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Multiple Linear Regression Analysis On Effect Of Time Variations And Voltage Variations On Spot Welding Against Shear Strength Of Aa5083 Material Using Ibm Spss Application

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Abstract. *Spot welding is one type of welding that is quite widely used in the vehicle industry, as well as ship manufacturing. This study used AA5083 aluminum plate which has a thickness of 1 mm , and overlapping joint. This study examine the effect of voltage and time variations on the value of the shear strength of the welded joint. The material is cut with a size of 200mm x 40mm, welded with voltage variations of 1.75V, 2.2V and 2.28V. And time variations between 1s, 1.5s and 2s, 300N constant pressure and uses copper electrodes with a diameter of 8mm. Multiple linear regression analysis is carried out and the effect of variabel X1 (stress) + X2 (time) on Y (shear strength) is 50.4%, where X1 is 22.7% and X2 is 27.8%. It states that there is no influence between X1 and X2 on Y, because the more dominant data is the data at 1.75V and 2.2V voltages which have no significant difference. At 2.28V the material will receive more heat so as to allow the material to melt and have a greater HAZ area as well as the material thickness decreases so that it will affect the shear strength very significantly.*

1. Introduction

In the current manufacturing process, there are many types of metal welding by way of welding, one of which is aluminium welding. Aluminium is widely applied in vehicle and ship body manufacturing. In the automotive industry, innovation between materials and integration between materials is needed to meet the specifications to be achieved and do not joint rule out aesthetic value. One of the ways to joining the two or more materials required a welding process. Welding is the process of joining two or more metals by heating the metal parts to be joined. Welding techniques are widely used in daily life and in industry. For example, in the automotive industry, as well as shipping. Good for ship panels, doors and car roofs. Spot welding is a form of resistance welding where a weld is produced at a point on the workpiece between the current-carrying electrodes, the weld area will have an area that is approximately equal to the electrode tip or as small as the tip of the electrode of different sizes.

Spot welding aluminium is a fairly complex process, because of the nature of aluminium which has a lower melting point compared to other metal materials. In addition, the welding results are expected to have high strength and fit the requirements.

Based on this, the study was conducted aiming to find out how the correlation between welding time, and stress at the AA5083 aluminium spot welding connection by shear testing. This analysis used secondary data from earlier experiment. The data will be analysed using the multiple linear regression method to obtain correlation data between the influence of time and voltage on the connection.

2. Research Methods

This study aims to see the effect of variations in stress and welding time on the shear strength of the material using multiple linear regression analysis. The research method used is a quantitative method. In this method used multiple linear regression analysis using the IBM SPSS application to find the correlation between the independent variables, namely stress (X1), and time (X2) to the independent variable, shear strength (Y). The data in this study are secondary data that has been done by previous researchers namely Br. Harley Anugrah with

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the title "The Effect of Time Variations and Electric Current Voltage on the Spot Welding Process on the Tensile Strength of the AA5083 Aluminium Plate Connection", the following are the equipment and research steps.

a.Spot welding machine

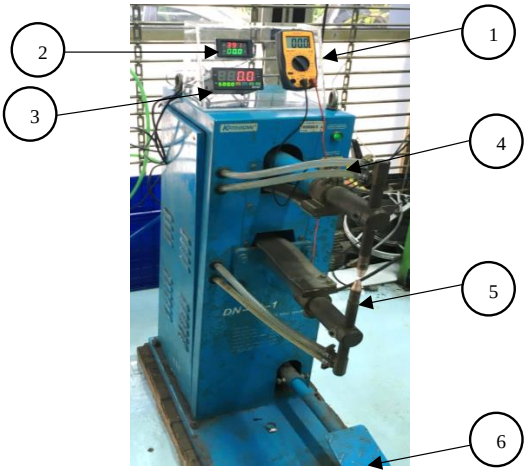

Figure 1. Spot welding machine

1. Digital multi meter
2. Digital voltmeter and ammeters
3. Load cell indicator
4. Water circulation pipes
5. Electrodes
6. The pressure lever

b. Tensile Testing Machine

Tensile testing machines are used to measure the shear strength of the material that has been welded.

c. Aluminium AA5083

The material used in this point welding test is aluminium AA5083 with a thickness of 1mm.

The following is a research flow chart.

