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Analysis of Welding Strength S45C Material in Spot Welding Process with Variations in Welding Press Time and Electrode Diameter

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Analysis of Welding Strength S45C Material in Spot Welding Process with Variations in Welding Press Time and Electrode Diameter

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Abstract. *Spot welding is one system of connecting to steel materials or other materials that make up sheets. The welding time and electrode diameter are the factors that determine the formation of welding nuggets. This study was conducted to analyze the effect of welding time and electrode diameter on the joint strength of the S45C steel plate with a thickness of 1 mm. The welding process takes place with variations in welding time lasting 1 second, 1.5 seconds, 2 seconds, 2.5 seconds, 3 seconds, and variations in the electrode diameter of 6 mm, 8 mm, 10 mm. The results of welding are then carried out a tensile test to determine the strength of the formed nugget. From the data obtained, an analysis is performed. The highest output voltage analysis result of a 6 mm electrode diameter is 0.92 V with a welding time of 1.5 seconds, 8 mm electrode diameter is 0.9 Volt with 2 seconds welding time and a 10 mm electrode diameter is 0.98 Volt with welding time 1 second. The results of the highest electric power analysis of the 6 mm electrode diameter were 9655.12 Watt with 3 seconds welding time, 8 mm electrode diameter was 9227.66 Watt with 3 seconds welding time, and 10 mm electrode diameter was 9260.64 Watt with 3 seconds welding time. The highest tensile stress analysis results were 20.97 N/mm² at 6 mm electrode diameter, 21.7825 N/mm² at 8 mm electrode diameter and 29.555 N mm² at 10 mm electrode diameter*

1.Introduction

Spot Welding is a welding method that is carried out on the surface of the plate by pressing between each other on the plate that is joined, and at the same time, an electric current flows so that the surface becomes hot and melted due to electrical resistance. This spot welding is widely used in the automotive industry for workmanship in the body or frame of a car. There are around 2000-5000 welding points in modern vehicles. Spot welding is the latest method of welding that is used to connect sheet metal. The process of welding is faster and neater results compared to using acetylene welding and electric arc welding because the welding produced no welding slag.

Welding press time gives different results on the plate, then by varying the welding time and electrode diameter, it is predicted to be able to increase the strength of the welding point in the form of a nugget. [1].

The size of the nugget and the shear strength of the plate in the spot welding process is affected by the welding heating parameters and the geometry of the electrodes in the study conducted by Baskoro (2018), experiments conducted using variations of the electrode tip (Cu) with the plate material (Fe), while the thickness variation of the plate is 0.6 mm, 0.8 mm, and 1 mm, and the holding time of variables 8s, 9s and 10s, this study was conducted aiming to determine the load capability and shear force of the welding results on the plate which is influenced by the tip variation diameter of the electrodes.[2]

The mechanical properties of the welding results are important things to consider in making the connection of the metal with the spot welding method, the strength of the connection and its ease are absolute conditions that must be met. Besides that, the use of electric voltage and electrodes contributes to changes that occur in the mechanical properties of the connection. Welding heating parameters and electrode diameter affect the size of the nugget and the shear strength of the plate connection.

Based on this, the study was conducted to analyze the mechanical properties that occur due to the influence of the variations in the use of the diameter of the electrodes and the time of the stresses performed when the spot welding process takes place.

In this study, experiments were conducted using variations in the diameter of the electrodes and medium carbon steel plate S45C with a thickness of 1 mm that was welded with a voltage of 2.2 volts with a variable time holding variable (1s, 1.5s, 2s, 2.5s, and 3s), the purpose of this study to determine the load capability and shear force of the welding results on the steel plate which is influenced by variations in the diameter of the electrodes.

