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COMPARATIVE STUDY OF FRICTION STIR WELDING AND TUNGSTEN INERT GAS WELDING PROCESS FOR ALUMINIUM ALLOYS-A REVIEW

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ABSTRACT:

Friction stir welding is emerging as new solid state welding process which can weld similar as well as dissimilar materials. TIG welding and FSW both are extensively used in the industries for welding of aluminium alloys. FSW can weld very thin as well as thick plates. This process does not consume filler rod or any protective inert gases. There is no melting take place in FSW, and hence there is no defects occurs associated with fusion welding. FSW is environment friendly and fast welding process. Like the FSW, TIG welding also bears some significant benefits such as it can be used in all positions and good weld can be produced with less spatter. The aim of this review paper is to compare the mechanical and microstructural aspects of the FSW and TIG welding because they carries the same feature like both can weld similar and dissimilar metals and can give good weld.

KEYWORDS:*FSW, TIG, Aluminium alloy tensile strength and hardness*

1. INTRODUCTION

Now-a –days, aluminium alloy used in various field like Automobile productions, Building construction, Railroad industries, Pressure vessels and tank (barrels), Aircraft engineering, Storage tank Pipeline industries Petrochemical industries Earth moving machinery, Shipbuilding industries etc. [1] It may be said that the welding process have two major function in the industries: (i) as means of fabrication and (ii) for maintenance and repair.

Friction stir welding (FSW) process invented by TWI, UK in 1991.it is solid state welding process in this process non consumable tool design with tool shoulder and pin is use for welding of work piece with different rotational speed. Heat is generated between the tool and workpiece due to the frictional force of mating surface. SW has more advantage in compression to fusion welding processi.e. its low process temperature, low melting

temperature so that this method is applicable for joining of thin workpiece and material to be difficult joining. [2]

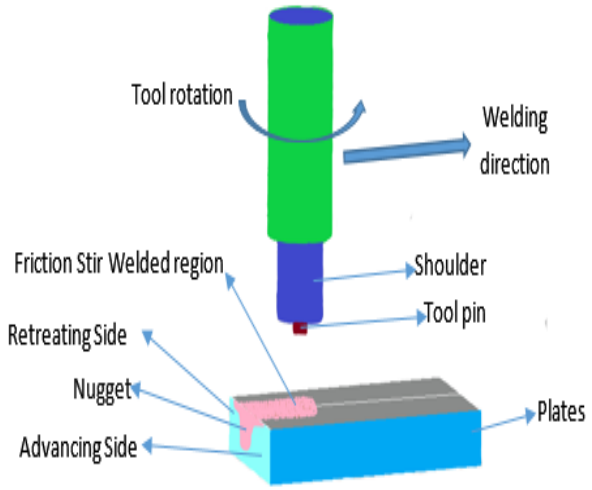

Fig.1 Friction Stir Welding

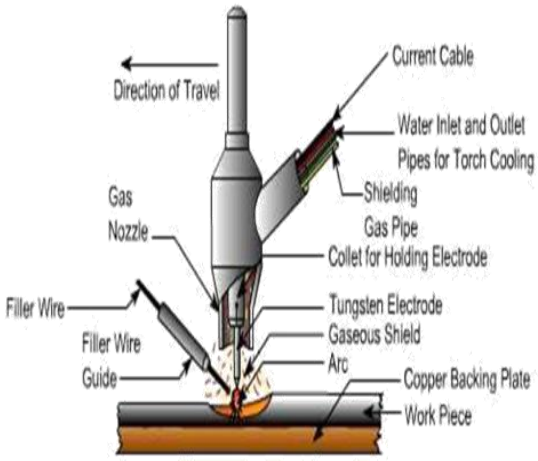

Fig.2 TIG welding [2]

In the welding classificationTIG welding comes under the electric arc welding process, TIG welding also called as Gas tungsten arc welding process (GTAW).TIG welding had introduced during second world war,Arc and molten pool shielding with an inert gas (CO_2), it was invented by Alexander in USA in year 1928 and the patent for TIG welding was received by Hobart and Devers in 1930 in USA [3]. In general for GTAW argon is used as shielding gas along with the AC power source .There is also a GTAW version where helium is used as shielding gas ,which helps to achieve a high temperature in the arc DCSP (direct current straight polarity) used instead of alternating current ,thickness of work piece 0.2 from 10 mm can be weld . In this process filler metal may or may not be used depending upon the thickness of work piece. [4]

2. MECHANICAL PROPERTIES OF ALUMINIUM ALLOYS

Mechanical properties are the best criteria to understand the weld quality of a joint.The aluminium alloys are extensively used in different industries and are required to weld the alloy plates to same or other alloys .Thus, it is important to evaluate the weld quality of aluminium alloys.

