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The joint properties for friction stir welding of Aluminum pipes

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Abstract : This work presents a systematic approach to the use of friction stir welding for joining pipes Al 6061 aluminum alloy welding was performed on the pipe with different thickness 2 to 4mm, rotational speeds 485 to 1800 RPM and a traverse speed 4 to 10mm/min was applied. The Mechanical properties of welded joints were investigated using different mechanical tests including nondestructive test (visual inspection) and destructive test (tensile strength and hardness).This paper presents the optimization of friction stir welding for pipe and also highlights the influence of material thickness, rotation speed and travel speed on mechanical properties of FSW 6061 Al alloy. The resultant friction stir welding efficiency increases with increase rotation speed and decreases travel speed and material thickness.

Keywords: FSW, Aluminum pipes, mechanical properties

INTRODUCTION

Automobile industry has been called as locomotive industry, as it is an industry with intensive technology and capital and presenting large industry linkage effects. Developing nations, therefore, regard it as the leading industry. It is the “world’s largest manufacturing activity”. The automobile industry, as a customer, motivates the development of iron–steel, petrochemical and tire industries. As a producer, it provides all types of motor vehicles for tourism, infrastructure maintenance, transportation, and agriculture. Therefore, any changes in the automobile industry will affect the entire economy. The quantity of automobiles in a country could be treated as an indicator of living standards. The Role of Automobile Industry in India GDP has been phenomenon. The rising productivity levels, which are associated to lower costs and increased production play a crucial

I. INTRODUCTION

In modern years, there has been a potent demand for lightweight transport equipment’s. The use of aluminium alloys to substitution ferrous alloys in transport equipment’s is most effective in reducing the weight of automobiles and aerospace vehicles. Considerable tonnages of aluminium alloys are used in the transport manufacture. In that esteem, the strength to weight ratios of aluminium alloys has thus been a predominant design consideration. Several strengthening mechanisms have been used in the else 30 years to incubate new aluminium alloys with high strength to weight ratios .Stampede hardening, precipitation hardening, and improvement of grain structure provide active strengthening mechanisms.

Fusion welding of mercantile aluminium alloys is mostly hard and not bespoke for some aluminium alloy groups . The existence of protective tenacious oxide film on aluminium alloys is accountable for such difficulties. Extensive surface planning to take off the oxide film are needful before welding of some aluminium alloys.

Fusion welding of Al-alloys, whilst, faces some other problems, such as, generation of welding defects such as blowholes, cracks, welding distortion, and angular distortion, which reduced the mechanical properties of weldments. Fusion welding of high stre ngth Al-alloys caused significant changes in microstructure of cold worked and age hardened alloys, which drastically decrease the mechanical properties of welded alloys. In this work study

Effective rotation speed travels speed and material thickness on mechanical properties by friction stir welding pipes

II. EXPERMINTAL WORK

A. **Material:** The chemical composition and mechanical properties of Al 6061 aluminum pipe parts used in the present study as delivered by the Miser Aluminium company are given in Tables (1-2).

Table (1) Chemical composition (weight %) of Al 6061 aluminum pipe

Weight %	Al	Si	Fe	Cu	Min	Mg	Cr	Zn	Ti
6061	Ball	0.6	0.70	0.2	0.15	0.80	0.33	0.23	0.12

Table (2) the mechanical properties of Al 6061 aluminum pipe

Alloy	Ultimate Tensile Strength σ UTS M pa	Elongation EL%	Hardness VHD
6061	252.690	8	86

B. Design and constructed

Setup friction stir welding: constructed apparatus is mounted on the drilling press machine bed to the two workpieces of the studied materials which will be welded by friction stir welding technique, Fig. (1). Showing Illustration, Drawing, and Construction Setup friction stir welding for pipe parts

