DESIGN AND EXPERIMENTAL INVESTIGATIONS OF FRICTION STIRR WELDING

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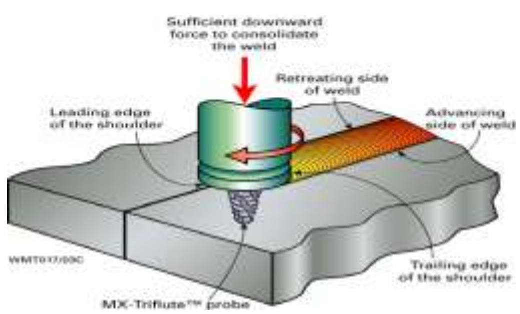
Abstract: Friction Stir Welding (FSW), invented by Wayne Thomas at TWI Ltd in 1991, overcomes many of the problems associated with traditional joining techniques. FSW is a solid-state process which produces welds of high quality in difficult-to-weld materials such as aluminum, and is fast becoming the process of choice for manufacturing lightweight transport structures such as boats, trains and aero planes. FEA analysis will be performed for friction stir welding of aluminum 5083 and aluminum 7475 at different speeds using ANSYS. Coupled field analysis, thermal and structural will be performed. A parametric model with the weld plates and cutting tool will be done in Pro/Engineer. The speeds are 800rpm, 650rpm and 450rpm. The effects of different tool pin profiles on the friction stir welding will also be considered for analysis. Tool pin profiles are circular. A parametric analysis has been carried out in order to examine the temperature distribution along the weld aluminum plates. The two process parameters i.e. Transverse speed and rotational speed are varied and the temperature profile are drawn and compared with experimental work. In additional to this the effect of these parameters on heat loss has also been scrutinized which facilitates in optimizing FSW process.

Key words: Friction stirr welding, aluminum alloy plates, speed, pin profile.

I. INTRODUCTION

Friction Stir Welding is the most recent upgrade to the Space Shuttle's gigantic External Tank, the largest element of the Space Shuttle and the only element not reusable. The new welding technique—being marketed to industry—utilizes frictional heating combined with forging pressure to produce high-strength bonds virtually free of defects. Friction Stir Welding transforms the metals from a solid state into a "plastic-like" state, and then mechanically stirs the materials together under pressure to form a welded joint. Invented and patented by The Welding Institute, a British research and technology organization, the process is applicable to aerospace, shipbuilding, aircraft and automotive industries. One of the key benefits of this new technology is that it allows welds to be made on aluminum alloys that cannot be readily fusion arc welded, the traditional method of welding.



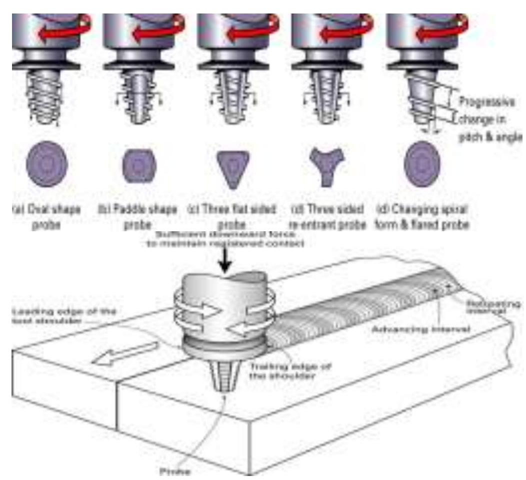
The principle of Friction Stir Welding

By keeping the tool rotating and moving it along the seam 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 aluminum, 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 aluminum. Since its conception in 1991 there have been considerable advances in process technology and there are now over 135 licensees of the process and over 1500 subsidiary patents have been filed. This paper will concentrate on improvements for tooling for the friction stir welding of aluminum alloys.

TOOL DESIGN

Tools consist of a shoulder and a probe which can be integral with the Shoulder or as a separate insert possibly of a different material. The design of the shoulder and of the probe is very important for the quality of the weld. The probe of the tool generates the heat and stirs the material being welded but the shoulder also plays an important part by providing additional frictional treatment as well as preventing the plasticized material from escaping from the weld region. The plasticized material is extruded from the leading to the trailing side of the tool but is trapped by the shoulder which moves along the weld to produce a smooth surface finish. Clearly, different materials and different thicknesses will require different profile probes and welds can be produced from just one side or by welding half the thickness then turning over to complete the other side. Some typical Whorl™ type probes are shown in

Fig 52 which can be designed to weld in excess of 60mm thick plate at higher speeds than conventional pin type probes.



