TO STUDY THE EFFECT OF DIFFERENT TOOL PROFILES ON ALUMINIUM AA3103 BY FRICTION STIR WELDING

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Abstract –Joining of dissimilar materials is very attractive for many applications as we can use the more costly one only where necessary. In fact , joining of aluminium alloys could be frequently faced in many cases including automotive, aerospace, electronics and shipbuilding industries, Where fusion welding simply is not appropriate due to the large difference of physical and chemical properties between the components to be joined. Problems including porosity formation, solidification cracking, and chemical reaction may arise during fusion welding of dissimilar materials although sound welds may be obtained in some limited cases with special attentions to the joint design and preparation, process parameters and filler metals. In contrast, friction stir welding (FSW) seems to be a very promising technique as it permits welding of aluminium alloys while avoiding the drawbacks of fusion welding. Products made of aluminium alloys have been becoming increasingly significant in industrial applications because of their technical and economic benefits. Many people carried out the welding tests on the aluminium alloys with taking the various parameters take in to consideration for the process. We are taking the material mentioned above for FSW tests with some different parameters. Also we will do the experimental study of the same welding joint. Finally, the direction of future research and potential applications are examined and it will become good option to the other welding processes.

Keywords *–Aluminium, FSW- Friction stir welding.*

1. INTRODUCTION

Friction stir welding (FSW) is a widely used solid state joining process for soft material such as aluminium alloys because it avoids many of the common problems of fusion welding. Commercial feasibility of the FSW process for harder alloys such as steels and titanium alloys awaits the development of cost effective and durable tools which lead to structurally sound welds consistently. Material selection and design profoundly affect the performance of tools, weld quality and cost. Also the FSW gives very good quality of weld for many soft materials like aluminium and hard materials like various steels, titanium etc. The process involves the heating the material of workpiece by rotation and friction of the tool in between the workpiece. The melted material mixes with each other and joint get formed. The detailed information of the process is as follows:

Friction stir welding (FSW) was invented at The Welding Institute (TWI) of UK in 1991 as a solid state joining technique, and it was initially applied to aluminium alloys. The process uses a spinning, non-consumable tool, similar to taper reamer, to generate frictional heat in the workpiece. By pressing this tool in to contact with a workpiece to be welded, the base metal heats up and once it reaches about 80% of its melting point it becomes soft and deforms easily. By keeping the tool rotating and moving it along the line of joint of workpiece to be joined, the softened material is literally stirred together forming a weld without melting. These welds require low energy input and are without the use of filler materials and distortion. Initially developed for non-ferrous materials such as aluminium, by using suitable tool materials the use of the process has been extended to harder and higher melting point materials such as steels, titanium alloys and copper. Since its invention at TWI in 1991, Friction Stir Welding (FSW) has become a major joining process in the aerospace, railways and ship building industries especially in the fabrication of aluminium alloys. The process uses the non-consumable tool to generate the frictional heat in the workpiece. This solid state joining process involves a rotating tool consisting of a shoulder and/or a probe. The shoulder applies a downward pressure to the workpiece surface, constrains the plasticized material around the probe, generates heat through the friction and causes plastic deformation in a relatively thin layer under the bottom surface of the shoulder. The rotating probe mainly drags along, plasticizes and mixes the adjacent material in the stir zone, creating a joint without friction.

The figure 1.1 shows that the schematic representation of the actual process of the friction stir welding of the two plates. In this process the tool plays a vital role in the process, that it contains some important primary functions as: (a) To heat the workpiece by friction. FSW is considered as the significant process development in metal joining in a decade and also considered as green technology due to its energy efficiency, environment friendliness, versatility. As compared to the conventional welding methods, FSW consumes very less energy. No any gas or flux is used, thereby making a process environment friendly. The process of joining does not involve any filler material and therefore any aluminium alloy can be joined without concern of the compatibility of the composition, which is a bigger issue fusion welding. In contrast to traditional friction welding, which is usually performed on small axis-symmetric parts that can be rotated and pushed against each other to form a joint, FSW can be applied to various types of joints like butt joint, lap joint, T-butt joints, filler joints and the movement of the material to produce the joint. The heating of base material is accomplished by friction between the tool and workpiece and followed by plastic deformation of the material. The material in contact with the pin or probe of the tool is heated and softens automatically and movement of the material from front to the back side of the tool gets happened continuously.

