RESEARCH PAPER ON EXPERIMENTAL WORK UNDERTAKEN TO EVALUATE PARAMETERS OF FRICTION STIR WELDED FERROUS ALLOY BASED SAMPLE

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ABSTRACT

Friction stir welding (FSW) is considered to be the most significant development in joining of materials in last 20 years. This research paper includes experimental work undertaken to evaluate FSW parameters in respect of friction stir welded ferrous alloy based sample. This paper also highlights the experimental tests undertaken on friction stir welded sample of ferrous alloy for various parameters to evaluate its performance characteristics and arrive at results to conclude feasibility of manufacturing ferrous alloy based automobile chassis by using FSW. The parameters evaluated are hardness and tensile strength of the friction stir welded ferrous alloy sample.

KEYWORDS

Fiction Stir Welding (FSW), Automobile Chassis, Ferrous Alloy Sample

1. INTRODUCTION

Friction stir welding technique is commercially used in several industries, such as ship-building, high-speed train manufacturing and aviation industry. FSW was developed and patented in UK in early 1990s by The Welding Institute (TWI), is usually used in welding of plates and is different from conventional friction welding (**Thomas and Nicholas, 1997**). In this method, the plates to be welded are clamped together rigidly in butt or overlap condition and a stirring tool with a suitable geometry moves along them, while the pieces to be joined are moved over each other in conventional friction welding method. In this method, the stirring tool rotating at a high rate is plunged into the clamped plates causing friction. The heat caused by the friction between the tool shoulder and the work piece results in an intense local heating that does not melt the plates to be joined, but plasticises the material around the tool. The plasticised material is pressed downwards by the tool shoulder, preventing the material from flowing out from the surface. The material is transported from the front of the tool to the trailing edge where it is forged into a joint. Thus, the work pieces are mechanically mixed under severe deformation conditions during this

solid state joining technique. The application of this method is shown schematically in Figure 1. Automobile industry is another area where the technique has potential. Efforts are underway to use FSW to manufacture automobile body parts such as doors, roofs and bonnets. The chassis of a automobile is fabricated by welding together several components and FSW can be utilised in fabricating automobile chassis based on Aluminium, Magnesium, Copper and Ferrous based alloys.

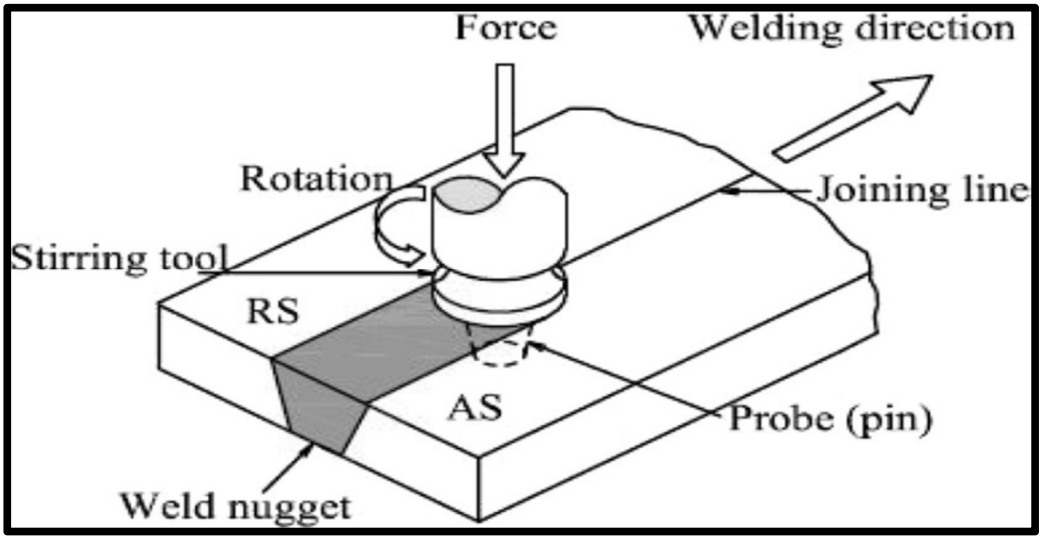

Figure 1 : Schematic Presentation of Friction Stir Welding Technique

Considering the utility of FSW, an experimental work was undertaken to evaluate friction stir welded sample of ferrous alloy for various parameters like hardness and tensile strength to to analyse its performance characteristics and arrive at results to conclude feasibility of manufacturing automobile ferrous alloy chassis by using FSW. The experimental work was carried out in the laboratories of the Department of Guru Kashi University, Talwandi Sabo, Punjab, Mechanical Engineering Department, School of Technology, Pandit Deendayal Energy University (PDEU), Gandhinagar, Gujarat and Base Workshop, Kirkee, Pune.

2. EXPERIMENT WORK

On evaluation of chassis joints for feasibility of utilising FSW for manufacturing of automobile chassis, it was observed that existing lap joints and T-joints in automobile chassis can be welded using FSW. Accordingly, ferrous alloy sheets were prepared as a sample for undertaking FSW experimental work. The metal analysis of ferrous alloy sample for estimation of constituted elements like Carbon, and Manganese in ferrous alloy samples was carried out using as per relevant Indian Standards at NABL accredited chemical laboratory of Base Workshop, Kirkee, Pune, and indicated 0.60 % of Carbon and 0.93 % of Manganese.