2. Method and Materials

The heat generated at the electrodes is affected by the current, the electrical resistance of the circuit, and the duration of pressure. The ratio to produce heat that occurs can be seen in the formula below:

$H = I^2 Rt$

With: H = Total heat generated (Joules) I = Current (A) R = Circuit electrical resistance (Ohm) t = Time during current flow (Second)

The heat that occurs in the welding process greatly affects the distribution of temperature, residual stress, and distortion. Heat also affects the subsequent phase transformations

effect on the microstructure and mechanical properties of welding.

the spots welding process is carried out using a spot welding machine as shown in Figure 1. There are three variations of the electrode diameter and five variations of the welding time used in this welding process. Equipment and materials used are:

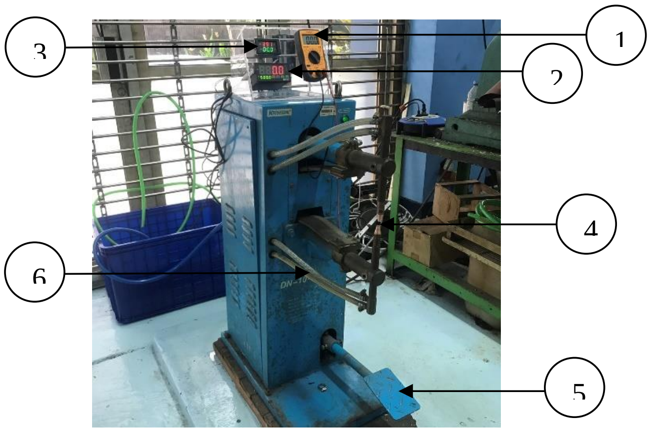

Figure 1. *Spot Welding Machine*

1. Multi Tester 4. Electrode
2. Force Gauge 5. Pressure lever
3. Voltmeter & Ampere meter 6. Cooling Liquid Circulation Pipe

The steel plate used is S45C medium carbon steel

Figure.2 Steel Plate S45C

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Three types of electrodes that have varying diameters include:

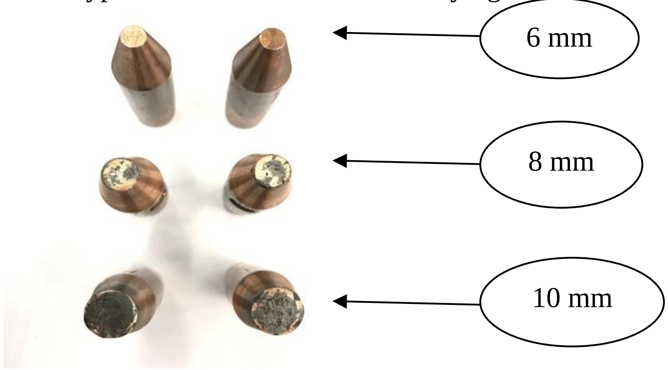

Figure 3. Electrode

Specimens that have been welded at the point are then subjected to tensile tests to measure the tensile strength of the joint. In this test, both plates are clamped by a flat vise and then a tensile test is performed.

Figure .4 S45C Specimen Tensile Test

The experimental process is shown in figure 5.