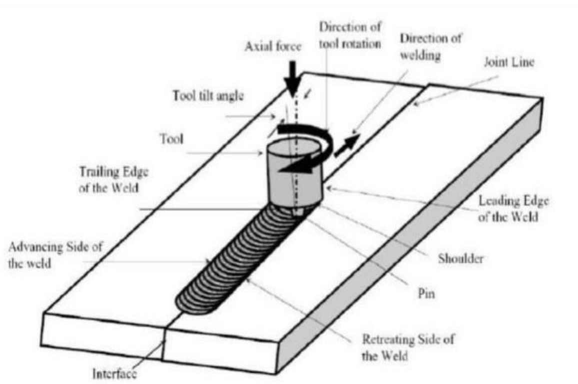

Fig. 1.1 Schematic Diagram of Friction Stir Welding

2. LITERATURE REVIEW

In the overview of literature, the paper related to the subject of study of the project reviewed and some of them are summarized as follows.

R. Rai, A. De, H.K.D.H. Bhadeshia and T. Debroy focused a large view of FSW in "Review- Friction Stir Welding Science and Technology" (Feb. 2011) in manner of parameter selection of the process of FSW. They had given the information about the feasibility of the FSW for harder alloys such as titanium, steels etc. Also they explained that the performance of the tools are totally depends on the selection of material and also the design of the process. They tried some tool geometries for some trials. The tool costs are depending on the wear ability of the tool. The review also tells that the important aspects of the FSW tools such as tool material selection, geometry of the tool, load Bearing ability etc. Also the tool shows good properties and life of aluminium gets increased.

R.S. Mishra and Z.Y. Maworks did the various experiments on the "Friction Stir Welding and Processing" (Aug. 2005) with various materials and mainly studied the process parameters with view in consideration of applications. They worked mainly on the aluminium alloys with some process parameters also gave the main points results that, the mechanisms are responsible for the formation of welds and microstructural refinement and also effect of process parameters on the microstructure of the base metals & joints. Also a lot work had been done on the tool design parameters for FSW. And tried to remove the defects occurred in the fusion welding of aluminium or other metals. They showed some of properties of microstructure of the metals with some images and resulted as the FSW has good microstructural behaviour than the other regular methods of welding.

S. Bhaumik, X. Molodova Studied the Effect of stress on the annealing behaviour of severely plastically deformed aluminium alloy 3103 by Institute of physical metallurgy and metal physics. They studied the influence of a mechanical stress during annealing on the softening behaviour of an ECAP deformed and a cold rolled aluminium alloy 3103 was investigated, also the work hardening behaviour and microstructural evolution during annealing.

S. Malarvizhi and V. Balasubramanian studied the concept of "Influence of tool shoulder diameter to plate thickness ratio on stir zone formation and tensile properties of friction stir welded dissimilar joints of AA6061aluminium and AZ31B magnesium alloy" (2012) experimented. They studied the process and used the tools of various shoulder diameters and analyze its effects on the weld quality, tensile strength and also the joint efficiency.

B.T. Gibson, D.H. Lammlein, T.J. Prater, W.R. Longhurst, C.D. Cox, M.C. Ballun, K.J. Dharmaraj, G.E. Cook done the study of "FSW process, automation and control" (2013) and provides the large overview and done the survey of latest research and applications regarding the process. They discussed the material flow from both the way as experimental and modeling too. The process variation includes the self-reacting FSW, stationary shoulder, friction stir processing and friction stir spot welding were discussed briefly. Multiple aspects of robotic friction stir welding are covered, including sensing, control and joint tracking .All possible methods of evaluating weld quality are surveyed in large view. The various applications are discussed, on recent advancement in aerospace, automotive and ship building.

3. OBJECTIVES

The Friction Stir welding of AA3103 is carried out to achieve some of the objectives like:

- To develop experimental setup of friction stir welding.
- To design and develop friction stir welding tools with different profiles for processing on AA3103 alloy.
- To study effect of process parameter on mechanical properties of FSW.
- To study material flow and weld structure by microstructure analysis of FSW weld.
- To avoid the health hazards occurred in fusion welding and minimize operation cost also Obtain the better welding strength and minimize defects.
- To increase the economic and technical beneficiary of friction stir welded Joints.

These objectives can be achieved by doing the trial test with all available operation Facilities like machines, tools etc. Due to that the cost may be decreased. Also the joint can obtain the good strength than the other processes of joining.

4. PROBLEM STATEMENT

Reviewing all the available information or literature regarding friction stir welding of aluminium alloys, the experimental study of friction stir welding of aluminium alloy (AA3103) is selected for the experimentation and study. The study can be done by using various types of parameters by keeping any one parameter constant. The tests carried out on the welding samples are:

- Effect of welding on strength and microstructure of the material.
- Heat affected zone of FSW of AA3103.
- Various tests carried out on the welding joint.