2.1 Tensile strength

Mahapatra S. and Sarangi H. [5] had done FSW and TIG welding on 3 mm thick commercially available aluminium alloy. They performed experiments at different speeds. They observed the tensile stress of doubled sided welding was larger than the single sided welding. For double sided welding, they found highest tensile stress was 121.6 MPa at 80A current. For single sided welding, highest tensile stress was 109.33 MPa at 110A .In case of FSW, highest value of tensile stress was 157.33 MPa at 1000rpm.

Ericasson M. et al. [6] had investigated 4 mm thick AA6082 for TIG welding and FSW. They found average yield and tensile strength for TIG were 145MPa and 219 MPa .For FSW , they found no influence on tensile properties .The fracture in FSW were occur in the weld or HAZ border line.

Singh G. et al. [7] were studied the effect of FSW and TIG welding on 6 mm thick plate of AA6082-T651.They found that the maximum tensile strength for FSW was265 MPa occur at welding speed of 25mm/min and tool rotation speed of 500rpm while in case of TIG welding, maximum tensile strength was 204 MPa occur at 140A current.They found the reason for lower tensile strength for TIG joints was the dendrite structure but FSW joints contains fine and equiaxed grains.

Munoz A.C. et al. [8] had investigated the 4 mm thick rolled plates of Al-4.5Mg-0.26Sc alloy for FSW and TIG welding. They found the maximum ultimate tensile strength for FSW was 300MPa and for TIG welding was 250MPa.

Shukla R.K. et al. [9] had studied the effect of FSW and TIG welding on the mechanical properties of4 mm thick rolled plates of AA6061T6. They were found the maximum ultimate strength for FSW was 159.9 MPa and for TIG welding was 139.6 MPa.

Zhao J. et al. [10] has investigated the 2 mm thick cold rolled plate of Al-Mg-Sc alloy. They were found the tensile strength and yield strength of FSW joint was 394 MPa and 286 MPa respectively while for TIG welding joint was 332 MPa and 217MPa respectively.

2.2 Hardness

Zhao J. et al. [10] had found the micro hardness of FSW joint of Al-Mg-Sc alloy about 30HV higher than that of TIG weld joint. The micro hardness at differentregion of weld joint obtained by FSW and TIG welding is shown in figure 1.

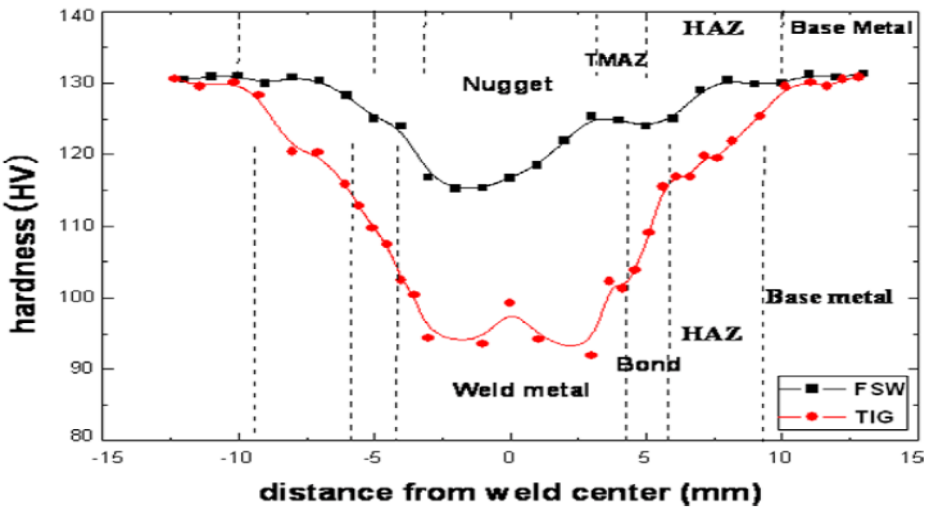

Fig.1 Distribution of micro hardness at different region of FSW and TIG joint [10]

Shukla R.K et.al.[9] had reported that the micro hardness TIG and FSW joint of AA6061 T6 was 55HV and 70 HV respectively. The hardness of TIG joint was lower than the base material due to higher heat input and use of low hardness $AlSi_5$ filler metal while hardness of FSW joint was lower than the hardness of base material because of dissolution of strengthening precipitates.