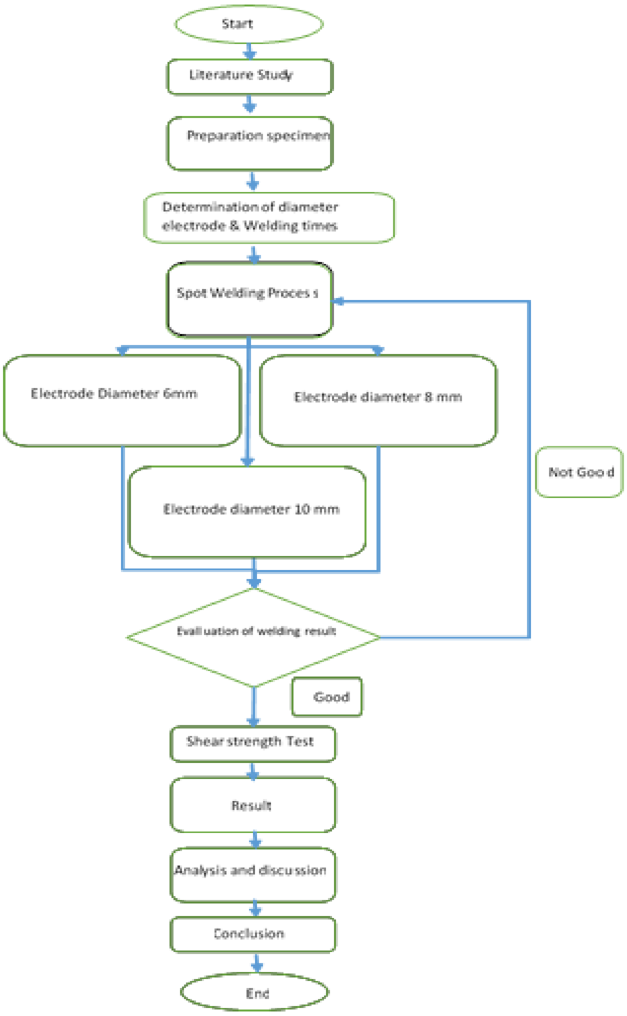

Figure 5. Flowchart Experimentation Process

3. Results and Discussion

Welding results are tested five times, then the average value is taken as can be seen in the following table:

Table 1. Average Out Voltage

Time (s)	**Out Voltage (V)**		
	Diameter 6 mm	**Diameter 8 mm**	**Diameter 10 mm**
1	0.9	0.88	0.98
1,5	0.92	0.86	0.88
2	0.86	0.9	0.88
2,5	0.88	0.88	0.88
3	0.9	0.86	0.9

Table 2. Electrical Power Average Used (W)

Time (s)	Electrical Power (W)		
	Diameter 6 mm	Diameter 8 mm	Diameter 10 mm
1	4745.04	4059.02	4797.12
1,5	6762.84	7623.8	6732.7
2	8016.28	7807.46	6985.84
2,5	9376.34	8340.18	8640.84
3	9655.12	9227.66	9260.64

Table 3. Shear Strength Value

Time (s)	Shear strength (N/mm²)		
	Diameter 6 mm	Diameter 8 mm	Diameter 10 mm
1	18.91	17.6167	21.99
1,5	18.32	17.9425	24.05
2	20.97	21.7825	23.8525
2,5	18.91	18.865	23.438
3	17.61	19.595	29.555

Comparison of the tensile strength obtained is shown in the figure below:

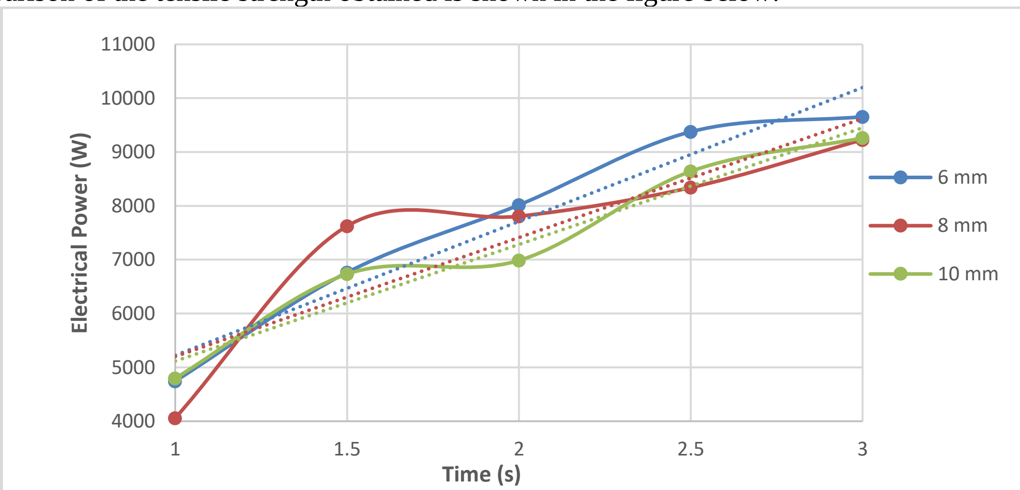

Figure 6. Times Vs Electrical Power

The effect of welding pressure on electrical power

Based on Figure 6, shows the comparison of the use of electrical power in the spot welding process using three variations in the diameter of the electrodes with varying welding times. The increase in welding time affects increasing power usage, this is because if the incoming current has an increase in the welded joint, then the penetration that occurs also increases. Based on the research data by the basic equation of heat input on spot welding, $Q = I^2.R.t$. Welding penetration is a measure of the area of the weld metal (nugget) that is in the area that is in contact with the electrodes. based on the results of the average electric power used it can be seen that the greater the diameter of the electrodes used, the smaller the electrical power used