PROBLEM DESCRIPTION

The objective of the present research is to develop a finite element simulation with improved capability to predict temperature evolution in aluminum alloys and to determine the optimal weld parameters using trend line equation. Experiments have been conducted on the AA5083 Aluminum alloy in a vertical axis CNC milling machine by programming . The peak temperature attained during Friction stir welding process along the direction of the weld line and the temperature perpendicular to the weld line from maximum temperature point are measured. Comparison is made between theoretical values from ANSYS and experimental values.

METHODOLOGY

- In this work frictional stir welded Aluminium 5083, Pure Aluminium7475 specimens are compared for mechanical properties. In this study FSW specimens are prepared at 11mm/min feed rate and The speeds are 800rpm, 650rpm and 450rpm.feed rate: 11mm/min
- In this experiment plate size of aluminium and copper are same and having 100 mm length, 50 mm width and 5 mm thickness. H13 material is used to manufacture the tools. Tool has pin diameter of 6 millimetre size. Tool dimensions: Shoulder Diameter-18mm, Pin Diameter 6mm
- Experiment Design Following are materials and parameters used for experiment Material: Aluminium 5083, Pure Aluminium7475 Thickness: 5mm Tool: Cylindrical Spindle Speed: The speeds are 800rpm, 650rpm and 450rpm.feed rate: 11mm/min.
- The 3D modeling of FSW is designed in Pro/Engineer.
- In static analysis, to determine the stress, strain and deformation.
- In thermal analysis, to determine the temperature distribution and heat flux

INTRODUCTION TO CAD

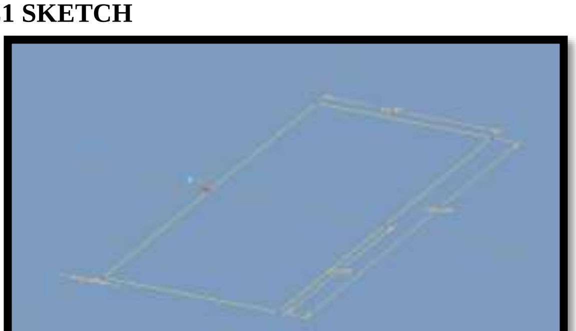
Computer-aided design (**CAD**), also known as **computer-aided design and drafting** (**CADD**), is the use of computer technology for the process of design and design-documentation. Computer Aided Drafting describes the process of drafting with a computer. CADD software, or environments, provide the user with input-tools for the purpose of streamlining design processes; drafting, documentation, and manufacturing processes.

INTRODUCTION TO PRO/ENGINEER

Pro/ENGINEER Wildfire is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated Pro/ENGINEER CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products.

MODELS OF COMPONENTS

PLATE1 SKETCH



EXTRUDE PART

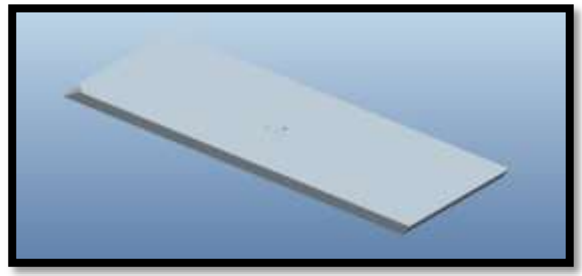
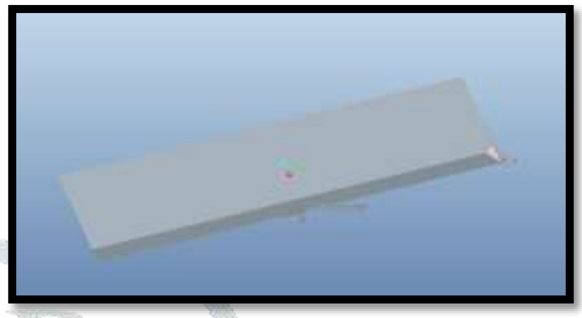
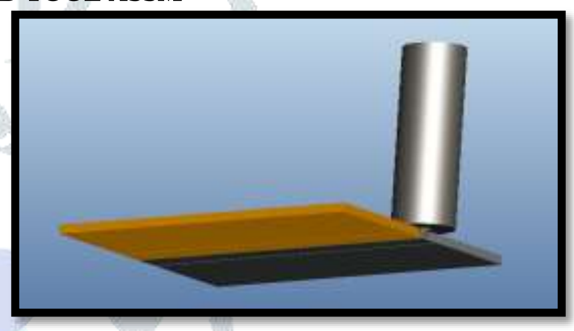


PLATE2



ROUND TOOL ASSM



INTRODUCTION TO ANSYS

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated, or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.

