ATHENA: Journal of Social, Culture and Society
Vol 2, Issue 3, July 2024, Page 378-382
ISSN: 2985 - 3605 (Media Online)
DOI: https://doi.org/10.58905/athena.v2i3.314

Effect Submerged Arc Welding (SAW) of Angular Distortion of T-joint

Yusuf Pradesar[1], Pranowo Sidi[2*]

[1]Faculty of Industrial Technology and Systems Engineering, Institute Teknologi Sepuluh Nopember, Surabaya, Indonesia
[2]Marine Engineering Department, Politeknik Perkapalan Negeri Surabaya, Surabaya, Indonesia

Email Corresponding: pranowo@ppns.ac.id

Abstract. Submerged Arc Welding(SAW),the molten weld metal is immersed in aflux that protects it from air contamination, forming welding slag which is strong enough to protect the weld metal until it solidifies. The used electrode was AWSA5.17EL12. The base metal being welded is ASTM A283 Grade A. In this study, the effect of angle distortion on the T joint was observed by changing the welding parameters. In order to obtain the optimal results, an attempt was made to link the welding parameters to the angle distortion through a mathematical model by using the Box Behnken statistic technique, the feasibility of which was then tested by using ANOVA analysis. What was obtained was analyzed with the help of the response surface methodology (RSM = Response Surface Methodology) then.

Keywords: Anova Analysis, Angular Distortion, SAW

1 Introduction

The welding process is a joint with local heating, where the heating temperature is relatively fast.As a result of this heating will occur grain growth, stretching and dissimilar metals quickly and notuniformly, resulting in changes in shape and size (distortion).This distortion causes the surface of the plate to be curved or wavy. Welding parameters need to be selected according to the welding conditions to be carried out. The problem that of ten arises is how to choose the right welding parameters, so that the changes in shape and dimensions that occur are not too large.

Several researchers have studied the occurrence of distortion due to welding. Anggono [1999] conducted a study on the effect of shielded metal arc welding (SMAW) welding heat input on angle distortion, with the conclusion that the thickness of the plate had the most effective on the occurrence of angle distortion, followed by the magnitude of the electric current and the welding speed having the least effect[1]. Suwanda [2001] conducted a study on minimizing distortion of mild steel welding with Submerged Arc Welding (SAW)[2]. The conclusion was that the larger the welding current, the greater the distortion. The greater the welding speed, the smaller the distortion, and the wider the plate used, the smaller the distortion. The biggest effect on distortion was given by current strength, followed by welding speed and plate width having the smallest effect. A study on the effect of Gas Metal Arc Welding (GMAW) parameters on distortion, with the conclusion that the parameters of voltage, current, welding speed and welding length affect the amount of distortion that occurs [3]. Angle distortions increased continuously with increasing voltage, NPD, torch angle and minimum angle distortion were found at maximum voltage and minimum WFR, while maximum angle distortion was found at maximum voltage and maximum WFR, NPD. maximum and maximum WFR, maximum torch angle and maximum WFR and maximum torch angle and maximum WFR[4]. The Taguchi experimental design approach proved satisfactory for this study[5]. Then, Lucas Martins Garcia et al (2021) said that understanding the mechanisms and parameters affecting distortion proved important for the prevention, control, and correction of deformation that occurs during the welding process [1]. There are several parameters of the submerged arc welding process which are thought to have a strong influence on the angle distortion and penetration depth of the T joint [6, 7]. Therefore, it is necessary to find the right setting of several parameters of the submerged arc welding process, so that the appropriate welding results are obtained.

ATHENA: Journal of Social, Culture and Society
Vol 2, Issue 3, July 2024, Page 378-382
ISSN: 2985 - 3605 (Media Online)
DOI: https://doi.org/10.58905/athena.v2i3.314

1.1 Submerged Arc Welding

Submerged arc welding (SAW) is a common arc welding process in which an arc is formed between the electrode and the workpiece. Powder flux is used to protect protective gases and slag (and can also be used to add alloying elements to the weld pool) that protect the weld zone, as shown in Figure 1.