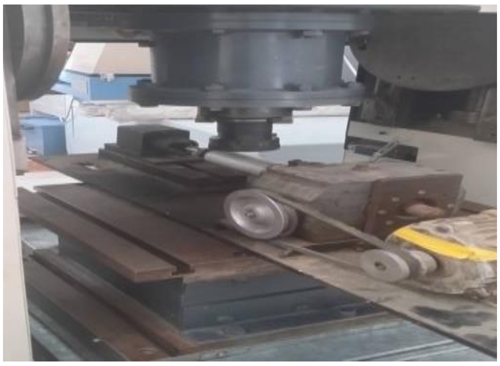

Figure 1 Friction stir welding machine

A. Tensile Testing:

Tensile testing, also known as tension testing, is a fundamental material science test in which a sample is subjected to uniaxial tension until failure. The score from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under other types of forces. Properties that are directly measured via a tensile test are an ultimate tensile strength (UTS), maximum elongation (EL %).

III. RESULT AND DISCUSSION

The Visual Testing is very significant, nevertheless neglected by many non-destructive testing personnel. The Visual Inspection is a non-destructive testing style that furnishes a wherewithal of detecting and examining an assortment of surface flaws surface discontinuities on joints. The Visual inspection is also the most exceedingly used method for detecting and check surface cracks, which are predominately substantial because of their relevance to structural failure mechanisms. Even when other NTD styles are used to detect surface cracks, visual inspection often provides a useful supplement [20].

Visual inspection of the external surface of welded specimens showed uniform semi-circular surface undulation, caused by the final sweep of the trailing edge of the rotating tool shoulder over weld nugget, under the effect of probe overhead pressure.

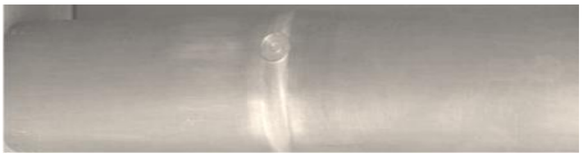

Figure 2: Exit Pin

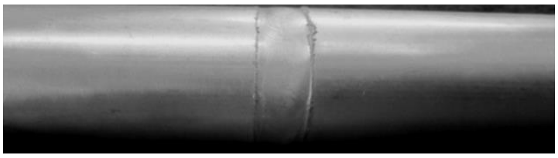

Figure 3: **Finished pipe**

A. Tensile Test Results

The outcomes of transverse tensile tests for the weld are summed up in Figure (4) to Figure (6). the base material higher tensile strength and elongation than the weld The tensile properties of the weld of pipes AL 6061 alloy depend on microstructures, such as grain size, because this alloy is mainly strengthened by soil- solution and work hardening. However, the apportionment of grain size and dislocation density were almost regular during the weld. This signalizes that the tensile properties of the present weld cannot be explained only by the apportionment of grain size and dislocation density.

Aside from grain size, crystallographic orientation also strongly influences plastic deformation during the tensile test because the plastic deformation arises from the gliding on the close-packed planes with the upper critical resolved shear stresses.

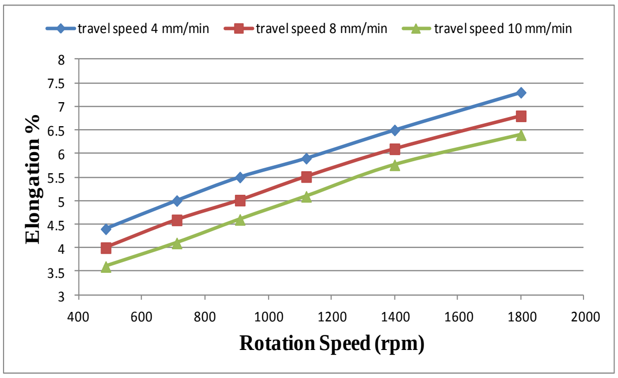

Figure 7: Relation between elongation and speed of Al 6061 (at thickness 2mm)

