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EFFECT OF FATIGUE TEST ON SPOT WELDED STRUCTURAL JOINT

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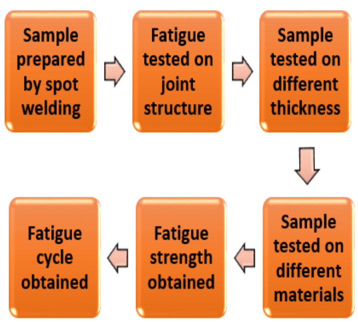
Graphical abstract



Abstract

Spot welding is mainly used method in joining sheet metals for body structure in automotive industry. The comprehension of the fatigue strength for the spot welds is very critical in automotive component design. Parameter for the resistance spot welding and fatigue machines is constant for each specimen used. The S-N curve is obtained from the fatigue testing for each specimen. This experiment parameters are varies the different thickness and different material combination in spot welding structure to investigate the fatigue life cycle and fatigue stress. For 1050A aluminium joint, fatigue life cycle and fatigue strength will decrease from number of cycle 500 at 16.58 MPa to number of cycle 61 at 6.62 MPa as the thickness increase. The fatigue life cycle and fatigue stress for galvanized iron will increase from number of cycle 46 at 9.25 MPa to number of cycle 1500 at 57.8 MPa when the thickness of joint increase. The finding from the combination of 1050A aluminum and galvanized iron on spot welded structure has shown no improvement in term of fatigue life cycle and fatigue strength because specimens experienced failure at number of cycle 19 with fatigue stress 2.36 MPa.

Keywords: Spot welding, fatigue test, fatigue stress, fatigue life cycle, S-N Curve

1.0 INTRODUCTION

The strength of spot welds in the vehicle structure determines the integrity of the structural performance during the vehicle operations. Most spot welds involved only shear forces and can likewise experience a significant amount of peel force or the force normal to the spot weld in certain stacking conditions. The mix of the stress states and geometric shapes of the spot welds lead to stress concentration that can bring in fatigue crack initiation around the spot weld. The presence of fatigue cracks will degrade structural performance and increase noise and vibration of the vehicle structure. Hence, in depth understanding of the fatigue strength for the spot welds is very crucial in automotive component design [1]. The fatigue crack starts at the inside surface of welded sheets in the heat affected zone (HAZ). It is imperative to know crack growth rate in the spot welded part and thus focus on the serviceability of the spot weld before rupture [2]. The quality of the spot-weld can be analyzed by destructive tests to figure out whether a satisfactory weld had been produced, for instance by using quasi-static tensile test and dynamic cycle test [3]. The hot spot stress approach was adopted to calculate the fatigue damage. It is revealed that the non-uniform corrosion could influence fatigue damage of welded joint, and that impact will be more and more significant with the growth of corrosion year [5]. With the broader utilization of a variety of aluminum alloys in the automotive industry for structural lightweight applications, the need for resistance spot welding (RSW) of dissimilar aluminum alloys is increasing. General Motors (GM) has developed a proprietary RSW process using a multi-ring, domed electrode geometry that significantly improves the performance of the aluminum resistance spot welds. In addition, to enhance structural performance, epoxy adhesives are also often applied prior to RSW to obtain weldbonded joints [6]. The objectives of this paper are to investigate the fatigue strength of different thickness and also different type of material in spot welded structures.

2.0 METHODOLOGY

2.1 Prepare and Cutting Material

In this experiment, 1050A aluminum and galvanized iron were used for spot welded joint. Each material has 1 mm and 0.5 mm thickness. Figure 1 shows the size of fatigue test specimens. The specimen was cut using shearing machine with dimension 100mm x 30mm according to Japanese Industrial Standard JIS G 3136.