5. DESIGN OF TOOL

In the main part of experimentation of FSW of AA3103 the design of tool and material selection are very important. This section includes the tool selection i.e. the tool geometry and material selection for the tool. All parameters related to the process are mainly of aligned with the tool. The detailed information regarding to this is as:

The tool of the FSW consists of the two parts as tool shoulder and tool pin or probe. The Tool shoulder dimension can be selected on the basis of the material of the specimen to be welded. Tool geometry affects the heat generation rate, transverse force and torque and thermo mechanical environment experienced by tool.

The tool design consists of the two Main dimensions as tool shoulder diameter and length and tool pin or probe dimensions. The more diameter of the tool shoulder gives more area to welding process; also helpful to Maintain the pressure on the workpiece in case of the two plates to be welded. After the entry of the pin in the workpiece the shoulder is the major part of becoming heated rapidly. Another important part of the tool is pin or probe of the tool. The pin or probe of the tool or friction stirring probe can produce deformational and frictional heating. Ideally, it is designed to disrupt the contacting surfaces of the workpiece, shear the material in front of the tool and move the material behind the tool. The depth of deformation and tool travel Speed are mainly governed by the probe. Main feature is the end shape of the probe is either flat or domed. The flat bottom probe design and manufacture is currently the most commonly used form. The main disadvantage of the flat probe is the high force during plunging. In contrast, a round or domed end shape can reduce the forge force and tool wear upon plunging, increase tool life by eliminating local stress concentration and improve the quality of the weld root directly at the bottom of the probe.

Contact of the pin with the workpiece creates frictional and deformational heating and softens the workpiece material; contacting the shoulder to the workpiece increases the workpiece heating, expands the zone of softened material, and constrains the deformed material. The shape of the tool pin influences the flow of plasticized material and affects weld properties. The tool shoulder facilitated bulk material flow the pin aided a layer by layer material flow. A triangular or trifluted tool pin increases the material flow compared with a cylindrical Pin. The axial force on the workpiece material and the flow of material near the tool are affected by the orientation of threads on the pin surface. With compared to the computed material flow fields resulting from the use of a triangular tool with convex surfaces and a trifluted tool and suggested that the later increased the downward force due to its strong mixing action.

Features such as threads and flutes on the pin are believed to increase heat generation rate due to larger interfacial Area, improve material flow and affect the axial and transverse forces. With use of various Tools shapes circular without thread, circular with thread, triangular and square. The square probe resulted in more homogeneous distribution of particles than the other tools whereas circular tool experienced much less wear primarily used for the FSW of the number of materials such as from soft materials like aluminium to the hard materials like steels these shapes includes cylindrical, conical, tapered structures with number of types of the pin end surfaces are made to have better effect of mixing the material while the process.

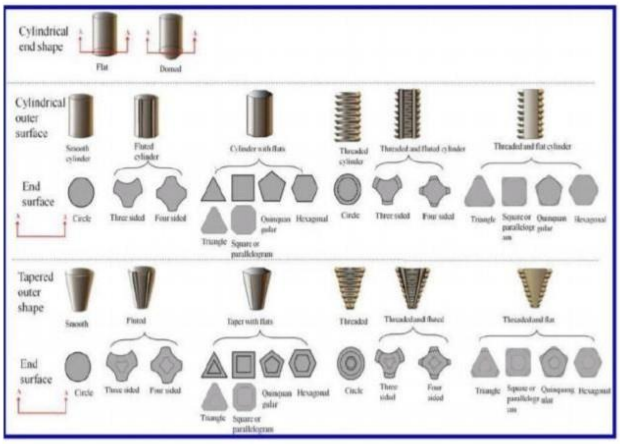

Fig 5.1 FSW tools probe

On this review of the tool geometries given in above figure we select the straight cylindrical threaded tool for the FSW process. The Flat-bottom cylindrical pin is selected in which friction velocity of a rotating cylinder increases from zero at the center of the cylinder to a maximum value at the edge of the cylinder. The local velocity coupled with the friction coefficient between the pin and the metal dictates the deformation during friction stirring. The tool we selected can be easily be made on lathe machine and can be used for the process.