Squillace A. et.al. [11]had investigated the AA2024-T3 of thickness 2mm and 3mm. TIG was performed on 2mm plate and FSW on 3mm plate. They were found that TIG weld joint allows the general decay of mechanical properties in both weld bead and HAZ. In case of FSW there was greater difference in micro hardness among the different welding zones. The micro hardness decreases in nugget and TMAZ whereas slightly increases in HAZ.

Munoz A.C. et al [8] had investigated the hardness of samples obtained by FSW and TIG welding. Some sample were heat-treated at 300^0C for one hour and then air cooled. They were found that decreases in hardness in FSW nugget was lower than the molten zone of TIG joint. Heat-treated sample of FSW shows negligible effect in hardness of nugget zone while the heat-treated sample of TIG welding shows considerable increase in hardness of molten zone

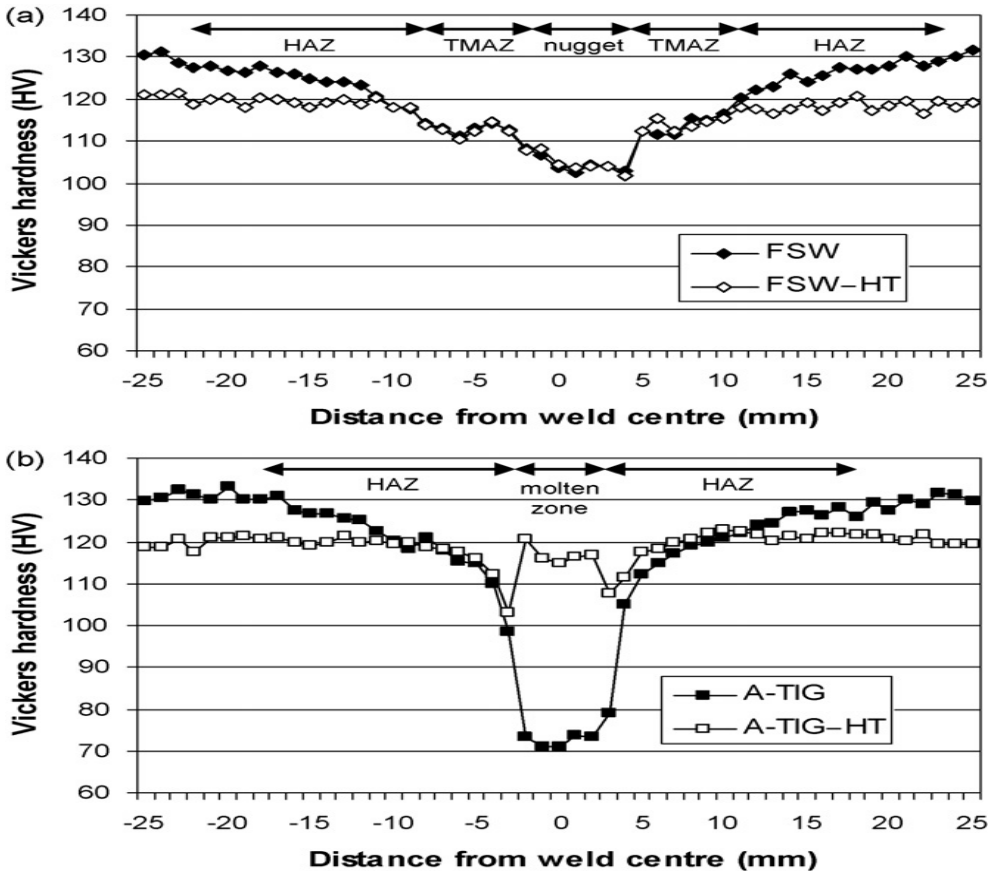

Fig.2 Hardness distribution (a) FSW (b) TIG Welding [8]

Patil C. et.al. [12] had investigated the hardness of joints obtained by FSW and TIG welding of similar AA7075-T651 joint and dissimilar joint of AA7075 T651 and AA6061-T6. They found maximum hardness value for similar AA7075-T651 TIG joint was 50.1 BHN whereas for FSW was 121 BHN. The hardness value for dissimilar joint of FSW was 65 BHN while for TIG welding was 70.7 BHN.

Singh G. et al. [7] investigated the AA6082-T6 for TIG welding and FSW. They found maximum hardness 58HV at 140 ampere current in the TIG weld zone while in case of FSW maximum hardness was 65 HV at 500 RPM in the stir zone. The reason for the lower hardness in TIG welding was low cooling rate of molten weld pool which forms wider dendritic spacing in the fusion zone and these microstructure offer lower resistance to indentation.