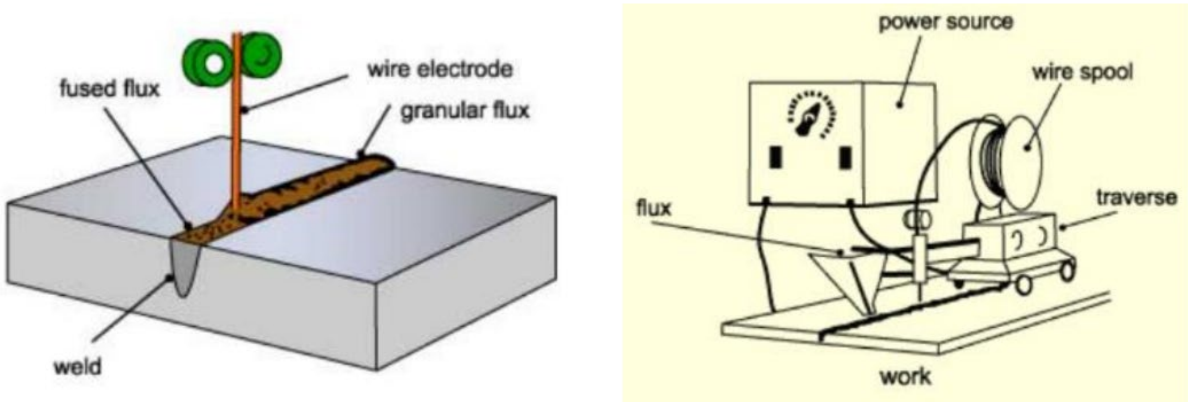

Figure 1. Welding Scheme and Submerged Arc Machine

The electrode can be solid wire or a core or strip made of sintered sheets or materials. The flux can be used to combine the constituents to form glass slag (which then forms a powder) or by agglomerating the constituents using a binder and corning process. Chemical properties and size distribution of fluxes to aid arc and determine the mechanical properties of metal welds and the shape of the beads.SAW is usually operated automatically and the welding current used is usually between 300 and 1000 amperes, arc stress and travel/welding speed all affect the shape of the bead, the depth of penetration and the chemical composition of the deposited weld metal. The operator cannot observe the weld pool directly, therefore it depends on the parameter settings and position of the filler wire.

1.2 Distortion

Due to local heating, the material will stretch and then shrink back non-uniformly. Areas that are close to the heating zone will have large stretch rates, while those that are somewhat much smaller. So, it belongs to the shrinkage process. With this non-uniformity, residual stresses will arise which will eventually result in a change in shape (distortion), whose shape can be transverse distortion, longitudinal distortion, or angular distortion. Occurring Angle changes are caused by uncontrolled distortion during welding or lack of preparation and inaccurate calculation of distortion by the welding operator. Distortion can occur because the heat generated is too large so that it will create a large opportunity forthe welded work piece to bend or change the angle. Figure 2, 3, and 4 shows the deformation for the butt weld and the angle weld.

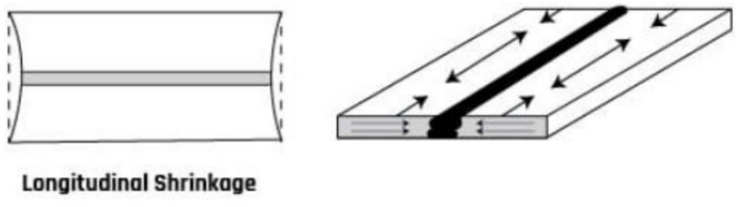

Figure 2. Longitudinal Shrinkage

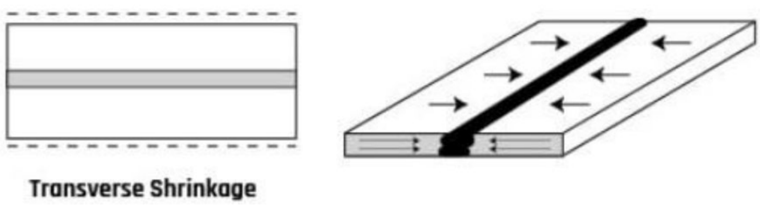

Figure 3. Transverse Shrinkage

ATHENA: Journal of Social, Culture and Society
Vol 2, Issue 3, July 2024, Page 378-382
ISSN: 2985 - 3605 (Media Online)
DOI: https://doi.org/10.58905/athena.v2i3.314

