DESIGN AND WELD CHARACTERSTICS OF FRICTION STIR WELDING FOR DIFFERENT SPEEDS FOR DISSIMILAR MATERIALS

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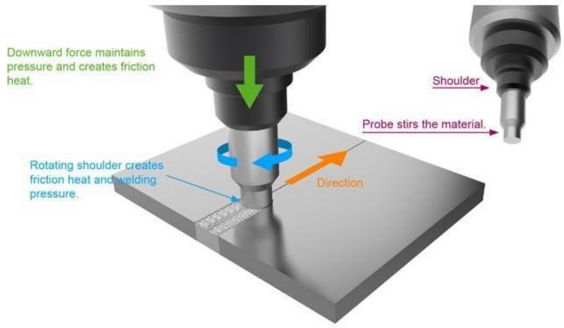
Abstract: This is to show that the FEA analysis here will be performed for friction stir welding of Aluminum alloy 6063 and AA7072 at different Speeds using Deform-3D. For this analysis, the effects of different speeds for the friction stir welding will be considered and the Tool pin profile is the taper. In this project, the experimentation is carried out at Taper tool pin profile and workpiece materials are Aluminum alloy 6063 and AA7072. The tool material is HCHCr (high chromium high carbon steel). This project evaluates the mechanical properties such as tensile strength, hardness, impact strength, and microstructure.

Introduction

Friction stir welding (FSW) is defined as a solid-state joining process which means that no molten state is included in assembling or welding the respective workpiece. The technique is well known for saving energy and is eco-friendly. This joining technique is mostly used to weld aluminum materials in the automobile and aerospace industries. The FSW procedure in which a tool is used in joining the workpiece and is not consumed so is called a non-consumable tool. A non-consumable spinning tool which is having a pin and a shoulder that is inserted into the adjacent edges of sheets or plates to be joined and moved along the line of joint till the end. This process is considered to be the most noteworthy development in the metal joining process. Also known as a "green" technology due to its energy efficiency, atmosphere friendliness, etc.

Principle

A non-consumable tool is used to join collected metal sheets which are made up of a pin and shoulder. This tool is used in Friction stir welding and is having two different functions one of which the workpiece is heated to a temperature in which it is not molten but melted plastically and the other function is to weld the workpiece it moves along the edges of the workpiece so that it is combined. The friction between the tool and the workpiece is the heating achieved by friction between the tool and the workpiece and because of the plastic deformation of the workpiece. The restricted heating softens the material around the pin and shoulder. The tool rotation leads to the movement of material from the front of the pin to the back of the pin and this completes the welding and a strong solid-state joint will be ready.



LITERATURE REVIEW

Sahu and Pal [1] were carried out experiments by using Taguchi's L18 factorial design of the experiment. Grey rational analysis was used for optimizing process parameters. The Percentage effect of an individual process parameter is measured on the weld quality. They used AM20 Magnesium alloy to form square but joint Process parameters were used for tool rotation speed, welding speed, shoulder diameter, and plunge depth. To discover ultimate tensile strength and to yield the strength, welding tensile test is calculated. yield strength is considered when the material is used in the final product, so that the material doesn't deform plastically and remain within the elastic regime. Ultimate tensile strength is considered during material forming and processing, so that the material is in the flow regime and doesn't cross the necking point. The optimized process parameters were found to be plunge depth at 0.12 mm, welding speed at 98 mm/min, rotational speed at 1100 rev/min, and shoulder diameter at 24 mm.

Pankaj Neoget al. [2] were conducted welding on a 6.35 mm thick plate of AA6063-T6 alloy using the friction stir welding technique. The square-groove is a butt-welding joint with the two pieces being flat and parallel to each other. This joint is simple to prepare, economical to use, and provides satisfactory strength, but is limited by joint thickness. Friction stir welding is one of the recent solid-state joining processes that has drawn the attention of the metal joining community. In this work the effects of tool rotation speed (TRS) and welding speed (WS) on the tensile strength of dissimilar friction stir welded AA6063-AA7072 joints are investigated. Response surface methodology is used for developing a mathematical model for the tensile strength of the dissimilar aluminum alloy joints. The model is used to investigate the effect of TRS and WS on the tensile strength of the joints. It is seen that the tensile strength of the joint increases with the increase in TRS up to a limit of 1050 rpm and decreases thereafter. T The relationship between the load and tensile strength is positive the tensile strength is increased along with the axial load increase.

E. Fereiduniet al. [3] used the effect of the rotational speed and dwell time on the joint interface microstructure and tensile-shear strength of friction stir spot welded Al-5083 aluminum/St-12 steel alloy sheets were investigated. Joining of the sheets was performed using an alternative friction stir spot welding (FSSW) process in which the welding tool tip did not penetrate. To weld the material Rotational speeds of 900 and 1100 rpm were used with dwell times of 5, 7, 10, 12, and 15 seconds. Then tensile and shear tests are carried out on three specimens for each processing condition and the average values were recorded. They found that joint strength increases up to a certain limit as dwell time increases and then starts declining.

