JEMMME (Journal of Energy, Mechanical, Material, and Manufacturing Engineering)
Vol. 5, No. 1, May 2020 | doi: 10.22219/jemmme.v5i1.10492

ISSN 2541-6332 | e-ISSN 2548-4281
Journal homepage: http://ejournal.umm.ac.id/index.php/JEMMME

Optimization on Spot Welding Joint toward Peel Load on SPCC Steel Sheet

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Abstract

Spot welding is a process of connecting two metal components through one or more connection points by using heat from electrical resistance which is carried by two electrodes to the metal to be connected with a certain welding time. The purpose of this study is to determine the effect of voltage and time of pressure used for spot welding on the shear strength and peel strength on the SPCC plate. The variables used in this study are independent variables of electric current variation of 2.30 V, 2.70 V, 3.20 V and time variation of 3 seconds, 4 seconds, and 5 seconds with 1mm plate thickness. The dependent variable in this study is the calculation of shear strength and peel strength in universal testing machine, and the controlled variable in this study is 1mm plate thickness characteristic of SPCC palate work piece. The research method was carried out using the ANOVA Factorial with the null hypothesis that there was no influence of the spot welding time and voltage on spot welding on the shear strength and strength of the SPCC material's peel. The results of the study are for the shear test seen from the calculation using MINITAB, the time variation of the pressure is no effect, while for the voltage and the combination of time suppression and voltage there is influence. For strength testing, the null hypothesis is rejected for all variations, which means that there is an influence on the strength of the peel test.

Keywords*: peel strength; spot welding; shear strength; time of suppression; voltage*

1. INTRODUCTION

Spot welding is a process of connecting two metal components through one or more connection [1][2][3] points by using heat from electrical resistance which is carried by two electrodes to the metal to be connected with a certain welding time. It is a sheet material [4] or plate with thickness variation. In the process, the spot welding is used to accelerate the processing time to join the sheet metal that it can increase the production result [5][6].

Shear strength on positive surface of an element is positive if it works in the positive direction of one of the positive axes and so it is in the negative direction [7][8][9][10]. The shear strength on negative surface of an element is positive if it works in the negative axe and negative if it works in positive direction [11].

Heat in this process is influenced by the plate thickness and the electric current. The different plate thickness causes the difference in welding time [12][13][14]. Controlling current will influence the result of welding [15][16][17]. The lower current used for welding leads to electrode difficult to ignite. It causes the welding surface jagged and the welding cannot reach the thickness. When the current is high, it results wider welding surface and deeper welding depth. Therefore, the shear strength is low and the brittleness increases [2].

The SPCC steel is defined as commercial quality cold rolled steel sheet. This kind of steel is the most suitable material for car body, electrical equipment, and so forth. It as SPCC can be applied in wider applications. This cold rolled steel sheet has 0.15% maximum carbon.

2. METHOD

Data of this experiment is the shear strength and the peel strength [18][19] of welding joint of Spot Welding. The data is based on the variation of voltage and pressure time. Therefore, this experiment needs universal testing machine to obtain the data. The variation of voltage is determined in 2.30 V, 2.70 V and 3.20 V, while the variation of pressure time is determined in 3 seconds, 4 seconds and 5 seconds. Material for this experiment is SPCC steel sheet [20][21]. By the number of 54 specimens under tensile test, the variation is conducted in three times testing.

