THE INFLUENCE OF WELDING PARAMETERS AND CORROSIVE ENVIRONMENT ON THE JOINT STRENGTH OF RESISTANCE SPOT-WELDED MILD STEEL SHEETS

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ABSTRACT

In the present work, mild steel sheets consisting two batches were welded by resistance spot welding at different welding parameters and exposed under different environments. The 5% sodium chloride brine was used in the salt spray test, produced a whole rusty surface on the tested specimens (batch 2). The welding joints were subjected to tensile-shearing test in order to determine the strength of the welded joints from ambient and in corrosive environment. Tensile-shear test showed significant differences on the failure load between these two batches where corrosion had affected the surface strength of the welded steel. The results also showed that the highest tensile shear strength is given by the specimen welded using 4kA current at 4 cycles.

Keywords: Mild steel, Spot welding, Microstructural, Tensile shear test

INTRODUCTION

Resistance spot welding is usually used in the fabrication of sheet metal assembly. It can be used to weld materials such as low carbon steel, nickel, aluminum, titanium, copper alloy, stainless steel and high strength low alloy steel. Resistance spot welding process is most applicable in the industrial fields of manufacture and maintenance (car industry, aerospace and nuclear sectors, electronic and electric industries (Hartmann, 1958, Swellam, *et al.*, 1994, Wang, *et al.*, 1991). The static strengths of spot welds have also been explored. Mechanical tests of spot welds in tension–shear, direct tension, torsion and peel specimens were also reported (Hartmann, 1958). Currently, mild steels are mostly used in applications where demands for corrosive protection are put forward. The most common cases reported were erosion corrosion. The aim of this

MATERIALS AND METHOD

The material used in this study was mild steel sheets, having 1 mm thickness. The suggested configuration and dimensions of the specimens are based on standard stated in American National Standard Institute (ANSI) and from the American Welding Society (AWS) as shown in Figure 1. present paper is to study on spot welded of mild steel towards variety of welding parameters (welding current, welding cycle) in ambient and corrosive environment.

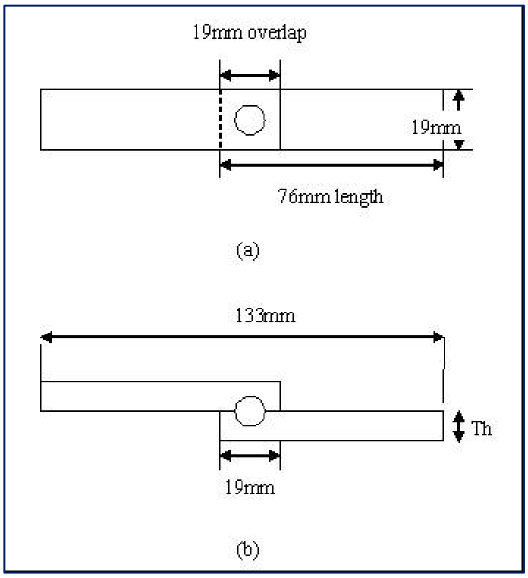

Fig.1 Standard dimension for tensile shear testing (a) Plan view, (b) Side view

The specimen was cut parallel to the rolling direction of the sheets. Cleansing of the specimen's surface was done by using acetone followed by washing and drying prior to welding. The amount of sheets used was 144 pieces divided into two (2) batches, 72 pieces per batch to be spot welding. Each batch consists the same welding parameters which are divided to welding current of 2kA, 3kA and 4kA. Each of this welding current was carried out with 3, 4 and 5 cycles. The first batch was exposed to ambient while the second batch was exposed through 5% sodium chloride corrosive environment by salt spray. The 5% of sodium chloride brine was prepared from 50g of sodium chloride powder with 1000L of distilled water. The pH of the solution was checked by a pH scanner indicated 5.87 as a weak acidic solution. Then, the welded specimens were stuck on a polystyrene board so they will stand still to allow corrosion occur thoroughly (Figure 2). The test was carried out for 24 hours.

Fig. 2 Setting of specimens in salt spray machine

A Gotech Universal Tensile Machine was used to carry out the tensile shear strength tests of the welded specimens. Two (2) pair of plate clamps was used to clamp specimens in this test, holding up the edge of the specimen adjacently as shown in Figure 3.