OBJECTIVE AND METHODOLOGY

The objective of the present research is to develop a finite element analysis with improved capability to predict strength evolution in aluminum alloys 70705&7072.to determine the optimal weld parameters using FEA and experimentally. Experiments have been conducted on the AA7072 and AA6063 in a vertical axis CNC milling machine by programming at different cutting tools (round, taper, and hexagonal). This project investigates the mechanical properties such as tensile, hardness, and microstructure.

METHODOLOGY

• In this work frictional stir welded Pure AA7072 and AA6063 specimens are compared for mechanical properties. In this study FSW specimens are prepared at an 11mm/min feed rate and speeds are 850rpm.
• In this experiment plate size of aluminum and copper are same and having 160 mm length, 110 mm width and 5 mm thickness. H13 tool steel material is used to manufacture the tools. The tool has a pin diameter of 6-millimeter size. Tool dimensions: Shoulder Diameter-18mm and Pin Diameter 6mm
• The 3D modelling of FSW is designed in CREO.
• In static analysis, to determine the stress, strain and deformation.
In the thermal analysis, to determine the temperature distribution and heat flux.

MATERIALS AND RESPONSES

In this project we are taken workpiece materials are aluminum alloy 7072 and aluminum alloy 6063 and tool material is HCHCr (High Carbon High Chromium steel)
AA7072:7072 Aluminum plate is a precipitation-hardened aluminum alloy containing magnesium and silicon as its major alloying elements. 7072 aluminum plate is one of the most adaptable of the heat-treatable alloys. Also, 7072 is popular for its medium to high strength requirements, good toughness and excellent corrosion resistance

AA6063:6063 is an aluminum alloy with zinc as the primary alloying element. It is strong when the strength is comparable to many steels, and has good fatigue strength and typical machinability, but has less resistance to corrosion than many other Al alloys. 6063 is widely used in mold tool manufacture due to its high strength, low density, thermal properties and its ability to be highly polished.

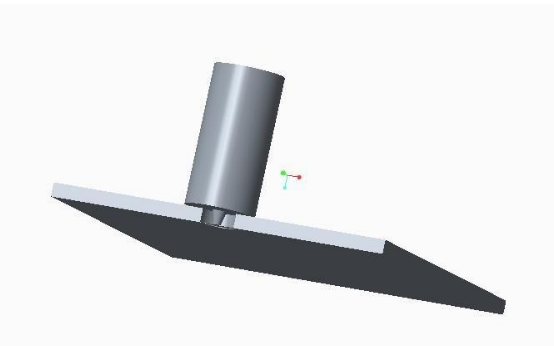
HCHCr: D3 Steel Having 12 % ledeburite chromium tool steel with great wears resistance. Essentially, utilized as cutting tools for sheets up to 4 mm thickness, trimming dies, blanking dies for paper and plastics, shear cutting edges, and rotational shear edges for sheet thicknesses up to 2 mm.

Tensile test: Tensile testing, which is also known as tension testing is a fundamental materials science and engineering test in which a sample is subjected to a controlled tension until it is a failure. Properties that are directly-measured through a tensile test are ultimate tensile strength, breaking strength, maximum elongation and decrease in area. The following properties can also be determined: Young's modulus, Poisson's ratio, yield strength, and strain-hardening characteristics from these measurements

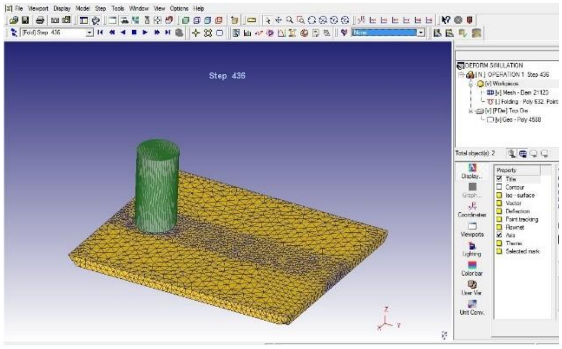
Brinell hardness (BH) test

Method of measuring the hardness of a material by pressing a chromium-steel or tungsten-carbide ball (commonly one centimeter or 0.4 inch in diameter) against the smooth material surface under standard test conditions (such as between 300 to 3000 kilograms of force for 5 to 30 seconds). Here the hardness is expressed as Brinell Hardness Number (BHN) which is computed by dividing the load in kilograms by the area of an indentation that is made by the ball measured in square millimeters.