2.1 FRICTION STIR WELDING PROCESS

The experimental work for FSW process was carried out at Mechanical Engineering Department, School of Technology, Pandit Deendayal Energy University (PDEU), Gandhinagar, Gujarat.

2.1.1 FRICTION STIR WELDING TOOL DESIGN AND MATERIAL

3 mm Thickness of Steel Weld Joint		
Design Criteria	**Design Criteria**	**Real Design**
Pin Length (90-95% of thickness) OR (0.2mm less than material thickness)	2.70 to 2.85 mm OR 2.8 mm	2.9 mm
Shoulder to Pin Diameter Ratio (SD/PD=2.6:1)	**Tool Pin**	
	Root Diameter 5 mm **Tip Diameter** 3 mm	**Root Diameter** 5 mm **Tip Diameter** 3 mm
	Shoulder Diameter 13 mm	**Shoulder Diameter** 18 mm/20mm/22mm
Threads (Left hand thread for clockwise rotation of tool)	Unthreaded	

Table 1 : Friction Stir Welding Tool Design Criteria

Tool Material					
Tool Material	**Hardness**	**TRS (N/mm^2)**	**Supplier**	**Machining**	**Cryogenic Treatment**
Tungsten Carbide (88%) + 12% Wt Co	**92.8 HRA**	**2100**	**Sinter Sud Pvt. Ltd. Italy**	**Creative Engineer Pvt. Ltd Ahmedabad**	**Cryonet Pvt. Ltd. Surat**

Table 2 : Details of Tool Material

2.1.2 EXPERIMENTAL SETUP

The FSW was carried out on FSW machine available at Pandit Deendayal Energy University (PDEU), Gandhinagar, Gujarat Welding Research Laboratory under the sponsored project of Indian Space Research Organisation (ISRO).

Fig 2 : Friction Stir Welding Machine

The value of FSW parameters considered to undertake FSW of ferrous alloy is as follows:

Sample ID	Tool Pin Shoulder Diameter (Mm)	RPM	Welding Speed (Mm/Min)	Tool Tilt Angle (°)	Tool Pin Offset (Mm)
SD18	18	1500	20	2	0

Table 3 : Friction Stir Welding Parameters

Fig 3 : Friction Stir Welding Sample of Ferrous Alloy

3. TEST RESULTS

After undertaking FSW on the sample of ferrous alloy sheets, it was tested for various parameters to evaluate its performance characteristics and arrive at results to conclude feasibility of manufacturing ferrous alloy based automobile chassis by using FSW. The parameters like hardness and tensile strength were evaluated at Strength of Materials laboratory testing facilities available at Base Workshop, Kirkee, Pune.

3.1 HARDNESS TEST

Two strips of FSW ferrous sample were tested for hardness using Rockwell Hardness Tester and the average hardness value observed for the samples were 33.275 HRC and 29.45 HRC.

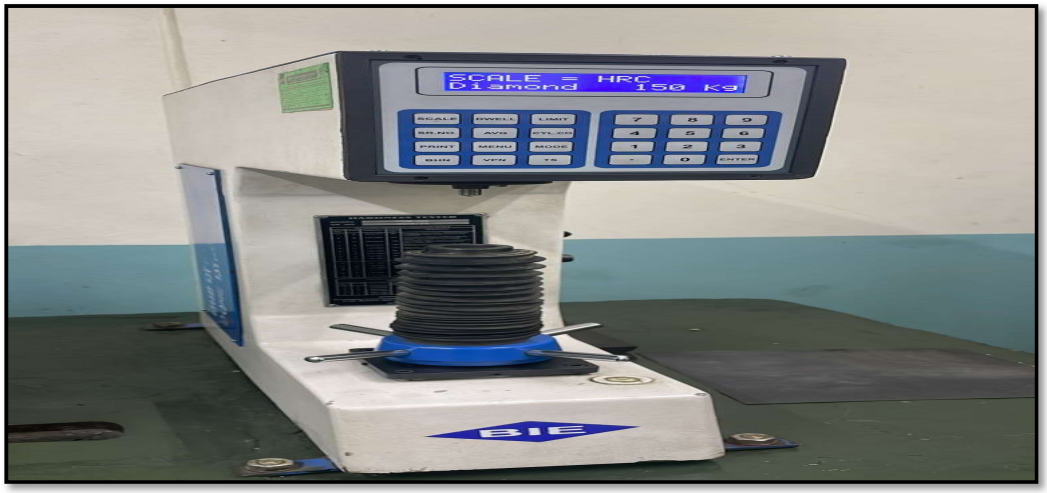

Fig 4 : Rockwell Hardness Tester

3.2 TENSILE TEST

Two strips of FSW ferrous sample were tested for tensile strength using Universal Testing Machine and the ultimate tensile strength values achieved were 933.33 Newton per Millimeter Square and 866.66 Newton per Millimeter Square.

Fig 5 : Universal Testing Machine

4. CONCLUSION

The successful FSW of ferrous alloy sample sheets and test results showing adequate hardness and tensile strength of welded protion indicate that FSW can be utilised for manufacturing of ferrous alloy based automobile chassis using tungsten carbide tool material. However, more reasearch can be undertaken with respect to utilisation of polycrystalline cubic boron nitride (PCBN) tools for FSW of ferrous alloys.

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