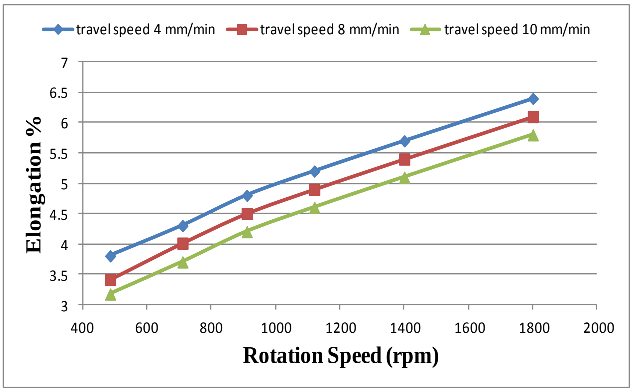

Figure 8: Relation between elongation and speed of Al 6061 (at thickness 3mm)

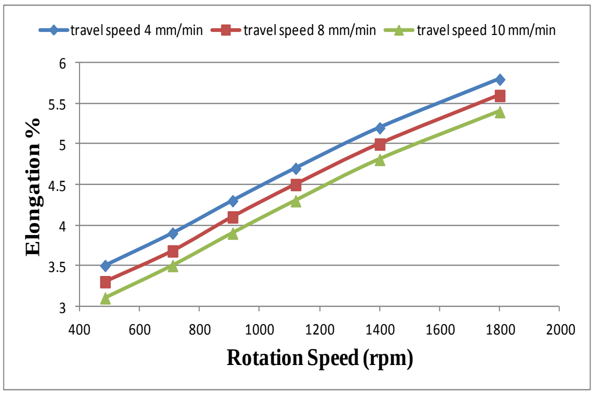

Figure 9: Relation between elongation and speed of Al 6061 (at thickness 4mm)

Hardness Results

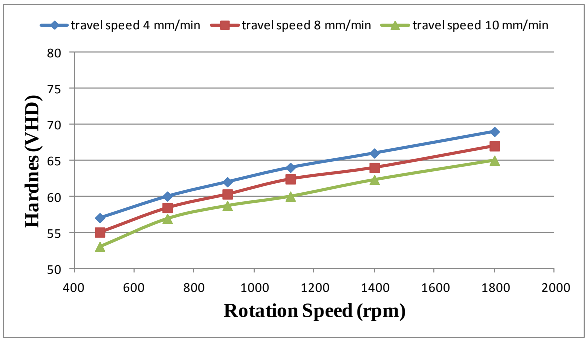

Figure 10: Relation between hardness and speed of Al 6061 (at thickness 2mm)

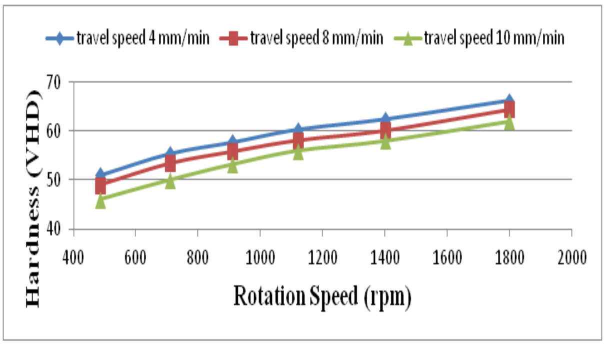

Figure 11: Relation between hardness and speed of Al 6061 (at thickness 2mm)

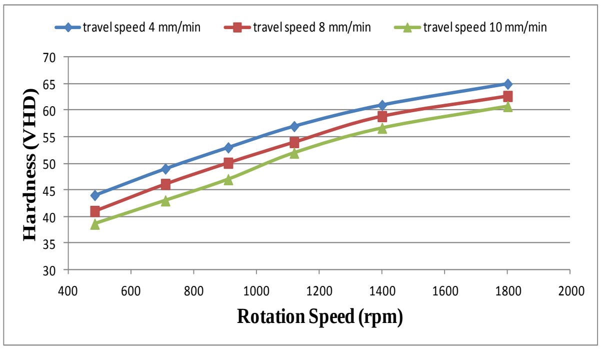

Figure 12: Relation between hardness and speed of Al 6061 (at thickness 2mm)