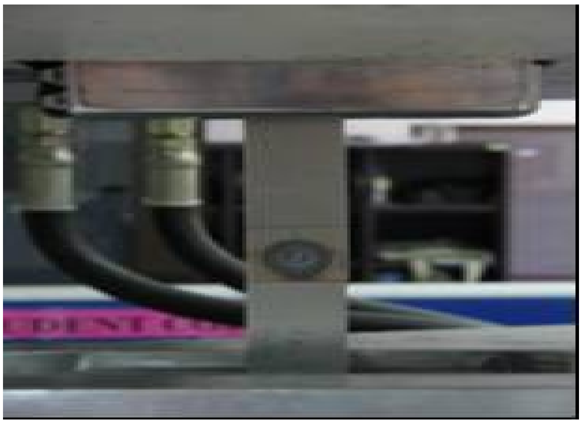

Fig. 3 Specimen position during tensile shear test

RESULTS AND DISCUSSION

The joints of spot weld according to the ANSI/AWS standard were sprayed with 5% sodium chloride for 24 hours. Result showed that the whole specimens have fully corroded (see Figure 4).

Observation of those corroded specimens explains the permeability of the mild steel to corrosion. The red colour rust was clearly appeared right after the specimens being removed from salt spray. Furthermore, the surface of the specimen shows some localized attack, some kind of intense dissolution on it. Under image analyzer, it was hardly to see any pits or holes on the surface except the rust covering almost the whole surface. The occurrence of corrosion was also found at the lap joint. Almeida (Almeida, *et al.*, 1999) in her research reported that the study of a day cycle involving salt spray indicated more severe corrosion attack outside the lap joints than inside them.

Fig. 4 Corroded specimens

An advanced chloride-rich wave in salt spray enhanced corrosion more extensively compared of being exposed in natural atmospheres, where successive wet and dry periods naturally occur, slowing the corrosion rate. Thus, a thick corrosion product layer, of which the main components are most probably ferric chloride accumulated from the upper panel outside the lap joint. During the tensile-shear test, the specimen elongates and the force of the load stress around the Heat-Affected Zone (HAZ) and finally, the specimen failed and deformed at a point called fracture point. The deformations involved elastic tension and bending of the specimen at the early stage and, then yielding and eventually fracture within the HAZ {see Figure 5 (a)}. The specimens from the non-corroded batch has formed fracture slightly at its HAZ area but the corroded batch seemed to be almost fractured and even the parent metal was tear off from the HAZ.

The tensile-shear test of both first and second batch displayed significant differences between each other. The failure load obtained was plotted relating to the welding current and cycles. The strength of the corroded specimens (see Figure 7) decreased significantly, making them much easier to fail compared to the non-corroded specimen (see Figure 6). Characteristic of these tensile-shears could be explained as the result of corrosion influence. The deteriorations of the specimen's surface discussed in salt spray test previously had clearly impaired its strength.

The existence of cavity around the lap joint may be one of the factors that lead to that total fracture. The strength of 2kA spot welded specimen declined massively after corrosion salt spray test. The results showed that the good strength of specimens could be spot welded by using 4kA current and at duration of 4 cycles.

Fig. 5 Failed specimens after tensile-shear test: (a) Non-corroded specimen (b) Corroded specimen

Fig. 6 Correlation between failure load and welding cycles (Batch 1)

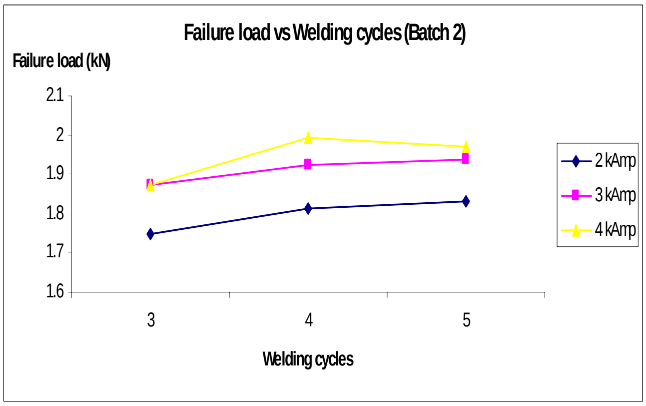

Fig 7. Correlation between failure load and welding cycles (Batch 2)

CONCLUSIONS

The compatibility of mild steel for spot welding was tested with various welding current and welding cycles. The 2kA of welding current in 3, 4 and 5 welding cycles are the weakest lap joint compared to the 3kA and 4kA in every welding cycle respectively. It is clearly shown that corrosive environment does affect the strength of the joint.

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