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Effect of Post Weld Heat Treatment on Mechanical Aspects on Friction Stir Spot Welded AA 6082 joints

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Abstract - *Friction Stir Spot Welding is an important variant of solid-state welding which is being successfully used in many sectors. In this paper, an attempt has been made to enhance the mechanical properties of Friction Stir Spot Welded Aluminium AA6082 joints by using post weld heat treatment process. The spot-welded joints were heat treated by fluctuating the heat treatment temperatures and the time duration of heat treatment. It was varied from 150°C to 350°C. Upon subjecting the spot-welded joints to heat treatment process, a considerable increase in the tensile properties of the joints were observed. Also, the modifications in the surface grain structure upon heat treatment was evaluated by using SEM investigations.*

Key Words: Aluminium, Friction Stir Spot Welding, Heat Treatment, Tensile Testing, Scanning Electron microscopy.

1. INTRODUCTION

Friction stir spot welding is a new type of solid ste welding process which is being used in many parts of the world for effective joining of similar and dissimilar materials.

Pandey et al. conducted investigations on friction stir spot welded Aluminium Alloys and evaluated the weldability of the 6 series alloy. The important friction stir spot welding process parameters were fluctuated and the evaluation was conducted. By using non-destructive evaluation techniques, the strength of the joints was ascertained [1].

Tebyani et al. conducted friction stir spot welding experiments, by using steel. For enhancement of the joint aspects, SiC Nano powder was used. The effect of incorporation of SiC nanopowder in the intermetallic region was evaluated [2].

Mubiyai et al. conducted friction stir spot welding experiments by using dissimilar materials such as Aluminium and Copper material. By fluctuating the important friction stir spot welding process parameters, the variation in the joint aspects were identified [3].

Shen et al. conducted fatigue assessment of friction stir spot welded joints. By fluctuating the type of tool used for fabricating the friction stir spot welded joints, a significant improvement in the overall quality and performance of the joints were observed [4].

Ni et al. evaluated the weldability aspects of friction stir spot welded Copper alloy joints. For enhancing the strength of the joints, ultrasonic assistance was used. A significant improvement in the tensile strength of the friction stir spot welded joints were observed on using ultrasonic assistance [5].

On evaluation of the previous literatures and important investigations post weld heat treatment of friction stir spot welded joints was not found. Thus, in this paper, an attempt was made for evaluation of the mechanical properties of friction stir spot welded AA6082 joints by using post weld heat treatment process.

2. MATERIALS AND METHODS

In this research, AA 6082 was chosen to be the base material. Rolled AA6082 sheets of 5 mm thickness was procured and it was sectioned to 100 mm in length and 30 mm in breadth, so as to be used as joint materials in lap joint configuration.

Friction Stir Spot Welding tool was fabricated by using H 13 tool steel. The tool had cylindrical shoulder with 16 mm shoulder diameter, 6 mm pin diameter and 3.5 mm pin length. The Friction Stir Spot Welding experiments were conducted in a Heavy type Vertical Milling Machine. Instead of milling tool, the friction stir spot welding tool was used for performing the experiments. The workpieces were held in the bed of the modified friction stir spot welding machine by using fixtures. The modified vertical milling computer numerically controlled machine used for performing the friction stir spot welding experiments have been indicated in Figure 1.

Fig -1. Friction Stir Spot Welding Equipment

Heat treatment is an important operation in the final fabrication process of many engineering components. Only by heat treatment it is possible to impart high mechanical properties to steel parts and tools for sophisticated applications. Heat treatment is considered to be very important tool of the metallurgist by which he can alter the properties of aluminium easily. The same aluminium can have a very wide range of mechanical properties if subjected to different heat treatment.

Objectives of heat treatment

To increase strength, hardness, wear resistance (bulk hardening, surface hardening).

To increase ductility and softness (tempering, recrystallization annealing).

To obtain fine grain size (recrystallization annealing, full annealing, normalizing)

To remove internal stresses induced by deferential deformation by cold working, cross cooling from high temperature during casting, welding (stress relief annealing)

To improve magnetic properties (hardening, phase transformation)

To improve electrical properties (recrystallization, age hardening, tempering).

Heat treatment of steels or aluminium can lead to several defects. The principal types of defects found in quenching of steels are internal and external cracks in the work, distortion and wrap. When the internal tensile stresses exceed the resistance of the steel to separation track occurs. The insertion of the tools in the furnace without preheating for tempering is one of the main causes of crack propogation. The crack formation is reduced by preheating the tool between 200°C to 300°C.