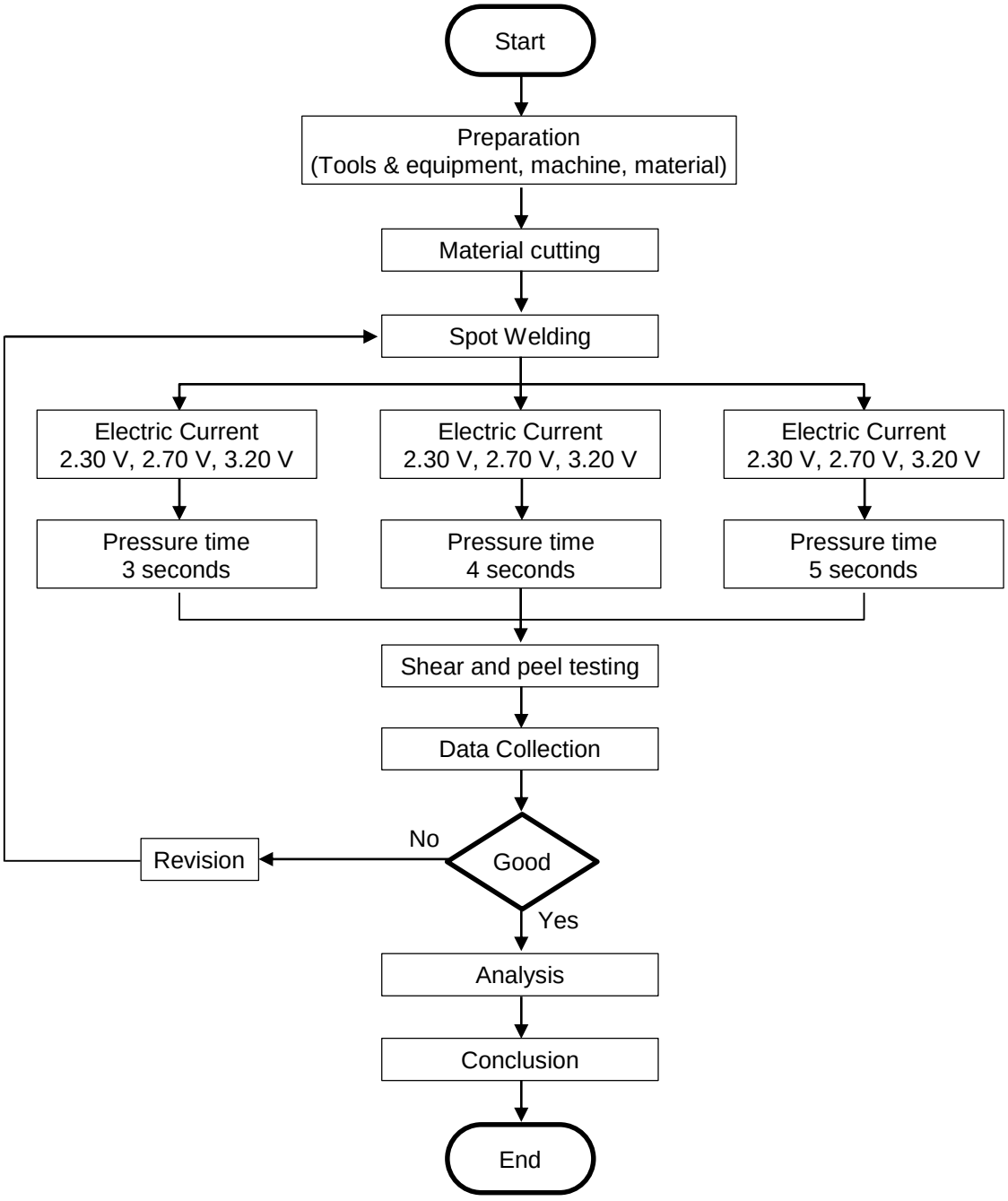

Figure 1. Research Procedure

The first procedure conducted for this experiment is cutting the material as the standard of shear and peel tests from ASTM D1002 [22][23][24]. Furthermore, the

material is welded by using spot welding method with voltage variation of 2.30V, 2.70V and 3.20V. The variation of pressure time for the spot welding is three seconds, 4 seconds, and 5 seconds.

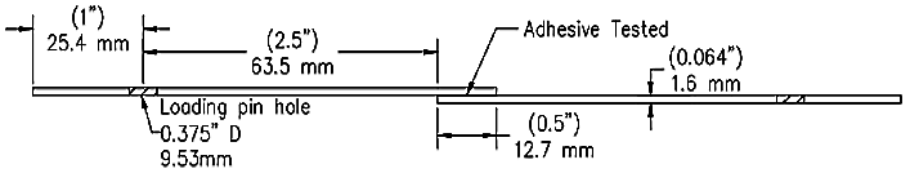

Figure 2. Standard of shear test of ASTM D1002

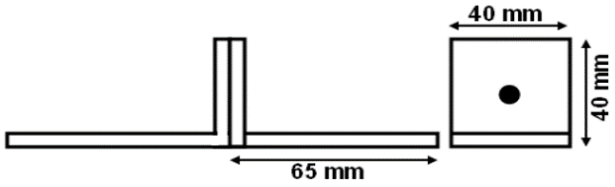

Figure 3. Standard of Peel Test of ASTM D1002

The next process is data collection on the shear and peel test. Before conducting the both tests, the procedure is preparing universal testing machine and camera. The camera is used to record data of force. The data of force is the number displayed on the digital screen. The material is attached to the chuck of universal testing machine and is tested. In the shear and the peel test, the data is not the force but the elongation. It is listed in every ½ mm elongation within the shear test and 1 mm in the peel test.