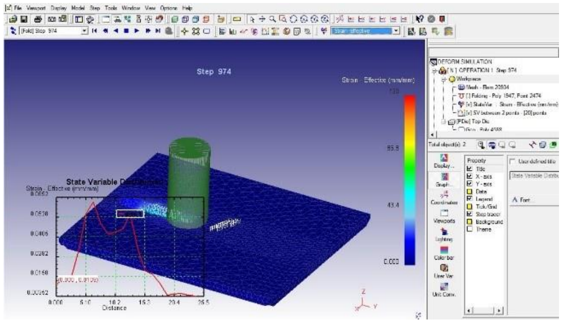
SEM: A normal scanning electron microscope operates at a high vacuum. Here a beam of electrons is generated by a suitable source, typically a tungsten filament or a field emission gun is a basic principle. The electron beam is thoroughly accelerated through a high voltage (e.g.: 20 kV) and is passed through a system of apertures and electromagnetic lenses to produce a thin beam of electrons and then the beam scans the surface of the specimen utilizing scan coils (like the spot in a cathode-ray tube "old-style "television).



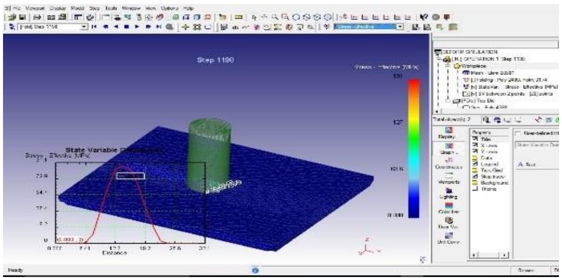
1Taper tool Assembly

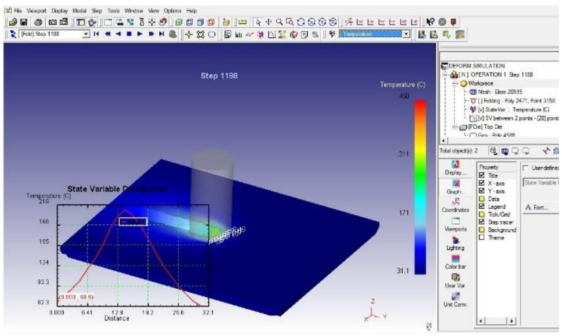


2SHEER STRESS



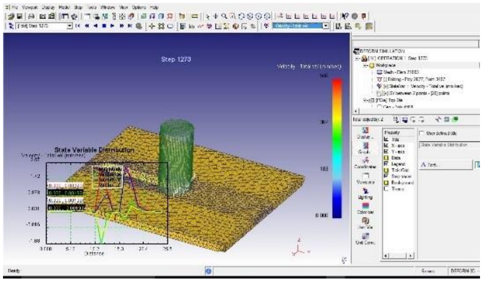
3STRESS





4TEMPERATURE DISTRIBUTION

TOOL	TOOL ROTATIONAL SPEED (rpm)	TOOL TRANSVERSE SPEED (mm/min)
	760	11,25
TAPER	1130	11,25
	1340	11,25



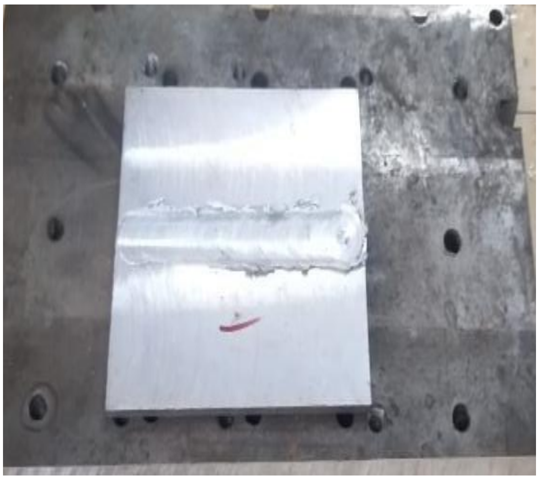
EXPERIMENTAL INVESTIGATION

Experimental investigation is done to verify the mechanical properties of friction stir welding of aluminum alloy 6063and AA 7072. The properties investigated are tensile strength micro structure and hardness compared after welding.

On the Vertical CNC machine, the welding is done.

EXPERIMENTAL PHOTOS

In this work, the process was done using a vertical milling machine which is having automatic feed. The respective experiments were conducted by the tool rotational speeds and the feeds that were set accordingly and the tool profiles are considered as Circular, hexagonal and Taper.