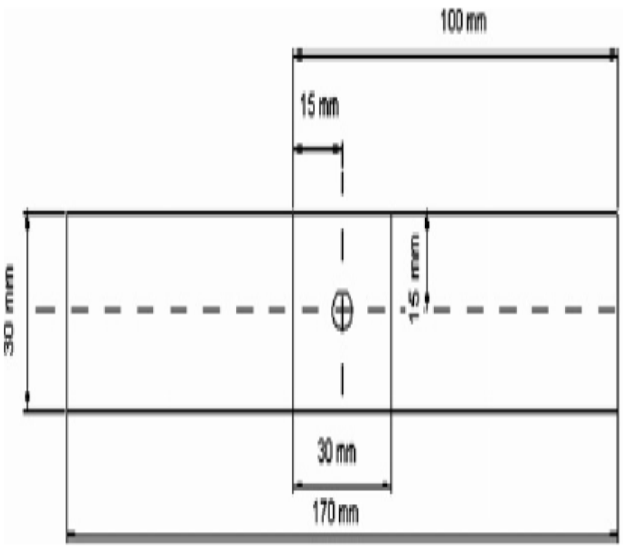


Figure 1 Size of fatigue test specimens

2.3 Joining

The Inventer AS-25 Resistance Spot Welding (RSW) was used to assemble each specimen. The type of joint in this resistance spot welding was lap joint which is capable of merging different material with different thickness. Figure 2 shows the samples prepared using RWS.Firstly, two 1050A aluminium sheets with thickness 0.5mm are joint together and another two sheets with the combination thickness of 1.0 mm and 1.0 mm. Next, two galvanized iron sheets with thickness 0.5 mm were joint together and and another two sheets with the combination thickness of 1.0 mm and 1.0 mm. Lastly,the different material type of 1050A aluminium and galvanized iron were joint together with thickness 1.0 mm for each sample. The resistance spot welding parameter were 8.0 kA of welding current, 8 bar of welding operating pressure and 250 ms of welding holding times.

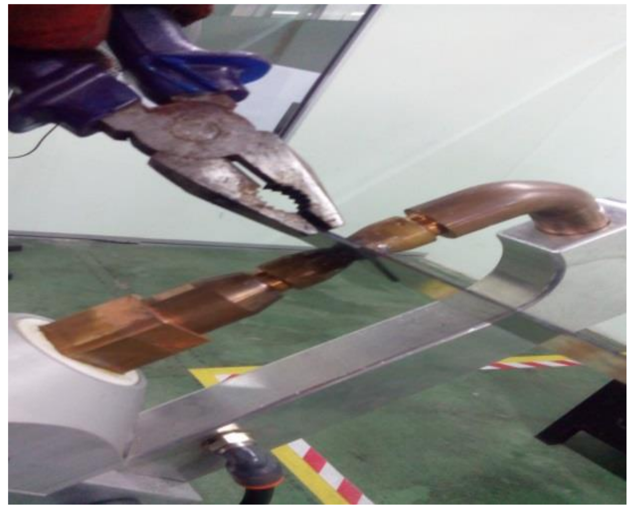


Figure 2 Sample prepared

2.4 Fatigue Test

The fatigue testing for every specimen were performed in laboratory condition using Air-Servo machine with a software package specifically designed for running fatigue tests. Figure 3 shows the mounting specimen with the jig. Every specimen was mounted in the grips 25 mm from both ends. All tests were performed using sine wave form operating at frequency of 3 Hz and the number of repetition is 10000 times.

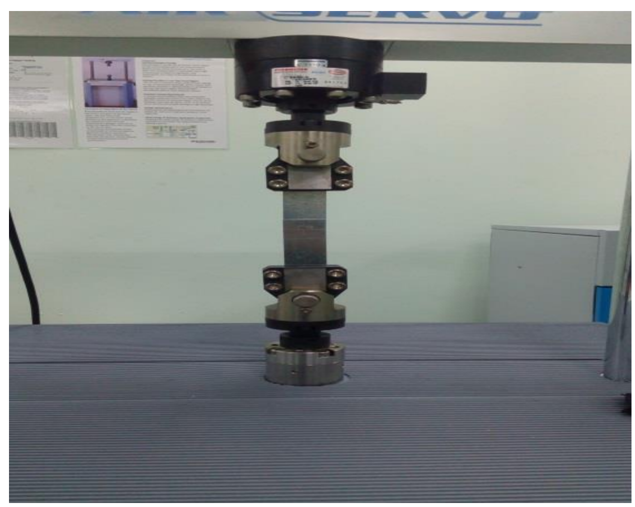


Figure 3 The mounting specimen with the jig

3.0 RESULTS AND DISCUSSION

3.1 Different Thickness

The graph in Figure 4 shows the S-N curve for 1050A aluminium joint with thickness 1.0 mm specimen. The 1050A aluminium joining experienced failure at cycle 500 with fatigue stress 16.58 MPa.