Figure 4. Shear test

Figure 5. The peel test

3. RESULT AND DISCUSSION

Result of the shear and the peel test can be seen on **Figure 6**, where the variation of voltage and variation of pressure time have different maximum shear strength and maximum peel strength.

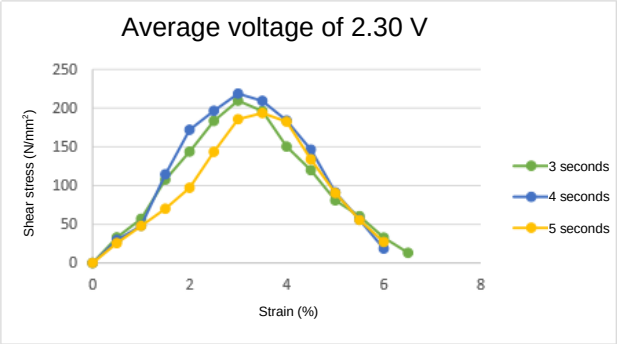

Figure 6. Result of shear test 2.30 V

Graphic of the average test of shear strength with the voltage of 2.30 V shows the correlation between the shear strength and the strain on the specimen. The green line on the graphic shows the result on 3 seconds of pressure time. The blue line shows the result of pressure time in 4 seconds and the yellow line in 5 seconds. The highest strain value is on the blue line with the pressure time of 4 seconds and the highest strain is in the green and the blue line with the pressure time of 3 and 4 seconds.

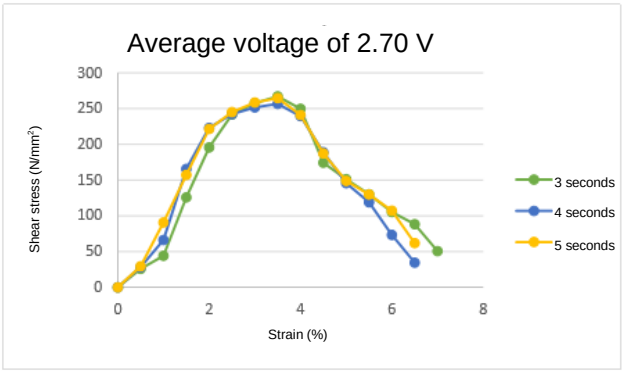

Figure 7. Result of shear test 2.70V

Shear test graph with a voltage of 2.70 V shows a graph of the relationship between shear stress and strain that occurs in a specimen that is given a variation of voltage of 2.70 V. The green line on the graph shows the specimen is given a time pressure of 3 seconds, the blue line on the graph shows the specimen is given time 4-second emphasis, and the yellow line on the graph shows the specimen given a 5-second time press. For the highest stress value is on the yellow line with 5 seconds of pressure time and the highest strain is in green with 3 seconds of pressure time.

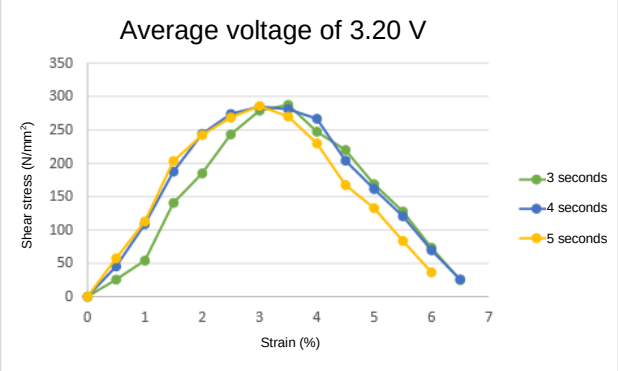

Figure 8. Result of shear test 3.20 V

Shear test graph with a voltage of 3.20 V shows a graph of the relationship between shear stress and strain that occurs in a specimen that is given a voltage variation of 3.20 V. The green line on the graph shows the specimen is given a time pressure of 3 seconds, the blue line on the graph shows the specimen is given time 4-second emphasis, and the yellow line on the graph shows the specimen given a 5-second time press. For the highest stress value is on the yellow line with 5 seconds of pressure time and the highest strain is in green and blue with 3 and 4 seconds of pressure time.

