level 2 which is at 10 minutes is optimal for get the smallest deformation. From the research conducted by applying the cutting parameter designed with the orthogonal array L9 Taguchi method, the deformation is greatly affected by voltage, this can be seen in the ANOVA table below by looking at the p-value it's value.

Table 7. Anova

Source	DF	Adj SS	Adj MS	F 6.44	P
Reggression	3	2.98201	0.99400		0.036
Ampere	1	0.59109	0.59109	3.83	0.108
Voltage	1	2.38907	2.38907	15.47	0.011
Pause time	1	0.00186	0.00186	0.01	0.917
error	5	0.77208	0.15442		
Total	8	3.75409			

In the ANOVA table Table 7 the *p-value* of voltage is 0.011. This means that the correlation is statistically significant, because the p-value is less than the level significance, therefore we can assume that the response variable is (deformation) and parameters in this case *voltage* have a significant correlation.

There are several analyzes that we can draw, in this case the results of the analysis of calculations and data processing using the taguchi method. The analysis are as follows: (1) Experimental combination design of L9 orthogonal array Taguchi method is the right combination design when we want to make a retrieval *sample* under conditions of limited cost, time, and material. This matter because the number of samples is not too much, but still deep enough conditions as a reference for sampling . In the selection of optimal parameters to minimize deformation, the amperage parameter at level 1, namely at 150 A, is optimal to get the smallest deformation. For parameter *voltage* onlevel 1 i.e. at 22 V is the optimum to get the smallest deformation. For the lag time parameter at level 2, namely on the 10 minute figure is optimal to get the most deformation small. By making *a hypothesis* and paying attention to the value of *alpha* (0.05).

In the ANOVA table, we know that the factors or parameters include *voltage, amperage,* and lag time, which have the most significant effect on deformation is *voltage.* From the results of modeling using regression analysis and residual plots, data observation design and the results are able to represent real or real data.

CONCLUSIONS

To answer the purpose of the research, there are conclusions from this study are as follows: (1) Of the several welding parameters that have been determined which significantly affect the deformation using the Taguchi method is the magnitude of *the voltage; (2)* Number of combinations of *amperage, voltage* and welding interval that has been used determined to minimize deformation in the FCAW weld using the Taguchi method as follows: (1) The amperage parameter is selected at level 1, which is 150; (2) In the *voltage* parameter , level 1 is selected, namely at 22 V; (3) In the delay time parameter, level 2 is selected, which is 10 minutes.

The suggestions in this study aim to complement and adding information to knowledge for further research is a factor or Other parameters that can be included in future research are possible affect the occurrence of deformation, such as the thickness of the plate used, type welding wire, etc.

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