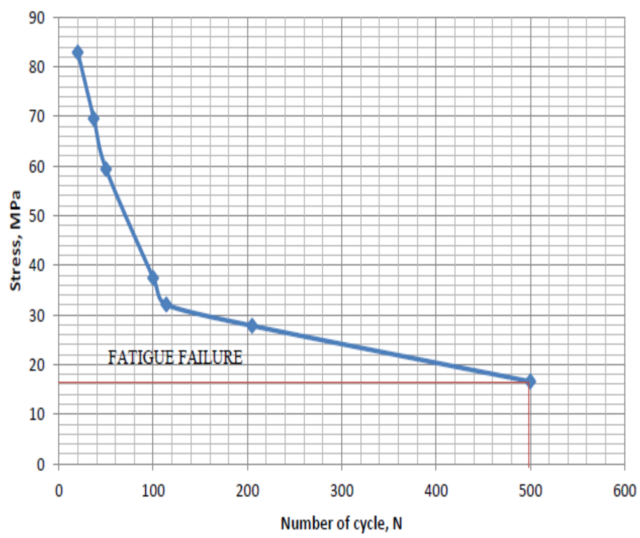


Figure 4 S-N curve for 1050A aluminium thickness 1.0 mm

Meanwhile, Figure 5 shows the S-N curve for 1050A aluminium with the increasing thickness to 2.0 mm. The 1050A aluminium joining experienced failure at cycle 61 with fatigue stress 6.62 MPa.

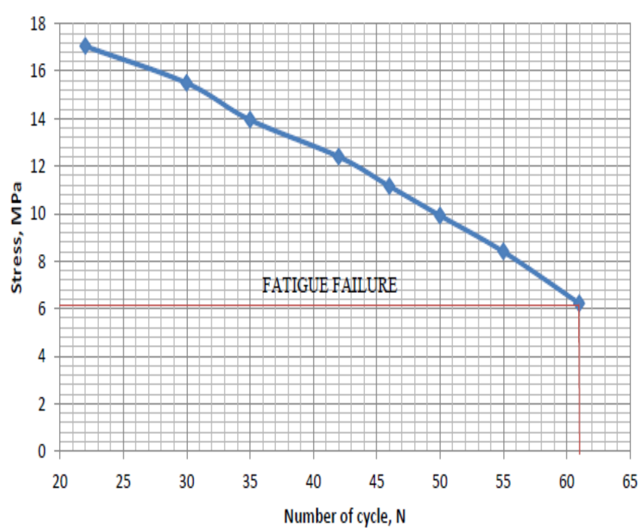


Figure 5 S-N curve for 1050A aluminium thickness 2.0 mm

This result show that the aluminium sheet thickness had a significant effect on fatigue life cycle as well as fatigue strength. For 1050A aluminium joint, fatigue life cycle and fatigue strength will decrease as the thickness increase. Thickness plays important role because thicker aluminium sheet resulted in lower percentage of melted area at joint.

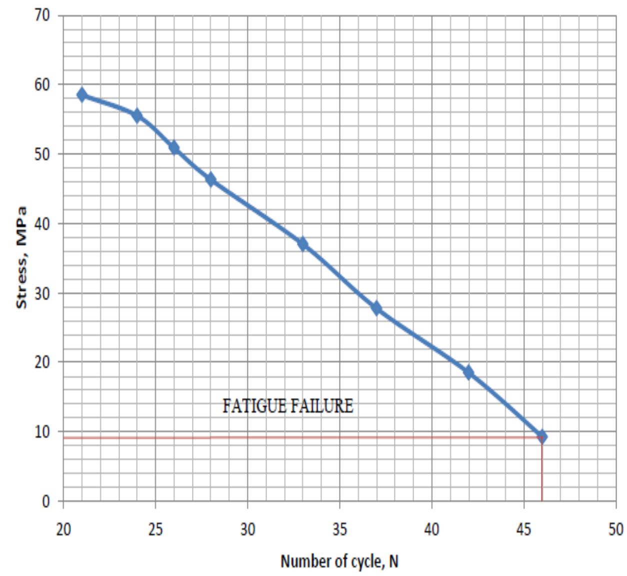


Figure 6 S-N curve for galvanized iron thickness 1.0 mm

On the other side, galvanized iron joining shows different trend. Figure 6 shows the S-N curve for galvanized iron joint specimen with thickness 1.0 mm. This sample experienced failure at number of cycle 46 with fatigue stress 9.25 MPa . As the thickness of galvanized iron joint increases to 2.0 mm, results showed that sample experienced failure at the greater number of cycle than the previous. The number of cycle was 1500 with fatigue stress was 57.8 MPa as shown in Figure 7. The fatigue life cycle and fatigue stress for galvanized iron RSW joint structure will increase when the thickness of joint increased. This phenomenon happened because lower melting point which resulted in higher number of cycle.