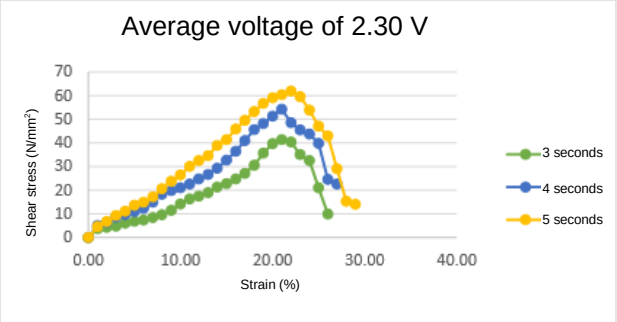

Figure 9. Result of peel test 2.30 V

Shear test graph with a voltage of 2.30 V shows a graph of the relationship between shear stress and strain that occurs in a specimen that is given a variation of voltage of 2.30 V. The green line on the graph shows the specimen is given a time pressure of 3 seconds, the blue line on the graph shows the specimen is given time 4-second emphasis, and the yellow line on the graph shows the specimen given a 5-second time press. For the highest stress value is on the yellow line with 5 seconds of pressure time and the highest strain is in yellow with 5 seconds of pressure time.

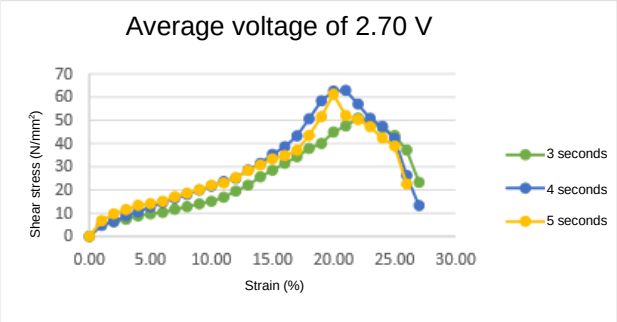

Figure 10. Result of peel test 2.70 V

Graphic of shear test with 2.70 V voltage shows the correlation between the shear stress and the strain on the specimen. The green line on the graphic shows that the specimen is given 3 seconds of pressure time. The green line shows the 4 seconds of pressure time and the yellow line is 5 seconds. The highest strain is on the yellow line with 5 seconds of pressure time and the highest strain is on the blue line with 3 seconds of pressure time.

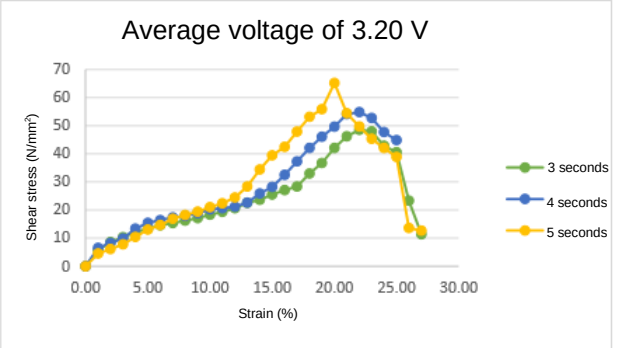

Figure 11. Result of peel test 3.20 V

Graphic of the shear test with 3.20 V voltage shows the correlation between the shear stress and the strain on the specimen. As the previous graphic, the green line shows 3 seconds of pressure time, while the blue is for 4 seconds and the yellow line is for 5 seconds. The highest strain is on the yellow line and the highest strain is on the green line.

Result of the shear test and the peel test, the influence of each variation toward the shear strength and the peel strength in as depicted in the Figure 12.

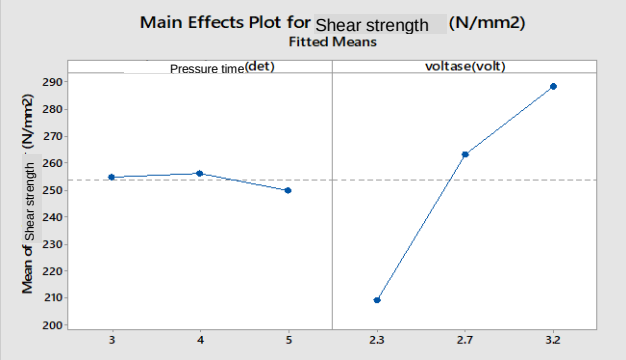

Figure 12. Main Effects Plot of shear strength

Figure 12 shows the influence of pressure time and spot welding voltage on shear strength. The change in pressure time and spot welding voltage affects the shear strength. The highest shear strength lies in the 3.20 V voltage with a pressure time of 4 seconds. While the lowest shear strength lies in the 2.30 V voltage with a pressure time of 5 seconds.