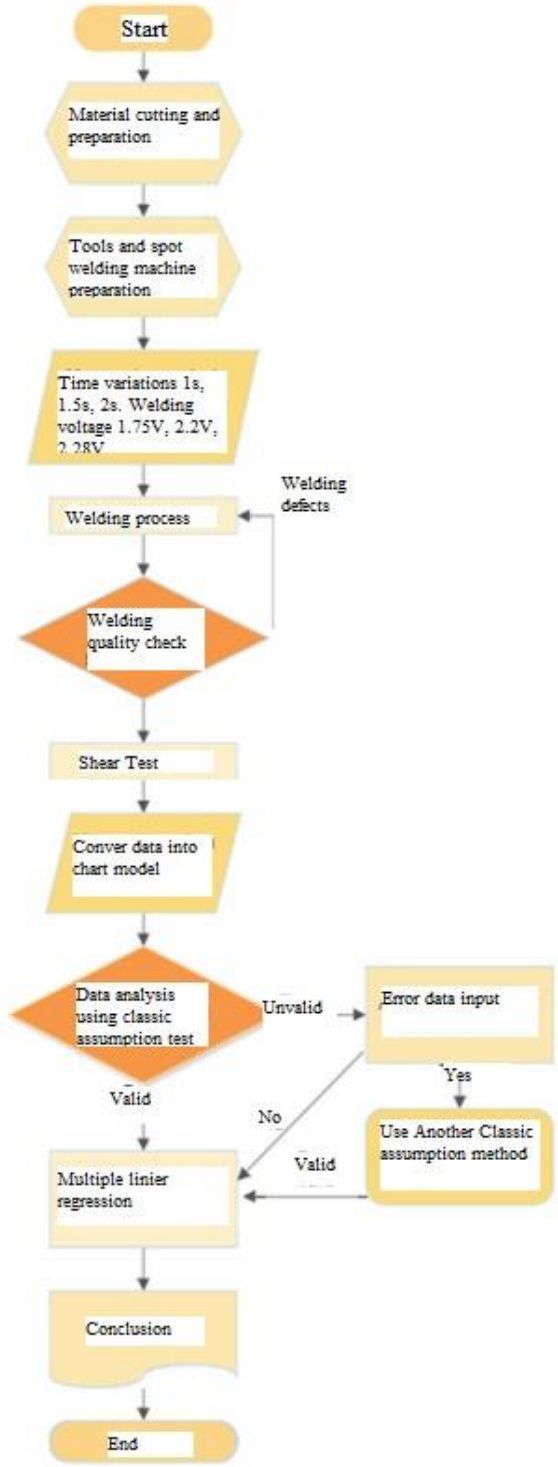

Figure 2. Flowchart of research

3. Results and Discussion

Welding Data Collection Process

The data of this research are secondary data which had already been done experimentally by Mr. Harley Anugrah. Experiments carried out with voltage variations between 1.75V, 2.2V and 2.28V, and time variations between 1s, 1.5s, and 2s. While the force of constant pressure at 300N and welding using copper electrodes with a diameter of 8mm. The material uses AA5083 aluminium with a specimen width of 40mm, length of 200mm, and thickness of 1mm. The material is then joined using spot welding with overlapping joint connections and then shear testing is performed

In this study, the method used is the experimental method, testing is carried out 5 times for each parameter. The average data obtained during testing is entered in tabular form as follows:

Table 1. Shear Strength Results, source: A. Harley (2019)

Out voltage (Volt)	Welding press time (second)	Shear strength (N/mm^2)					average
		1	2	3	4	5	
1,75	1	1,62	1,64	1,63	1,66	1,62	1,63
	1,5	2,39	2,40	2,40	2,43	2,40	2,40
	2	3,10	3,15	3,13	3,13	3,16	3,14
2,2	1	1,82	1,78	1,74	1,74	1,80	1,77
	1,5	2,74	2,79	2,76	2,74	2,77	2,76
	2	3,80	3,79	3,82	3,83	3,80	3,81
2,28	1	3,66	3,67	3,68	3,70	3,69	3,68
	1,5	5,99	6,03	6,02	6,01	6,03	6,02
	2	12,64	12,62	12,67	12,67	12,65	12,65

From the results of table 1, data converted into graphic.

