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Modeling of Friction Stir Welding on Conventional Vertical Milling Machine and its Validation

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Abstract

Friction stir welding(FSW) is a solid state welding technique, it uses a rotating tool to generate the necessary heat for the process. FSW is initially used to weld aluminium and its alloys because the defects like porosity, alloy segregation, hot cracking, hydrogen entrapment etc. are not encountered with this process those are mainly appeared in fusion welding processes [1]. Process uses a non consumable rotating tool which slides along with rotation on the faying surface of work-pieces to be weld. To obtain the desired strength, it is essential to have complete control over the relevant process parameters on which the quality of a weldment is based. The process was duly named friction stir welding (FSW), and TWI filed for world-wide patent protection in December of 1991 by TWI. TWI (The Welding Institute) is a world famous institute in the UK that specializes in materials joining technology. Many of the typical problems related to fusion welding of aluminium alloys can be avoided by using non conventional joining techniques. Since FSW is governed by two completely mechanical processes, i.e. mixing and forging, it is possible to join heterogeneous aluminium alloys without filler metal. Using specially designed tools and machines up to 75mm of aluminium can be welded in a single pass. This paper describes a low-cost method of transforming a conventional milling machine into a simple FSW work station It is also a cleaner and more efficient process compared to conventional technique.

Keywords: FSW, milling machine, rotational speed, welding speed and frictional heat, Aluminum alloys.

Introduction

Friction stir welding (FSW) process was invented at The Welding Institute (TWI), UK in 1991. FSW is initially used to weld aluminium and its alloys because the defects like porosity, alloy segregation, hot cracking, hydrogen entrapment etc. are not encountered with this process those are mainly appeared in fusion welding processes. Process uses a non consumable rotating tool which slides along withrotation on the faying surface of work-pieces to be weld. To obtain the desired strength, it is essential to have complete control over the relevant process parameters on which the quality of a weldment is based. FSW arrangement can made on conventional milling machine, by making a friction stir welding tool and mounting it in the spindle of conventional milling machine.we have manufactured a FSW tool for a 6mm thickness aluminium plate, whose probe length is 5.2mm ,probe diameter is 6mm and tool shoulder diameter is 18mm.

Materials and methods

Material for tool and workpieces

1. We have selected high carbon steel as the material for tool manufacturing. Because of following reasons.
   - It retains its properties at elevated temperature.
   - Good machinablity.
   - Less wear.
   - Having long life.

2. We have selected aluminium for FSW, due to following reasons.
   - It is a soft material.
   - Welding of aluminium by conventional methods leads to hot cracking.
   - It is widely used material in many industries like shipbuilding, aircraft industry, construction industries.

Method:-

We are converting the conventional vertical milling machine to a mini workstation for FSW here. We made a FSW tool according to the thickness of

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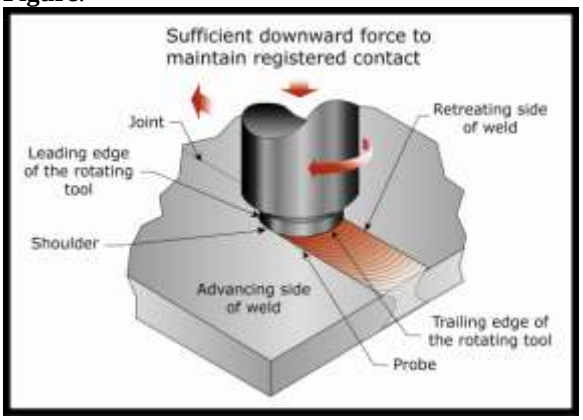
workpieces (i.e. 6mm), and all the dimensions of FSW tool are shown in the table 1 given below.

Table 1

Diameter of probe	6mm
Length of probe	5.2mm
Tool shoulder diameter	18mm.
Tool end diameter(same as attachment of milling machine	16mm

We have first prepared the faying surfaces of aluminium to be joined then a cylindrical, shouldered tool with a profiled probe is rotated and slowly plunged into the joint line between two pieces butted together. The parts have to be clamped onto a backing bar in a manner that prevents the abutting joint faces from being forced apart. Frictional heat is generated between the wear resistant welding tool and the material of the work pieces. This heat causes the latter to soften without reaching the melting point and allows traversing of the tool along the weld line. The maximum temperature reached is of the order of 0.8 of the melting temperature of the material, after one pass of FSW tool I will be ejected out from the work pieces.

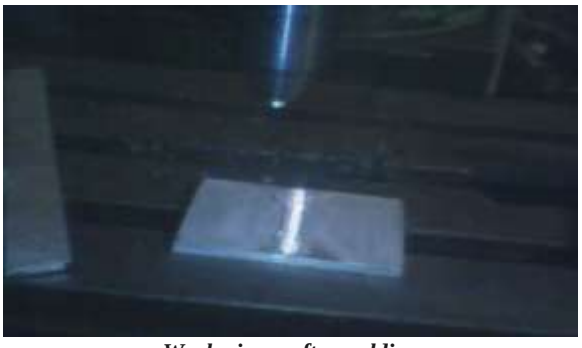
Figure:



FSW process

FSW tool

Work pieces before welding



Work pieces after welding

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FSW weldment

Results and discussion

We have prepared a sound weld at 1170rpm rotational speed and at 30mm/min. transverse speed on conventional vertical milling machine. And weldment is having a weld strength of 220mpa while the ultimate tensile strength of aluminium is 310mpa which means the efficiency of our FSW weld is about 70%. And no any evidence of hot cracking is there, hence it is a best method/ technique of joining aluminium.

Formulae:

D/d=3

where,

D =diameter of tool shoulder.

d=diameter of tool probe.

Tables:

Table 2 parameters for FSW

Rotational speed(rpm)	1170
Transverse(welding) speed	30mm/min.

Conclusion

Friction stir welding can be done on a conventional vertical milling machine with the help of a FSW tool which is made up of high carbon steel, with proper clamping arrangements.

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