Fig. 5.2 FSW tools with different diameters

Normally the selected structure of the tool becomes harder to insert in to the plate. So, minute taper is given at the flat bottom of the tool to minimize the starting oppose from the workpiece. Due to this taper the entry of the tool get easily in to the workpiece as per the number of structures of the tool probes can be selected for better mixing of the material in the weld region of the plates. The tool pin gone through the major stress and under the effect of heat generation while the process. So the material of the tool should be compatible with that. The parameters are select on the basis of some literature review and trial and error method. The trial on the desired conventional milling machine has been taken and then the parameters required for 3 mm thick AA3103 samples were decide.

- **Material selection for tool**

Table 5.1 Tool materials and Suitable weld metals

Sr No	Tool Material	Suitable weld material
1	Tool steels	Al alloys, copper alloys
2	WC -Co	Aluminium alloys, mild steel
3	Ni-Alloys	Copper alloys
4	WC composite	Aluminium alloys, low alloy steel and magnesium alloys, Ti-alloys
5	W-alloys	Titanium alloys, stainless steel and copper alloys
6	PCBN	Copper alloys, stainless steels and nickel alloys

The table 5.1 shows the some of tool materials are to be used for suitable weld materials. Generally tool steel is one of the most commonly used tool material in the welding process of aluminium, copper and magnesium alloys. These materials are easily available and have good machinability and thermal fatigue resistance. Tool steels have a resistance to damage from abrasion and deformation in the FSW of aluminium alloys. Tool steels can be used to weld both similar and dissimilar materials as lapped joints or butt joints. There are some of tool steels used generally for aluminium alloys are High Carbon High Chromium (HCHCr) tool steels has a very high tool wear resistance available in various tool steel grades.

6. EXPERIMENTS OF FSW ON AA3103

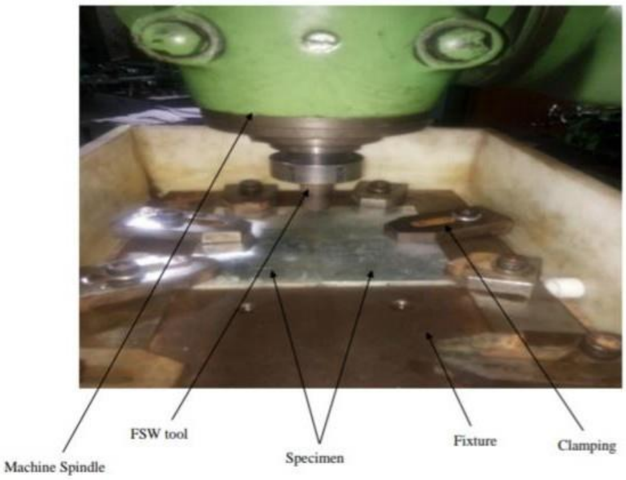

Fig. 6.1 Construction of setup

In the experimentation of FSW of the selected aluminium alloy i.e. AA3103 the test setup is establish and conduct the trials on the set up. One of the important aspects of friction Stir welding process is the utilization of readily available machines and tools such as Conventional milling machine and use of inexpensive tool for producing the welded joint. The detailed view of experimentation is as:

In this work, friction stir welding of AA3103 is developed in a conventional milling machine with a vertical head attachment to accommodate the high spindle speeds. The use milling machine has manual and automatic feed system in which manual feed is used for the trials. The conventional milling machine with vertical spindle attachment is used for the experimentation of the FSW of AA3103. The machine conditions are check before starting the trial. The fixture mount on the table for the fixing the plates of alloys. The Specimen can be mounting in the fixture to avoid the movement of the plates along the transverse or cross transverse direction. The plates of alloys are set for the pre testing arrangement of the machine. The height and distance between the spindle or tool can be adjusted to from the plate surface with the help of three handles or wheels as knee elevating handle, table transverse handle and table cross transverse handle. With the help of these three handle the plate or specimen can be brought to the desire height or position we want.

7. CONCLUSION

The experimentation of friction stir welding of AA3103 is conducted on milling machine to vertical spindle attachment is used for the trials. Due to conduction of the trial on this machine the cost of the process get minimize. The welding joint trials of this aluminium alloy is carried out and the testing of those joints will be done for checking of the weld quality by the factors like cracks, porosity, blow holes; also the effect of heat on the grain structure of the weld material. These tests are shown the process capability of the milling machine towards the FSW of the desired material. It can also have many advantages over the other traditional processes like fusion welding, TIG welding etc. Also it can be used in many fields to avoid the defects generated in the fusion welding method with better weld quality and strength too. For these various issues we are trying this process FSW for the aluminium alloy (AA3103) and achieve some objectives.

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BIOGRAPHIES

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