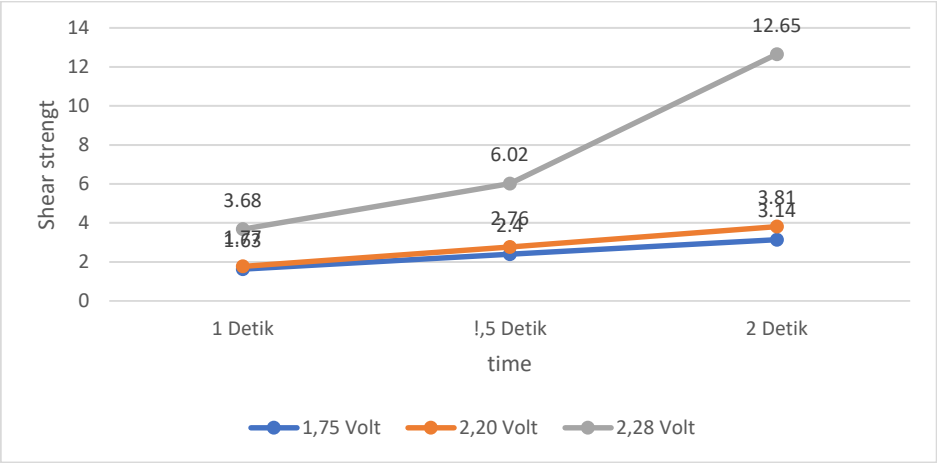

Figure 3. Shear Strength, source: A. Harley (2019)

Processing Shear Test Results

From the above data, multiple linear regression analysis is performed with IBM SPSS application to determine the correlation between the stress variable, and the time variable to the value of the material shear strength. First, a classic assumption test is performed, where the classic assumption test is performed to find data errors. The following is a classic assumption test conducted:

1. Probability Plot Normality Test

Regression models are said to be normally distributed if the data plotting (dots) represent the actual data following a diagonal line.

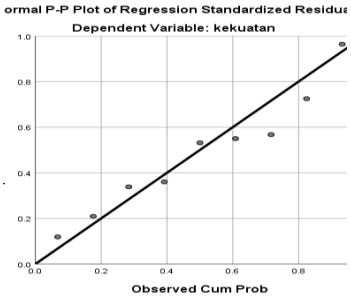

Figure 4.. Probability Plot

The points follow the diagonal line pointing up, meaning that there is a linear and positive relationship between X and Y variable. This positive relationship can explain that if the voltage and time are increased, the strength will also increase.

2. Tolerance and VIF Multi collinearity Test

There were no symptoms of multi collinearity in the regression, if the tolerance value> 0.100 and the VIF value <10.00.

Table 2. Coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-15.752	8.999		-1.750	.131		
	tegangan	6.596	3.984	.476	1.656	.149	1.000	1.000
	waktu	4.173	2.277	.527	1.833	.116	1.000	1.000

a. Dependent Variable: kekuatan

Based on these data, the tolerance value at voltage and time is 1,> 0.100 and the VIF value is <10. Therefore, it is concluded that there are no symptoms of multi collinearity.

3. Glejser Heteroscedasticity Test

Performed on a regression analysis results. Based on the Glejser heteroscedasticity test law, it is said that heteroscedasis does not occur if the significant value (Sig.) Is greater than 0.05.

Table 3. Glejser Test Coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-5.679	4.480		-1.268	.252		
	tegangan	2.053	1.983	.320	1.035	.341	1.000	1.000
	waktu	2.088	1.133	.569	1.842	.115	1.000	1.000

a. Dependent Variable: Abs_RES

Sig value can be seen in the table above. Based on the table above, it can be seen the value of Sig. each one is 0.341 for voltage and 0.115 for time. So it can be concluded that there are no symptoms of heteroscedasticity in the regression model.

4. Durbin Watson's Autokoleration Test
There are no symptoms of autokoleration, if the Durbin Watson value lies between du to (4-du).

Tabel 4. Model Summary

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.710[a]	.504	.339	2.78827	.834

a. Predictors: (Constant), waktu, tegangan

b. Dependent Variable: kekuatan

From the above data it can be seen that the value of Durbin Watson is 0.834. Whereas the du value is found in the Durbin Watson table with a significance of 0.05 based K (number of independent variables) = 2, and N (number of samples) = 9

Table 5. Durbin Watson with a Significance Rate of 0.05

n	k=1		k=2		k=3	
	dL	dU	dL	dU	dL	dU
6	0.6102	1.4002				
7	0.6996	1.3564	0.4672	1.8964		
8	0.7629	1.3324	0.5591	1.7771	0.3674	2.2866
9	0.8243	1.3199	0.6291	1.6993	0.4548	2.1282
10	0.8791	1.3197	0.6972	1.6413	0.5253	2.0163
11	0.9273	1.3241	0.7580	1.6044	0.5948	1.9280
12	0.9708	1.3314	0.8122	1.5794	0.6577	1.8640
13	1.0097	1.3404	0.8612	1.5621	0.7147	1.8159
14	1.0450	1.3503	0.9054	1.5507	0.7667	1.7788
15	1.0770	1.3605	0.9455	1.5432	0.8140	1.7501