EXPERIMENTAL INVESTIGATION

Experimental investigation is done to verify the mechanical properties of friction stir welding of aluminum alloy 5083 and aluminum 7475. The properties investigated are tensile strength and hardness compared before and after welding.

The welding is done on Vertical CNC machine.

TOOL	SPEED (rpm)
circular	800
	650
	450

In this work, the process was done using a vertical milling machine having automatic feed. The tool rotational speeds and the feeds were set accordingly and the respective experiments were conducted. The tool rotational speeds considered were 450,650 and 800rpm's and the feed rate considered is 20 mm/min respectively.

Machine used for Friction Stir Welding

Machine Specifications

- Motor Capacity-7.5 HP
- Rotation Speed- 35 to 800rpm
- Feed Rate-16 to 800 mm/min.
- Make –HMT
- Bed length 1000*400*450 mm

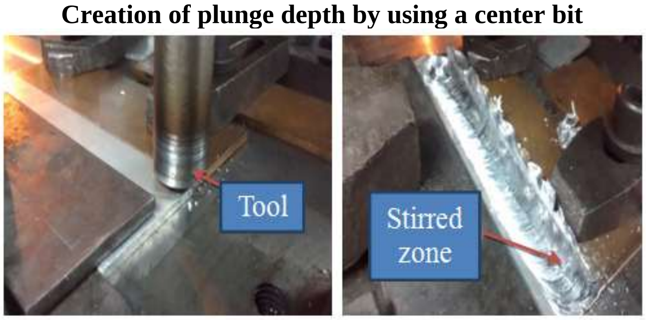
The Tool

Tool steel refers to a variety of carbon and alloy steels that are particularly well-suited to be made into tools. Their suitability comes from their distinctive hardness, resistance to abrasion and deformation and their ability to hold a cutting edge at elevated temperatures. As a result tool steels are suited for their use in the shaping of other materials.

Process

The dimensions of the plates taken were 100*50*5 mm. They were cut into the desired size by shearing process. Both plates were clamped to the machine bed. Plunge depth was given by a center bit at the place of joining of the plates and a hole was created for the tool to traverse on the plates to be friction stir welded. After the hole has been created, tool is passed on the intersection of the two plates by applying pressure on the plates by using the tool shoulder. Tool is moved on to the other side of the weld by automatic feeds. After the tool has been inserted, sometime is given for the friction to develop and the material to get heated up to the red hot condition of the plates. This time is called as time of indentation. Generally it is taken as 5 to 8 seconds. After the tool reaches the other side, the plates are said to be friction stir welded.

Creation of plunge depth by using a center bit



Tool inserted and the stir zone after FSW process

Friction stir welded plates

TEST RESULTS

test	Sample 1	Sample 2	Sample3	Average
Tensile	112.805N/ mm2	114.686N/ mm2	101.618N/ mm2	261.3636N/ mm2
Impact	32	0	0	32
Hardn ess	47.5	47.9	48.3	47.90

CONCLUSION

In this project cutting tool taper is designed for doing Friction Stir Welding of two dissimilar materials Aluminum alloy 7475 and aluminum alloy5083 running at speeds of 450,650 & 800rpm. Modeling is done in Pro/Engineer. Structural analysis is performed on the circular tool to verify the deformation and stresses. By observing the results, stresses values are increases by increasing the speeds. Two plates of the aluminum alloy 7475 and aluminum alloy 5083 are welded experimentally on a vertical CNC machine using 800rpm speed for circular cutting tool. Tensile strength, impact and hardness are evaluated after welding. By observing the tensile test results, ultimate tensile strength values are increases by increasing the speeds. By observing the hardness test results, when speed will increases than hardness will decreases. By observing the impact test results the impact more at high speed that is 32 joules. So it can be concluded the cutting tool speed 800 rpm is the better.

REFERENCES

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