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Improvement of mechanical properties in treated spot welded joint

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Abstract

Post Weld Impact Treatment (PWIT) is one of the treatment methods that is usually applied on weld region to reduce the level of residual stress originated from the welding process. During the spot weld process, the formation of stress is produced around the weld area and degrades the mechanical properties of the joint. This paper focused on the improvement of mechanical properties of the spot welding joint via Pneumatic Impact Treatment (PIT) process. This study uses the low-carbon steel with a welded single lap shear joint that has a constant thickness of 1.2 mm. All the welded samples were subjected to tensile-shear test, failure mode and hardness test. The tensile-shear load and fusion zone hardness of RSW joint after PIT was improved by 8% and 27%, respectively. The results indicated improvement in tensile-shear strength and hardness of treated samples as compared to the as-welded samples. From the observation done, the failure mode type was generally accepted as failure for spot-weld joint. The improvement of mechanical properties is envisaged as the result of the mechanical pulses produced by unique fluidic muscle conveyed to the surface of the RSW joint during PIT process.

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Keywords: spot welded; mechanical properties; pneumatic impact treatment

1. Introduction

Low-carbon steel accommodates the biggest percent of material welded with the resistance spot welding process [1]. Resistance spot welding (RSW) is a welding technique that joins two or more metal sheets through fusion on the contact area of electrode tips. This procedure basically makes use of two copper electrodes to compress the sheets

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together and supplies a huge amount of current through the contact area of electrodes [2]. Whilst the melting point of the steel is reached, the steel will begin to fuse and a nugget starts to form. The current is then switched off and the nugget is cooled down to solidify under pressure [3] and because of the weld thermal cycle, a heterogeneous structure could be created in the spot weld and the region around it.

The melted and solidified regions of base metals are then, referred to as weld nuggets and it includes three major zones which are the fusion zone (FZ) which is melted during the welding process and is re-solidified showing a cast structure, heat affected zone (HAZ) which is not melted but undergoes microstructural changes, and base metal (BM) which remains unaffected during the welding process. Generally, spot welding joints occur in two distinguished failure modes that are the interfacial failure (IF) and pullout failure (PF) [4].

In the spot welding process, the mechanical properties of the joining metals are related to the residual stress and also influence the in-service performance of the structures [5]. The improvement of weld properties in some cases can be achieved by post-weld heat treatment. High Frequency Mechanical Impact (HFMI) has significantly been developed as a reliable, effective and user- friendly method for post-weld treatment in order to improve dynamic load capacity of the structures [6]. It is also known as the Pneumatic Impact Treatment (PIT) where it is a high frequency hammer peening method where pins are accelerated by air pressure and produces plastic deformation which results in beneficial compressive resistive spot in the material, reduction of residual stresses and smoother weld toe profile. The induced compressive residual stresses in the treatment prevent the track cracking and the crack propagation on the surface [7]. Consequently, high frequency hammer peening was investigated as a mean for improving mechanical properties in RSW.

Several literatures [8-11] had reported on the local mechanical properties of spot welded low carbon steel, however scarcely have assessed the effects of impact treatment on the mechanical properties on RSW. In this study, the PIT hammer peening was used to introduce the compressive residual stress into low carbon RSW. The influence of the peening on the mechanical properties of the RSW samples was evaluated.

2. Methodology

This section presents the method on the preparation of low-carbon steel RSW samples, spot-weld treatment process, tensile-shear test procedures and hardness measurement method. The Pneumatic Impact Treatment (PIT) was used in the spot-weld treatment process.

2.1. RSW Samples Preparation, Treatment and Testing Equipment

The lap-shear joint are made of low-carbon steel grade JIS G3141 and was cut into 105 mm x 45mm pieces in accordance to the AWS D8.9m standard. The two pieces of sheet (Fig. 1) was welded using JPC 75 kVa [1]. The machine was set to AC waveform, and the 5 mm diameter electrode was truncated 30^{o}. The chemical composition and mechanical properties of these steel are listed in Table 1.

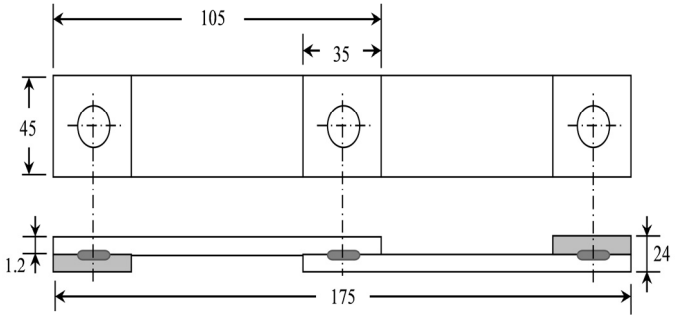


Fig. 1. Spot-welded sample

4. Conclusion

The tensile-shear load of RSW PIT exhibits the highest value (8.81 kN) as compared to RSW as-welded (8.20 kN). The effect of post-weld impact treatment on the failure type was significant. Spot-welded joint treated with pneumatic impact treatment tends to have the pullout failure with tearing at base metal. This failure showed that, by implementing pneumatic impact treatment, the applied compressive stress diminished the tensile residual stress that occurred in the samples and was highly plastically deformed. The spot-welded joint via pneumatic impact treatment has an effect on the hardness value. The hardness of the fusion zone of RSW PIT attained the highest hardness value of 268 HV, followed by as-welded RSW with a hardness of 211 HV.

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