The joints fabricated at high rotational speed (1800rpm) exhibited superior tensile properties compared to other joints. Similarly, the joints fabricated with high material thickness are showing good tensile properties comparable to that of a less material thickness see fig. See fig. (7-9) Hardness measurement of the joints

Graphical results for tensile strength, elongation%, and hardness

A. Rotational Speed

The Rotational speed is directly proportional to the tensile strength of the weld. The frictional heat input increases with increase in the rotational rate of the tool. Thus the increase in the Rotational speed enhances the heat input of the process which in turn results in better material flow and increases the material to be displaced in a unit time. The maximum tensile strength of the weld is also seen when the process parameter rotational speed set at a higher level in the process window. Thus the rotational speed at 3rd level is the best possible level for the desired responses considered.

B. Travel speed

As travel speed is one of the important process parameters, the considered level doesn't affect the responses as the variation in the level average is not appreciable. This implies within the selected range of process window the levels can be fixed at any level to have the desired output.

C. Material thickness

the tensile strength of the welded joints depends on the material thickness. The material thickness with flat surfaces is associated with eccentricity, which allows the material to flow around the pin. The tapered pin profile produces the pulsating action as the ratio between the static volumes to the dynamic volume is more than one.

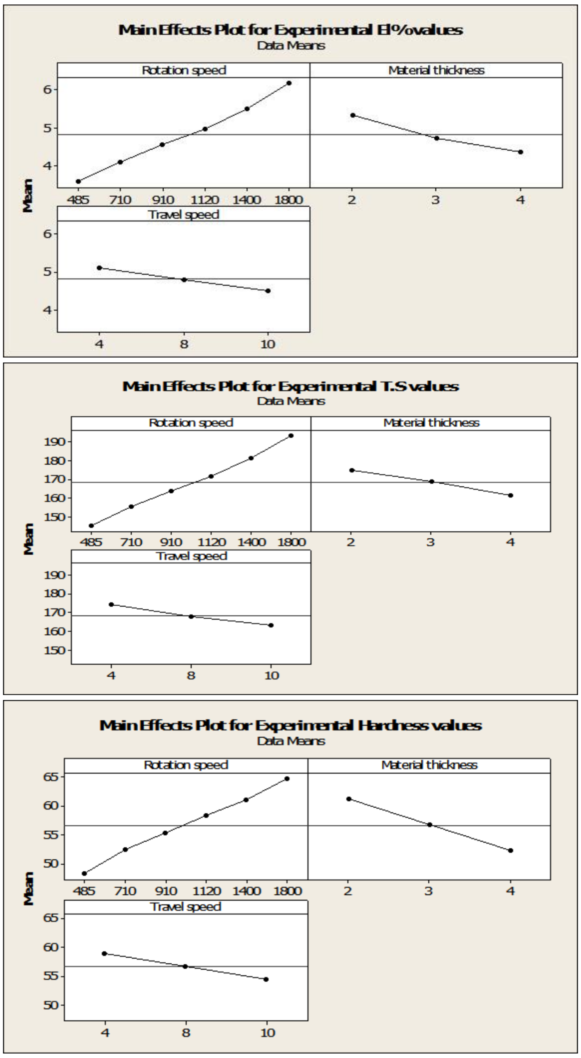

Figure 13: Main effects plot for tensile strength, elongation, and hardness values

VI CONCLUSION

1. The FSW weld efficiency increases with increase rotation speed and decreases travel speed.
2. The FSW efficiency increases with decrease the material thickness.
3. The joint efficiency of FS welded (ratio of ultimate tensile strength of welded joint to that of the base material was found 80, 78% and 76% for 6061 at thickness 2,3and 4mm.
4. The hardness values decrease gradually across the weld, with the minimum hardness value in the weld center or weld nugget.

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