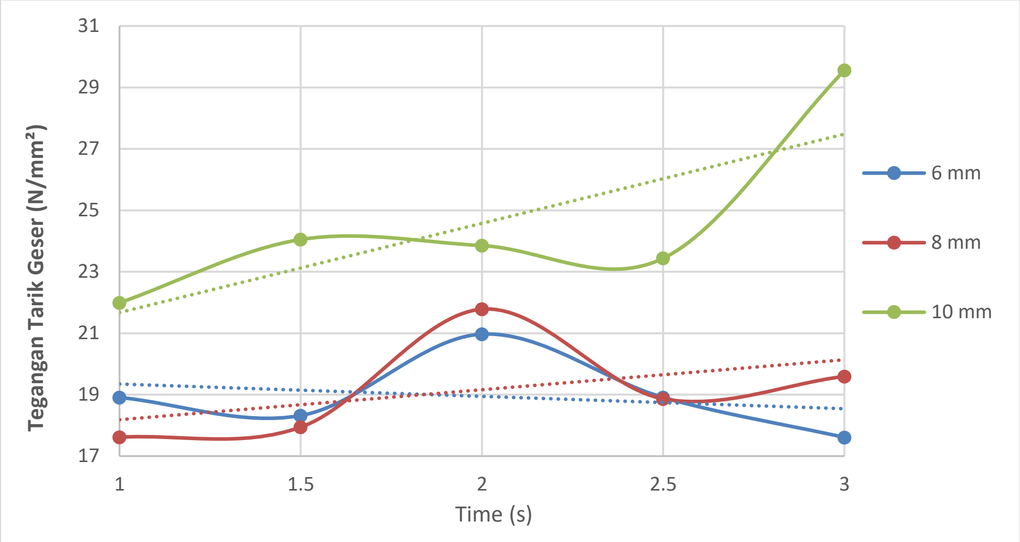

Figure 7. Effect of Welding Pressure Time on Welding Strength

Effect of diameter on the strength of the welded joint

Figure 7 shows that the shear tensile strength obtained at 6 mm electrode diameter shows that when the welding press is 1, 1.5 to 2 seconds, the shear stress that occurs at the connection has increased. This is because the longer contact of the electrodes produces greater nuggets and the influence of heat is also greater which results in the refinement of the grains on the weld metal. However, when the welding pressure is 2.5 and 5 seconds, the shear tensile stress decreases. From the average results it can be seen that the use of electrodes with a diameter of 6 mm the longer the welding press time, the value of the shear tensile strength gets smaller, this is because the size of the electrode diameter of 6 mm does not make a connection but do deep penetration if the welding time is increased to produce a low shear tensile strength that is due to the 6 mm diameter electrode having a small cross-sectional area so that the resulting pressure becomes larger and for electrodes of 8 mm and 10 mm the longer the welding time the higher the shear tensile strength results, this caused by the diameter of the electrode 8 mm and 10 mm making a good connection because the heat input that occurs is greater and does not cause penetration so that the resulting shear tensile strength becomes greater when the welding press time is increased. That's because the 8 mm and 10 mm diameter electrodes have a large cross-sectional area so they don't change in pressure.

4. Conclusion

Based on the discussion of the research carried out, the following conclusions are obtained: The highest average shear tensile strength is 20.97 N/mm² at the time of 2 seconds welding press with 6 mm electrode diameter, shear tensile strength of 21.7825 N/mm² at 2 seconds welding press time with 8 mm electrode diameter and shear tensile strength of 29,555 N/mm² at 3 seconds welding press time with a 10 mm diameter electrode.
Increasing the welding press time and diameter of the electrodes results in increased shear tensile stress.
The best welding results using the welding parameter diameter of 10 mm electrodes with a welding press time of 3 seconds shear tensile strength of 29,555 N/mm².

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