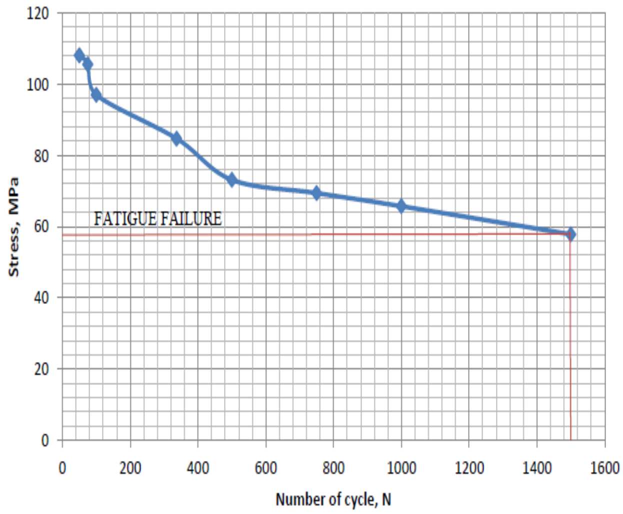


Figure 7 S-N curve for galvanized iron thickness 2.0. mm

The different in trend for 1050A aluminium and galvanised iron is because of the difference in melting point. 1050A aluminium has higher melting point than galvanised iron, resulting in less complete melting and solidification at the joint compared to galvanised iron, resulting in lower number of cycle with increase thickness.

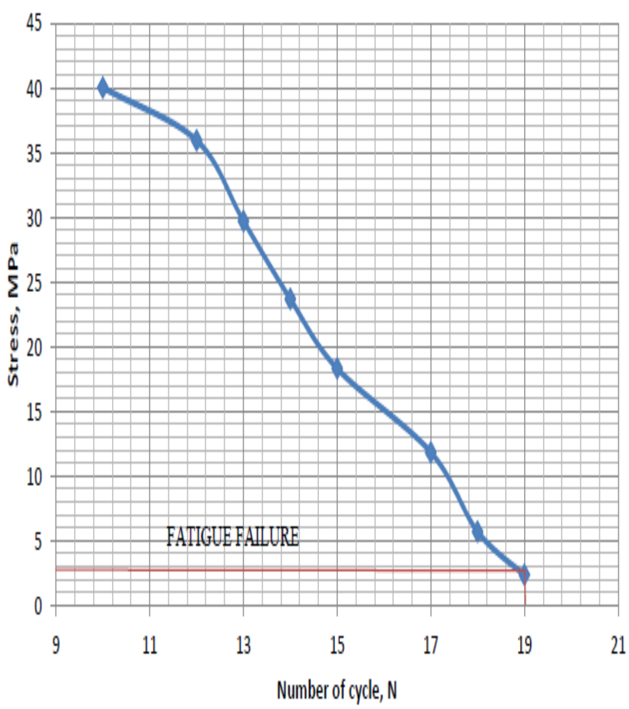


Figure 8 S-N curve for 1050A aluminium and galvanized iron thickness 2.0 mm

3.2 Different Type of Material

The second part of the experiment is to test the effect of using different type of material towards fatigue life cycle and fatigue strength. Figure 8 show the S-N curve for 1050A aluminium and galvanized iron sheet combination with thickness 2.0 mm .These specimens experienced failure at number of cycle 19 with fatigue stress 2.36 MPa. This is because due to the heat unbalance between this sheet metal which occur during the resistance spot welding operations. The specimens have different material properties especially for electrical resistance. Each material have different value of electrical resistance, affecting the result when assembled using resistance spot welding. Since the welding parameter were set at the constant values which were 8.0 kA of welding current ,8 bar of welding operating pressure and 250 ms of welding holding times.Thus, the strength of joining structure were developed based on these paremeters.Therefore, the strength for this different material combination joint became weaker as compared to the previous result due to unstable crystalline structure of the combination since both materials are incompatible to each other. As a result, it will directly effect the fatigue life cycle and fatigue stress of the joining.

4.0 CONCLUSION

Based on the testing in this investigation, it can be concluded that thickness, melting point and types of material have a major impact on fatigue life cycle and fatigue strength for spot welded structural joint. This finding contributes the knowledge on behavior of spot welded structure in fatigue environment. Due to mechanical, electrical and thermodynamics properties of material and joining process which is spot welding, these are the factor that contribute in determining the strength of the joint structure as well as fatigue life cycle. As for 1050A aluminum, the fatigue life and fatigue strength show the weaker values when thickness of joint is increased. It is opposite with galvanized iron fatigue life cycle and fatigue stress because it shows that the values increased accordingly when thickness of material is increased. The finding from the combination of 1050A aluminum and galvanized iron on spot welded structure has shown no improvement in term of fatigue life cycle and fatigue strength .

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