Distortion occurs due to uneven heating, too fast cooling, part incorrectly supported in surface, incorrect dipping in quenching and stresses present before preheating. Distortion can be prevented by preheating the tool or check furnace capacity, reduce the hardening temperature, and by reviewing the method of dipping. The heat treatment furnace used in the research has been indicated in Figure 2

Fig -2. Furnace used for heat treatment

The Friction Stir Spot Welding experiments were conducted as per the values of process parameters indicated in Table 1

Table -1: Friction Stir Spot Welding Process Parameters

Tool Rotational Speed	Rpm	1200
Plunge Depth	Mm	3.5
Dwell time	Seconds	21

By using the vertical milling machine, and by using the friction stir spot welding process parameter values as per Table 1, the experiments were conducted. The Spot welding joints have been indicated in Figure 3

Fig -3. Friction Stir Spot Welded Joints

The joints were subjected to heat treatment as per the process parameters indicated in Table 2

Table -2: Heat Treatment Process Parameters

S No	Treatment Temperature °C	Reaching Time
1	175	2 hrs
2	200	2 hrs
3	225	2 hrs
4	250	2 hrs
5	275	2 hrs

3. RESULTS AND DISCUSSIONS

As per ASTM E 08 standards, tensile tests were conducted. The tensile test results for the different heat-treated samples have been indicated in Table 3.

Table -3: Tensile test results

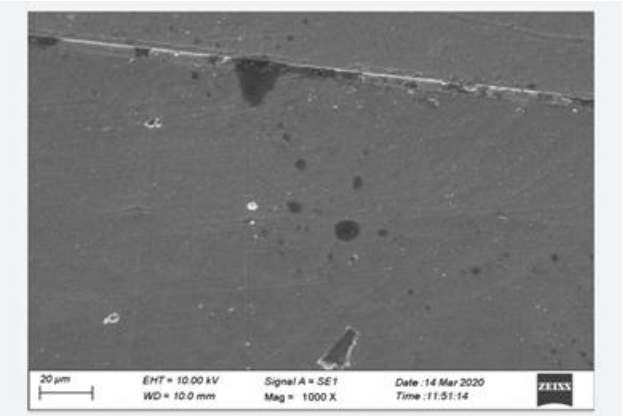
S No	Treatment Temperature °C	Tensile Strength
1	175	169 MPa
2	200	183 MPa
3	225	191 MPa
4	250	196 MPa
5	275	185 MPa

Using Vickers microhardness testing equipment, the surface microhardness of the heat-treated friction stir spot welded joints have been evaluated. The microhardness values of the heat-treated friction stir spot welded joints have been indicated in Table 4.

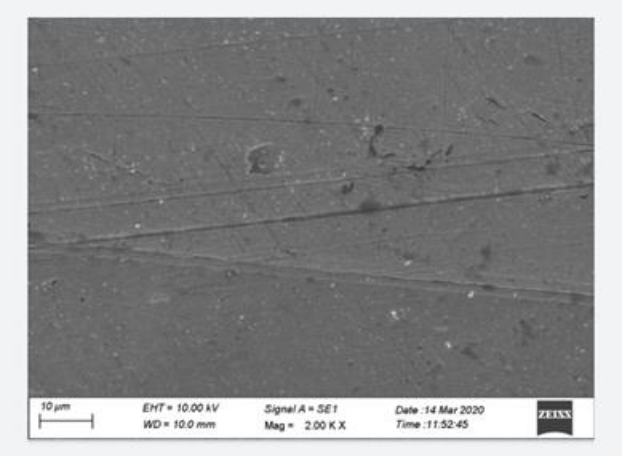
Table -4: Microhardness test results

S No	Treatment Temperature °C	Microhardness
1	175	76 HV
2	200	71 HV
3	225	68 HV
4	250	63 HV
5	275	71 HV

The SEM micrographs of the heat-treated joints have been indicated in Figure 4. Figure 4 (a) indicates the heat-treated surface with small agglomerations of secondary phase particles in the aluminium matrix. Figure 4 (b) indicates the heat treated region of welded AA 6082 Friction Stir Spot Welded joints, in which the grains are found to be more or less annealed.



(a)



(b)

Fig - 4 SEM micrographs of heat-treated joints

4. CONCLUSIONS

Thus, in this manuscript, an attempt has been made to enhance the mechanical aspects of AA 6082 friction stir spot welded joints by using post weld heat treatment process. A significant increase in the tensile aspects was observed on using post weld heat treatment process. On microstructural evaluation, the grains were found to be annealed.

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