Based on the table above, it can be obtained that the du value is 1.6993. Thus, du (0.834) <Durbin Watson (1.6993) <4-du (2,3007). Because Durbin Watson's value lies between du and 4-du, the conclusion is that there are no symptoms of auto coleration.

Based on the classic assumption test, no errors were found in the data, so that multiple linear regression can be done. Multiple linear regression aims to obtain a correlation between welding voltage, and welding time on the average shear strength of the welded joint. Here is a test of multiple linear regression analysis.

1. Partial t Test Based on Significance Value

Partial t test is a test of the influence of the X1 and X2 values individually on the Y variable. If the Sig. <0.05 then the independent variable (X) partially influences the dependent variable (Y). Based on table 2 it can be seen that the data has a Sig. > 0.05 which is the voltage Sig. = 0.149 and Sig. = 0.116. Thus, it can be concluded that the stress and time variables do not affect the shear strength.

2. Partial t Test Based on the value of t_{count} and t_{table}

Furthermore, in addition to being able to look at the significance value, a partial t test can also be done based on the t_{count} and t_{table} values. If $t_{count} > t_{table}$ means that the independent variable (X) partially influences the dependent variable (Y). The formula for finding a table is

(α / 2; n-k-1) => (0.05/2; 9-2-1) => (0.025; 6)

Table 6. Distribution of Value table

d.f	$t_{0.10}$	$t_{0.05}$	$t_{0.025}$	$t_{0.01}$	$t_{0.005}$
1	3.078	6.314	12.71	31.82	63.66
2	1.886	2.920	4.303	6.965	9.925
3	1.638	2.353	3.182	4.541	5.841
4	1.533	2.132	2.776	3.747	4.604
5	1.476	2.015	2.571	3.365	4.032
6	1.440	1.943	2.447	3.143	3.707
7	1.415	1.895	2.365	2.998	3.499
8	1.397	1.860	2.306	2.896	3.355

Based on the table above, the value of t table is 2.447. While the data t count obtained from the coefficient table is t arithmetic voltage (X1) = 1.656 and t count time (X2) = 1,833.

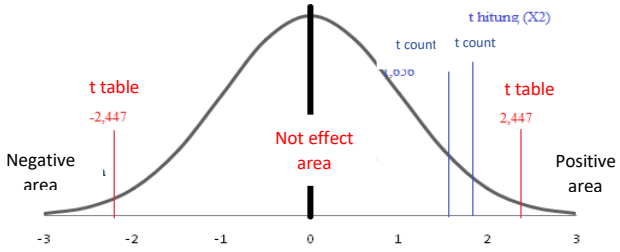

Figure 5. Partial t Test Based on Calculated Values and Tables

The graph above shows the t_{count} area with a $t_{partial}$ where X1 and X2 are in the area unaffected because the value is between the ttable values. Thus the partial t test results based on the calculated value and table also show that the variables X1 (voltage) and X2 (time) do not affect the variable Y (shear strength).

3. Simultaneous F Test Based on Significance Value

Simultaneous F test is a test of the combined effect of variables X1 and X2 on the variable Y. If the Sig. <0.05, it means that the independent variable (X) simultaneously (combined) affects the dependent variable (Y).

Table 7. ANOVA Test

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	47.437	2	23.719	3.051	.122[b]
	Residual	46.647	6	7.774		
	Total	94.084	8			

a. Dependent Variable: kekuatan

b. Predictors: (Constant), waktu, tegangan

Based on the table above, it can be seen that the significance value is 0.122 where the value is> 0.05. So it can be concluded that the values of X1, and X2 simultaneously have no effect on the Y variable. 4. Simultaneous F Test Based on Calculated Values and Tables If the value of Fcount> F table, it means that the independent variable (X) simultaneously influences the dependent variable (Y). The formula for finding Ftable: (k; n-k) => (2; 9-2) => (2; 7)

Table 8. Distribution of F for Probability 0.05

df untuk penyebut (N2)	df untuk pembilang (N1)								
	1	2	3	4	5	6	7	8	9
1	161	199	216	225	230	234	237	239	241
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68

Based on the table above can be obtained the value of F table that is equal to 4.35. Whereas the F_{count} was obtained from the ANOVA test table which is 3.051. Thus it can be obtained that $F_{table} > F_{count}$, it can be concluded that the variables X1 and X2 have no effect on the Y variable.