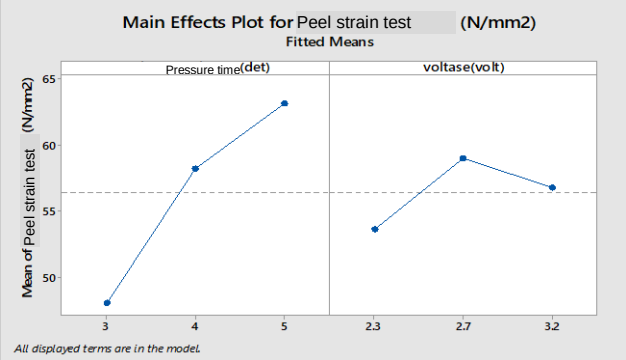

Figure 13. Main Effects Plot of Peel Strength

Figure 13 shows the influence of pressure time and spot welding voltage on the strength of the peel test. The change in pressure time and spot welding voltage affects the strength of the peel test. The highest peel strength lies in the 2.70 V voltage with a compressive time of 5 seconds. The lowest peel strength lies in the 2.30 V voltage with a pressure time of 3 seconds. Figure 14 shows the data interaction between the time variations in emphasis on voltage variations.

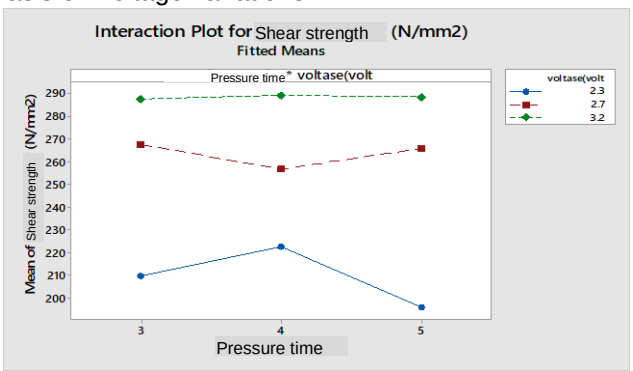

Figure 14. Interaction Plot of shear strength

The graph of the Interaction Effect plot in Figure 14 shows the average data of the shear strength. There is an effect of variations in pressure time and spot welding voltage. The highest shear strength is at 3.20 V and the lowest shear strength is at voltage 2.30 V at the lowest pressure time of 5 seconds.

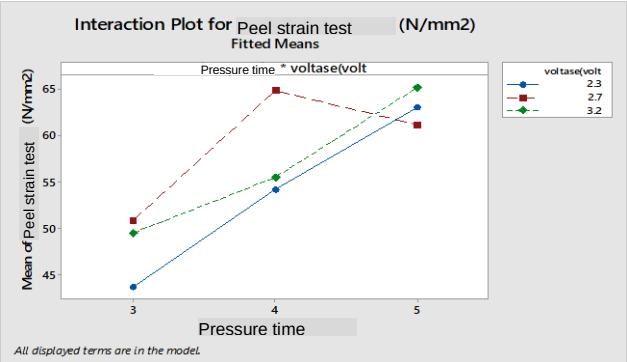

Figure 15. Interaction Plot Kekuatan Peel

The Interaction Effect plot plot in Figure 15 shows the average data from the strength of the peel test, that there is an effect of variations in time pressure and spot welding voltage. The highest peel strength is found at 2.70 V voltage and the lowest average peel strength is at 2.30 V. at the lowest pressure time of 3 seconds.

4. CONCLUSION

There is an influence between the voltage variations on the spot welding joint on the shear strength and strength of the SPCC steel peel. The results of the factorial ANOVA prove that α <0.05 H0 is rejected, meaning that there is a significant influence on the testing process.

There is no influence between the variations of the time pressure on the spot welding connection to the SPCC shear strength. The results of the factorial ANOVA prove that α > 0.05 H0 is accepted, meaning that there is no significant effect on the testing process.

There is an influence between the variations of the time pressure on the spot welding connection to the strength of the SPCC steel peel. The results of the factorial ANOVA prove that α < 0.05 H0 is rejected, meaning that there is a significant influence on the testing process.

There is an influence between voltage variation with the time of pressure on the spot welding connection on the shear strength and strength of the SPCC steel peel. The results of the factorial ANOVA prove that α < 0.05 H_0 is rejected, meaning that there is a significant influence on the testing process.

Further research can be done related to the use of the rotating test to determine the strength of the welding nugget when rotated and also to use the cross tension test to determine the strength of the welding nugget when the two work-pieces are crossed.

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