2.3 Microstructure

Zhao J. et al. [10] studied the microstructure of joints obtained by TIG welding and FSW of Al-Mg—Sc alloy they found microstructure and mechanical properties in the FSW joint are asymmetric.the mechanical properties of FSW were better than TIG welding due to well preservation of cold microstructure, good thermal stability of Al_3(Sc, Zr) particles and low welding temperature.

Munoz A.C. et al [8] had investigated Al-4.5Mg-0.26Sc alloy for FSW andTIG welding. They found no Al_3Sc precipitates in the molten zone. But after heat treatment, Al_3Sc coherent precipitates were observed in the TIG weld.

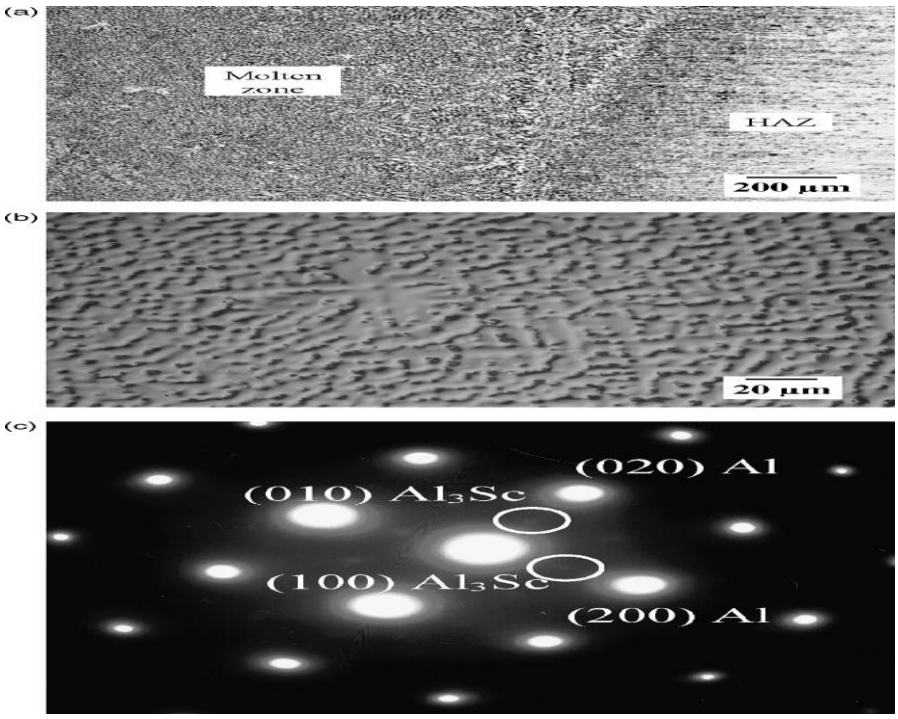

Fig. 3 **(a)** Optical micrograph of A-TIG (b) optical micrograph at higher magnification(c) diffraction pattern of heat-treated A-TIG weld center.[8]

Ericasson M. et al. [6] had studied the microstructure of FSW and TIG joint of aluminium alloy 6082 they found dendetric microstructure in the weld joint of TIG having solute particles near the dendritic boundaries. In case of friction stir welding, the nugget zone was composed of recrystallized and superplaticized structure and it makes very fine grains.

Mishra A. et al. [13] had investigated microstructural properties of AA6061-T6 weld joints obtained by FSW and TIG welding.They found equi-axed grains in the stir zone and clear appearance of onion ring in the nugget zone. The grain size in the nugget zone was smaller than other zones.in case of TIG welding the intermetallic dendritic structure was form in the weld zone where as in HAZ, intermetallic granular structures were formed.

Walter V.et.al. [14] had studied the effect of FSW and TIG welding of Al-Si-Mg alloy they found large grains and dendritic structure in the TIG weld joint the microstructure does not show any significant changes in the HAZ. In case of FSW, very fine grained microstructure were formed due to recrystallization in the NZ. In the TMAZ, the deformed grains of the parent material can be found.

3. CONCLUSION

In this paper, the various aspects of the FSW and TIG welding was reviewed and the effect of these welding processes were classifiedinto different sections. The outcomes from this paper can be concluded as:

1. The joint efficiency of friction stir welded material was found better than the TIG welded material. The tensile strength obtained by the friction stir welding was found better than the TIG welding.
2. Most of the authors reported that the hardness value for FSW joint was higher than the TIG joint.
3. The nugget zone of FSW joints contains the recrystallized, equi-axed and fine grains while the weld zone of the TIG welding contains intermetallic dendritic structure .
4. The heat input in TIG welding wasgreater than the FSW welding.

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