5. Percentage of the Combined Effects of Variable X on Y Variables

The percentage of the effect of variable X on variable Y can be seen in table 4. Model Summary. The percentage value can be seen in the R square section that is 0.504 x 100%. In order to get the percentage value of the influence of the variables X1 and X2 on the variable Y in the simultaneous F test that is equal to 50.4%.

6. Percentage of Effect of Variable X Against Variable Y Individually

To find the magnitude of the percentage, first look for the value of EC (effective contribution) and RC (relative contribution).

The search formula for EC:

$$EC\ (X)\% = \text{Betax x correlations coefficient x } 100\%$$

And RC formula :

$$RC\ (X)\% = \frac{EC\ (X)\%}{R_{square}}$$

Correlation coefficient values can be seen in the correlations table.

Table 9. Correlations

Correlations

		kekuatan	tegangan	waktu
Pearson Correlation	kekuatan	1.000	.476	.527
	tegangan	.476	1.000	.000
	waktu	.527	.000	1.000
Sig. (1-tailed)	kekuatan	.	.098	.072
	tegangan	.098	.	.500
	waktu	.072	.500	.
N	kekuatan	9	9	9
	tegangan	9	9	9
	waktu	9	9	9

From this table we can get the value of the correlation coefficient of voltage to strength is 0.476 while the correlation coefficient between times to strength is 0.527. While the Beta coefficient is obtained from table 2. Coefficients. From this table, the Beta value (regression coefficient)

for the voltage is 0.476 while the Beta value for the time is 0.527. Based on the formula and the data, then the percentage value of the effect of the variable X1 to Y is 22.7% and the effect of the X2 variable to Y is 27.8%.

4. Conclusion

From the results of the study entitled " Multiple Linear Regression Analysis on Effect of Time Variations and Voltage Variations on Spot Welding against Shear Strength of AA5083 Using IBM SPSS Application**"** it can be concluded that:

1. Based on linear regression testing using the IBM SPSS application, the effect of voltage variation / X1 (27.8%) and time variation / X2 (22.7%). expressed no effect on the value of the shear strength / Y. This is because the value of shear strength at voltages 1.75V and 2.2V (1.63 N / mm2 at 1.75V voltage and time of 1 second. 2.40 N / mm2 at 1.75V voltage and 1.5 seconds time. 3.14 N / mm2 at 1.75V voltage and time of 2 seconds 1.77 N / mm2 at 2.2V voltage and time of 1 second 2.76 N / mm2 at 2.2V voltage and 1.5 seconds time 3.81 N / mm2 at 2.2V voltage and time 2 seconds) does not differ too significantly compared to the value of the shear strength at 2.28V voltage (3.68 N / mm2 at 2.28V voltage and 1 second time. 6.02 N / mm2 at 2.28V voltage and 1.5 seconds time. 12.65 N / mm2 at 2.28V voltage and time 2 seconds) which has a very high value. So in the multiple linear regression analysis states that there is no influence between X1 and X2 on Y, because the more dominant data is the data at 1.75V and 2.2V voltage which have no significant difference. So the data at 2.28V voltage is considered as error data.
2. From these data it can be concluded that at a voltage of 2.28V the material has a shear strength value that is very much different from the stresses of 1.75V and 2.2V, because at a voltage of 2.28V the material will receive more heat so as to allow the material to melt so that it will enlarge the HAZ area and will affect the shear strength very significantly.
3. It can also be concluded that the test has not found the time, and the right stress for spot welding on AA5083 aluminium material, as well as the stressing force on the test not in accordance with the welding specifications of AA5083 material. So that when welding is carried out with too long a time or a gap that is too large and the pressure force is too big, the thickness of the connected specimen will thin so that it affects the shear testing process, resulting in errors in the value of the shear strength obtained. Therefore we need the right voltage, time and compressive force so that the connection has a good shear strength value.
4. Based on multiple linear regression testing, time variation / X1 (27.8%) has more effect on shear strength compared to stress variation / X2 (22.7%). While the effect of X1 + X2 on the shear strength / Y is 50.4%.

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