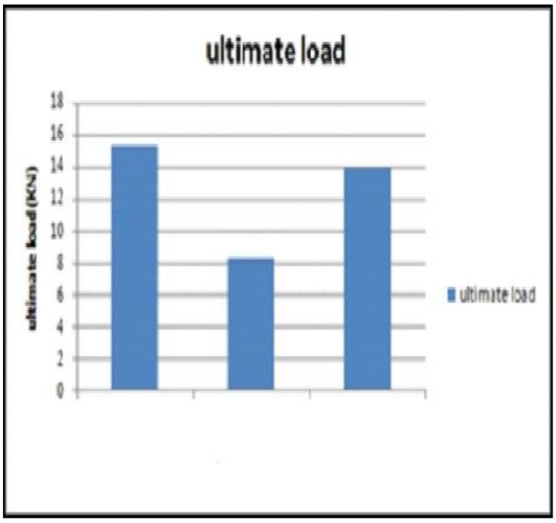


RESULTS AND DISCUSSIONS

Hardness test results

The hardness of the weld joins and then composites was evaluated using Hardness Testing Machine, Mitutoya, Model of Japan with the no HM113 with HV 0.05 load and diamond indenter is used. The indentation time for hardness measurement is 15 seconds. An average of three readings are taken for each hardness value and were considered for plotting the graph as shown in the respective Figure

Tensile Test



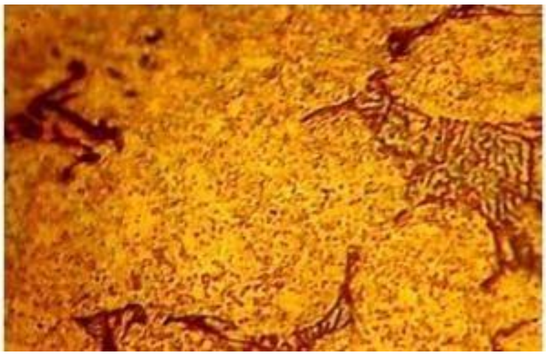
According to the plot, the ultimate load increases at hexagon tool profile compared to other two tool profiles.

METALLOGRAPHIC ANALYSIS

Here optical and scanning electron microscopy (SEM) is used for the inspection where Metallographic weld specimens were cut, mounted, polished and examined. SEM microscope that is used here was a JEOL JSM-6460 which is equipped with Oxford Instruments INCA-350 energy-dispersive spectroscopy system.

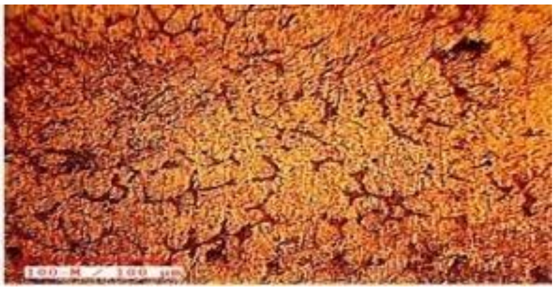
Sample 1-hexagonal tool

Sl.no	Thickness of the plate(mm)	Tool rotational speed(rpm)	Tool transverse speed(mm/min)	Breaking Zone	Weld Quality
1	6	760	11	Middle of the weld zone	Poor
2	6	760	25	Middle of the weld zone	Poor
3	6	1130	11	Outside the weld zone	Good
4	6	1130	25	Outside the weld zone	Good
5	6	1340	11	Outside the weld zone	Good
6	6	1340	25	Middle of the weld zone	Poor



Sample -2-taper tool

Sample-3-round tool



Micro structure of a prepared surface specimen tested by inverted metallurgical microscope range of 25X -500X magnification. Micro structure of polished surface resulted cluster formation of reinforcement particles as shown in the sample 1. Clear identification of non-metallic particles distribution in between metallic particles resulted by etching process as shown in the sample -2. The formation of dendritic structure resulted by solidification process observed before heat treatment of weld zone.

CONCLUSION

In this project different cutting tool pin profiles is designed for doing Friction Stir Welding of two dissimilar materials Aluminum alloy 6063 and AA7072 running at speeds 850rpm. Modelling is done in CREO.

Structural analysis is performed on the different tool pin profiles to verify the deformation and stresses.

Thermal analysis to determine the temperature distribution and heat flux.

By observing the static analysis results, stresses values are decreases at hexagonal tool pin profile.

By observing the thermal analysis, the temperature values reduce at hexagonal tool pin profile compared other tool pin profiles.

In this thesis, two plates of the Aluminum alloy 6063 and AA7072 are welded experimentally on a vertical CNC machine using 850rpm speed for cutting tool. Tensile strength, microstructure and hardness are evaluated after welding.

By observing the tensile test results, ultimate tensile strength values are increases by hexagonal tool pin profile.

By observing the hardness test results, hardness values are increases by hexagonal tool at weld zone.

So, it can be concluded the cutting hexagonal tool pin profile is the better.

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