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PROGRESSES IN FRICTION STIR WELDING:AN OVERVIEW

Deepanshu Singh Solanki[1], Divyansh Rodle[2], Harshit Suryawanshi[3]

Department of Mechanical Engineering
,Lakshmi Narain College Oftechnology, Bhopal (M.P.) (India)

ABSTRACT

Aluminium alloys series 2XXX and 7XXX are not usually considered weldable by traditional methods. They are mostly used as a part of aerospace structures. The common practice joining technology is riveting. Growing technology of friction stir welding (FSW) has shown promising results in welding of these alloys. In this paper we have investigated application of

FSW technology in aircraft structures mainly as substitution of riveting on stringer reinforced panels. Manufacturing process steps were determined and further optimisation procedures were suggested. Knowledge platform for setting basic welding parameters has been created and comparison of a sample of riveting and FSW technologies on a simple final element method model sample was examined in order to identify differences in stress distribution character in the riveted and FS welded samples.

I. INTRODUCTION

Friction stir welding at the beginning was carried out in 1991 at The Welding Institute (TWI) of United Kingdom. This was emerged as a solid state welding technique primarily for aluminium alloys. It was invented due to difficulty of making high strength fracture and fatigue resistant welds in aerospace aluminium alloys. Highly mixed aluminium series like 2xxx and 7xxx series are considered as non weldable because of defects like porosity in the fusion zone and likewise poor solidification microstructure.Mechanical properties were als lost as compare to base material. Surface preparation and oxidation was also a major problem in resistance welding . In FSW, a non-consumable rotating tool having a shoulder and threaded pin is depressed until shoulder marks strong connection with the upper surface of the work piece [1]. The rotating tool then navigate end to end the butting surfaces of two rigidly fastened plates placed on a back-up plate .The diameter of the pin is kept slightly larger than the thickness of plates while its length kept shorter than the depth of the plates to avoid the damage of tool pin and base plates .The heat is produced due to friction among the tool and the base material and to a smaller amount at the pin work piece contact interface, which reasons the weld base material to soften nearby the pin at a temperature lesser amount than its Nmelting point . The softened material exposed to extrusion below the shoulder by the traverse and rotary movement of the tool is transferredstartingthe advancing side to the retreating side where it is associated into a monolithic joint [4-5]. The half work plate on whichway of rotation issimilar as that of welding is named advancing side, whereas other side on which rotation is opposite is known as the retreating side. This dissimilarity can result into unevenness in heat transfer, properties and material flow of the weld of the two sides. Friction stir welding (FSW) is recognised as a substantial attainment of grain refinement technique [6]. Considering resultant quality of weld FSW exceeds other fusion weldin processes in the absence of liquation, solidification cracks and porosity

On the other hand, there have been some problems concerning FSW micro structural features in earlier few years, which adversely affect its strength [7].With the significant rise in the flow stress ductility drops off abruptly at a critical test temperature due to very large microstructural instability [6].The intrinsic thermal instability perceived inthe weld microsructure at high temperatures, since abnormal grain growth (AGG) was evidently seen in the friction stir weldings of AA2519 and AA7050, AA2195 [7], and AA7010 [8],AA6061 afterexposing them to PWHT(post-weld heat treatment) created a negative impact.Secondary recrystallization and abnormal overstated grain growthare all substitutesfor the happening ofgrain growth inside the material structure, moreover some grains may substantially grow and consuming the minor grains,generating grains sizes of fewhundred microns upto millimetres [9]. Abnormal grain growth is a microstructure evolution process where some grains grow at the cost of the finer matrix grains, and it commonlyoccurs when the normal grain growth of the matrix grain ceases.Even though for some purposes AGG has been proved to be advantageous such as in case of electrical steels.

Common Difficulties with Fusion Welding of Aluminium Alloys

In the welding of aluminium and its alloys some problems arise during welding and also after welding. Some of th fusion welding problems arised during fusion welding is given below:

1. Solidification cracking starts in some high strength aerospace aluminium alloys because of their high range of freezing. At the fusion boundary low melting point eutectic phases initiate liquation cracking.
2. In the weld metal porosity is also a major problem. The main reason for the porosity is gas dissolution and trapping in the molten weld metal as it solidifies, hence bubbles start growing in the solidified weld.
3. To achieve quality welds free from defects such as lack of fusion, oxide film entrapment and porosity it is necessary to disperse and remove thin oxide film before and during welding.
4. Alloying elements lost from the weld metal pool which results in the reduction of strength.
5. In alloys like aluminium hot cracking may arise which is not found in the case of pure metal.
6. Softening occurs in the cold worked alloys so strength of the alloy reduces because of heat input during welding. Coarsening of the grains also occur.

II. PROGRESSES IN FRICTION STIR WELDING

As the friction stir welding process has been developed initially for joining aluminium, it was inevitable that interest would emerge in applying it to other materials. An increasing volume of work is appearing on friction stir welding of materials such as magnesium, copper, titanium and steels. It has been known for some time that many steels can be welded by the process, including C-Mn steels used in shipbuilding, but the process is not yet ready for shipyard use. The main reason for this lies in the tools used to make the weld. In aluminium, the process seldom achieves temperatures above 500°C, and there are therefore a number of materials which can be used which will operate well at these temperatures. When welding C-Mn steels, much higher temperatures of between 1000°C and 1200°C are achieved, and the options for tool materials are greatly reduced, especially when the high forces present are considered. It is essential that the tool does not degrade by wear, deformation, microstructural instability, reaction with the workpiece or fracture.

So far, two tool material types have given promising results, although neither meets all of the criteria for an industrial tool material. These materials are refractory alloys based on the tungsten - rhenium system, and a ceramic

solution based on polycrystalline cubic boron nitride (PCBN). [5] Tungsten - rhenium alloys exhibit excellent high temperature strength and toughness, but are prone to wear and deformation, in particular when higher strength steels are used. However, they are much cheaper than PCBN, and have an advantage in that they can be machined relatively easily. PCBN is a very hard material (boron nitride is thought to be the second hardest material known), and therefore wear rates are very low. However, the fracture toughness of the material is, like almost all ceramics, very low, and the tools are prone to cracking and sudden failure unless handled with great care. The extreme hardness of the materials means that they are very difficult to process to more
complex shapes. The tools undergo a very complex manufacturing process, and are therefore rather expensive.

III. CONCLUSION

FSW technology brings a lot of advantage to the area of joining of aluminium alloys series 2XXX and 7XXX compared to riveting .Design changes in the riveted construction have to be done in order to use FSW as a direct substitute of riveting technology. The changes in design have to respect different character of the joint. Fatigue tests might be required to allow certification of the construction.

Availability of data required for design of FSW technology processes in open books is limited but provides sufficient base to estimate roughly possible benefits of the usage of the technology or eventual switch from riveting joining technology to FSW. Information about basic welding parameters is sufficient to be used as starting values for optimisation process on the real construction, materials and tools. This causes higher financial requirements for new adopters of the technology.

Production of the stringer-reinforced panel using technology of FSW provides possibility of improvement of mechanical properties of the panel, reducing weight of the plane construction, introduction of fully automated production into the manufacturing process and raising its efficiency. Further investigation is needed, however, to determine fatigue properties of FS welds in order to allow certification of the aircraft structure

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