Figure 4. Butt-joint and T-joint
Source:(https://technoweld.com.au/2019/07/30/basics-of-distortion-in-welding/)

2 Methods

The used material used was ASTM 283 Grade A steel, and the electrode used is AWS A5.17 EL 12

2.1 Free Parameter

The independent parameter is a parameter whose amount can be determined based on certain considerations and the purpose of the research itself [7, 8]. In this study as independent parameters could be seen in following table 1.

Table 1. Free Parameter

Number	Parameter Process	Level		
		-1	0	1
1	X_1 = Tlate Thickness	8	10	12
2	X_2 = Welding Current	350	400	450
3	X_3 = Welding Speed	40	50	60

2.2 Response Parameters

In this study, the response parameter is the amount of angle distortion, as shown in Figure 3

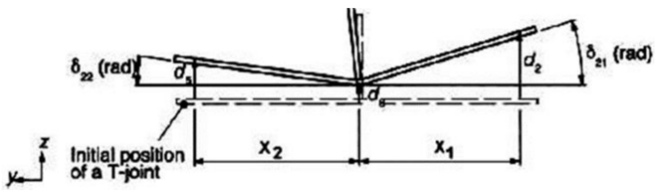

Figure 3. Angular Distortion (Miller, 1998)

2.3 Experimental Data

The test results data were shown in table 2

Table 2. Experimental Data

No.	Plate Thickness [mm]	Welding Current [Ampere]	Welding Feed [cm/minute]	Angular Distortion [radian]
1	10	400	50	0.030
2	10	400	50	0.028
3	10	350	40	0.030
4	12	350	50	0.022
5	12	450	50	0.038
6	10	350	60	0.036
7	10	450	40	0.040
8	12	400	60	0.034

ATHENA: Journal of Social, Culture and Society
Vol 2, Issue 3, July 2024, Page 378-382
ISSN: 2985 - 3605 (Media Online)
DOI: https://doi.org/10.58905/athena.v2i3.314

9	8	450	40	0.062
10	8	400	60	0.058
11	10	400	20	0.030
12	10	450	60	0.042
13	12	450	40	0.026
14	8	350	50	0.064
15	8	400	40	0.064

3 Result and Discussions

3.1 Second Order Estimation

Second-order polynomial model estimated of distortion of welding parameters (X_1 = plate thickness), X_2 = welding current, and X_3 = welding speed) are as follows:

$$\widehat{Y_1} = b_0 + b_1.X_1 + b_2.X_2 + b_3.X_3 + b_{11}.{X_1}^2 + b_{22}.{X_2}^2 + b_{33}.{X_3}^2 + b_{12}.X_1X_2 + b_{13}.X_1X_3 + b_{23}.X_2X_3 \quad \text{Equation 1}$$

From the second-order estimation using Minitab software, ANOVA results could be obtained such astable 3 and the value of the regression coefficient table 4.

Table 3. ANOVA Table of Second Order Angular Distortion

Source	Degree of Freedom	Seq. Sum of Square	Adjusted. Sum of Square	Adjusted, Mean Square	F-value	P-value
Regression	9	0.002973	0.002973	0.000330	170.88	0.000
Linear	3	0.002173	0.002173	0.000724	374.66	0.000
Square	3	0.000666	0.000666	0.000222	114.87	0.000
Interaction	3	0.000134	0.000134	0.000045	23.10	0.002
Residual error	5	0.000010	0.000010	0.000002		
Lack of Fit	3	0.000007	0.000007	0.000002	1.75	0.384
Pure Error	2	0.000003	0.000003	0.000002		
Total	14	0.002983				

S = 0.001390 R-Sq = 99.7% R-Sq(adj) = 99.1%

Table 4. Angle Distortion Regression Coefficient of Second Order Polynomial Form

Term	Coef	P=value
Constant	0.029333	0.000
X_1 (plate Thickness)	- 0.016000	0.000
X_2 (welding currents)	0.003750	0.001
X_3 (welding speeds)	0.001250	0.052
$X_1 * X_1$	0.012833	0.000
$X_2 * X_2$	0.004333	0.002
$X_3 * X_3$	0.003333	0.006
$X_1 * X_2$	0.004500	0.001
$X_1 * X_3$	0.003500	0.004
$X_2 * X_3$	- 0.001000	0.210

From table 4, it could be seen that the parameters that statistically significantly influence the distortion response sequentially were plate thickness, welding speed and current strength. The empirical model of angular distortion on welding parameters could be formulated as follows:

ATHENA: Journal of Social, Culture and Society
Vol 2, Issue 3, July 2024, Page 378-382
ISSN: 2985 - 3605 (Media Online)
DOI: https://doi.org/10.58905/athena.v2i3.314

$$\widehat{Y_1} = 0.02933 - 0.016.X_1 + 0.003750.X_2 + 0.00125.X_3 + 0.012833\,.X_1{}^2 + 0.004333.X_2{}^2 + 0.00333.X_3{}^2 + 0.0.450.X_1X_2 + 0.0035.X_1X_3 + 0.0010.X_2X_3 \quad \text{Equation 2}$$

3.2 Discussion of the results of the Distortion Model

Equation 2 showed the empirical model of the angular distortion over the welding parameters. The obtained model was in the form of a second order polynomial. From table 4 it could be seen that the coefficients indicated the magnitude of the influence of the welding parameters. The influence of the welding current strength parameter had the strongest influence compared to the other parameters. The smaller the current used, the smaller the angle distortion that occurred, and vice versa.

4 Conclusions

From the analysis carried out, the conclusions obtained are from the four hull shape modifications, namely single V-Hull, Single U-Hull, Trimaran, Catamaran. Obtained the hull that has the most efficient and effective manoeuvring value is the hull with a single V-Hull shape.

References

[1] Garcia, L.M.; Noronha, V.T.; Ribeiro, dan J. Effect of Welding Orientation in Angular Distortion in Multipass GMAW. (2021), JournalManufactur and Material Processing, 5, 63. https://doi.org/10.3390/jmmp5020063.

[2] Suwanda, Totok, (2001).*MinimalisasiDistorsi Pada PengelasanPelat Baja LunakDenganSubmerged Arc Welding Pada LebarPelat Dan KedalamanPenetrasi yang berbeda*, ProsedingSeminarNasionalPascasarjana, PPs, ITS, Surabaya.

[3] Rusdianto, Jaka, (1999), *AnalisaPengaruhParameterPengelasan GMAW TerhadapDistorsi yang Terjadi Pada Pengelsan Baja SS400 Ketebalan 12 [mm]*, Tugas Akhir yang tidakdipublikasikan, ITS, Surabaya.

[4] Malhi A. S., Singh, H., Saurabh, Y., dan Khanna, P., (2020). Estimation of Angular Distortion of FCAW welded SS 202 plates by Mathematical Modeling, International Research Journal of Engineering and Technology (IRJET), Volume: 07 Issue: 08, halaman 2997 - 3004

[5] Samal, T., Khanna, P., (2020), Prediction of Angular Distortion in MIG Welding of SS 202 using Taguchi Technique, International Research Journal of Engineering and Technology (IRJET), Volume: 07 Issue: 05, 2halaman636 – 2641

[6] Wiryosumarto, Harsono, Prof., Dr., Ir., dan ToshieOkumura, Prof., Dr., (2004), *TeknologiPengelasanLogam*, Jakarta, PT. PradnyaParamita.

[7] Yoshiki, M. Yasushi, M, Masahito, M.,dan Masao, T., (2006), *Measurement and Numerical Simulation of Angular Distortion of Fillet Welded T-joints*, Proceedings of the Japan Welding SocietyVol.24, No.4(20061105)halaman. 312-323.

[8] Montgomery, D.C., (1991), *Design and Analysis of Experiment*, John Wiley and Sons, Canada.

[9] Myer, R.H., dan Montgomery, D.C., 2002. *Response Surface Methodology, Process and Production Optimazation Using Design Experiment.* John Wiley and Sons, Canada.