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Analysis of Micro structural Grain Size and Temperature Distribution in Aluminum Alloy 6061 Using Friction Stir Welding

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ABSTRACT: Friction stir welding is a solid state joining and relatively a new welding process that has a significant advantages compared to the fusion welding process such as joining conventionally non fusion weld able alloy, being a solid state joining process it produces weld with reduced distortion and improved mechanical properties. The usage of aluminum alloy are widely used in different industrial application such as ship building, and automobile industries due to their light weight good mechanical strength and high corrosion resistance. The main aim of the project is to optimize the tool profile among the four tool profile in friction stir welding which increase the yield strength and hardness. In this project, the main parameters considered are heat input from the tool shoulder and tool pin. the temperature distribution analysis is carried out using the abacus software. the four work piece are welded with the four different tool pin profile at the speed and feed rate of 1200rpm and 1.25 mm/sec. after welding the work piece, hardness and tensile test are performed to check the strength of the work piece. scanning electron microscope is used to check whether any defects and porosity in the work piece after welding

I. INTRODUCTION TO WELDING

1.1 WELDING

Welding is a process of joining two metals pieces by the application of heat. Welding is the least expensive process and widely used now a days in fabrication. Welding joints different metals with the help of a number of processes in which heat is supplied either electrically or by means of a gas torch. Different welding processes are used in the manufacturing of auto mobile bodies, structural works, tanks and general machine repair work. In the industries, welding is used in the refineries and pipeline fabrication. It may be called as a secondary manufacturing process.

1.2 TYPES OF WELDING

There are 35 different types of welding process and several soldering methods, which are used in the industries today. There are various ways of classifying the welding for example, they may be classified on the basic of source of heat (flames, arc etc). In the general various welding processes are classified as follows.

Gas welding
Arc welding
Resistance welding
Solid state welding
Thermo chemical welding
Radiant welding
Fusion welding

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II. LITERATURE REVIEW

2.1 FRICTION STIR WELDING PROCESS, AUTOMATION AND CONTROL
B.T. GIBSON D.H. LAMMLEIN T.J. PRATER This article provides an introduction to the basic principles of friction stir welding (FSW) as well as a survey of the latest research and applications in the field. The basic principles covered include terminology, material flow, joint configurations, tool design, materials, and defects. Material flow is discussed from both an experimental and a modeling perspective. Process variants are discussed as well, which include self-reacting (SR-FSW), stationary shoulder, friction stir processing (FSP), friction stir spot welding (FSSW), assisted FSW, and pulsed FSW. Multiple aspects of robotic friction stir welding are covered, including sensing, control, and joint tracking. Methods of evaluating weld quality are surveyed as well. The latest applications are discussed, with an emphasis on recent advances in aerospace, automotive, and ship building. Finally, the direction of future research and potential applications are examined.

2.2 FRICTION-STIR DISSIMILAR WELDING OF ALUMINIUM ALLOY TO HIGH STRENGTH STEELS: MECHANICAL PROPERTIES AND THEIR RELATION TO MICROSTRUCTURE
R.S. COELHO A. KOSTKA J.F. DOS SANTOSA. KAYSSER-PYZALLA The use of light-weight materials for industrial applications is a driving force for the development of joining techniques. Friction stir welding (FSW) inspired joints of dissimilar materials because it does not involve bulk melting of the basic components. Here, two different grades of high strength steel (HSS), with different microstructures and strengths, were joined to AA6181-T4 Al alloy by FSW. The purpose of this study is to clarify the influence of the distinct HSS base material on the joint efficiency. The joints were produced using the same welding parameter/setup and characterized regarding microstructure and mechanical properties. Both joints could be produced without any defects. Microstructure investigations reveal similar microstructure developments in both joints, although there are differences e.g. in the size and amount of detached steel particles in the aluminium alloy . The weld strengths are similar, showing that the joint efficiency depends foremost on the mechanical properties of the heat and the thermo mechanical affected zone of the aluminium alloy.

2.3 FINITE ELEMENT MODELLING OF FRICTION STIR WELDING- THERMAL AND THERMO MECHANICAL ANALYSIS
C.M. CHEN, R. KOVACEVIC In this paper, a three-dimensional model based on finite element analysis is used to study the thermal history and thermo mechanical process in the butt-welding of aluminium alloy 6061-T6. The model incorporates the mechanical reaction of the tool and thermo mechanical process of the welded material. The heat source incorporated in the model involves the friction between the material and the probe and the shoulder. In order to provide a quantitative framework for understanding the dynamics of the FSW thermo mechanical process, the thermal history and the evolution of longitudinal, lateral, and through-thickness stress in the friction stirred weld are simulated numerically.

2.4 PREDICTING TENSILE STRENGTH OF FRICTION STIR WELDED AA6061 ALUMINIUM ALLOY JOINTS BY A MATHEMATICAL MODEL
K. ELANGOVAN, V. BALASUBRAMANIAN S. BABU AA6061 aluminium alloy (Al–Mg–Si alloy) has gathered wide acceptance in the fabrication of light weight structures requiring a high strength-to weight ratio and good corrosion resistance. Compared to the fusion welding processes that are routinely used for joining structural aluminium alloys, friction stir welding (FSW) process is an emerging solid state joining process in which the material that is being welded does not melt and recast. This process uses a non-consumable tool to generate frictional heat in the abutting surfaces. The welding parameters such as tool rotational speed, welding speed, axial force etc., and tool pin profile play a major role in deciding the joint strength. An attempt has been made to develop a mathematical model to predict tensile strength of the friction stir welded AA6061 aluminium alloy by incorporating FSW process parameters. Four factors, five levels central composite design has been used to minimize number of experimental conditions. Response surface method (RSM) has been used to develop the model. Statistical tools such as analysis of variance (ANOVA), student’s t-test, correlation co-efficient etc. have been used to validate the developed model. The developed mathematical model can be effectively used to predict the tensile strength of FSW joints at 95% confidence level.

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2.5 INFLUENCES OF TOOL PIN PROFILE AND TOOL SHOULDER DIAMETER ON THE FORMATION OF FRICTION STIR PROCESSING ZONE IN AA6061 ALUMINIUM ALLOY

K. ELANGOVAN, V. BALASUBRAMANIAN AA6061 aluminium alloy (Al–Mg–Si alloy) has gathered wide acceptance in the fabrication of light weight structures requiring a high strength-to-weight ratio and good corrosion resistance. Compared to the fusion welding processes that are routinely used for joining structural aluminium alloys, friction stir welding (FSW) process is an emerging solid state joining process in which the material that is being welded does not melt and recast. This process uses a non-consumable tool to generate frictional heat in the abutting surfaces. The welding parameters such as tool rotational speed, welding speed, axial force, etc., and tool pin profile play a major role in deciding the weld quality. In this investigation an attempt has been made to understand the effect of tool pin profile and tool shoulder diameter on FSP zone formation in AA6061 aluminium alloy. Five different tool pin profiles (straight cylindrical, tapered cylindrical, threaded cylindrical, triangular and square) with three different shoulder diameters have been used to fabricate the joints.

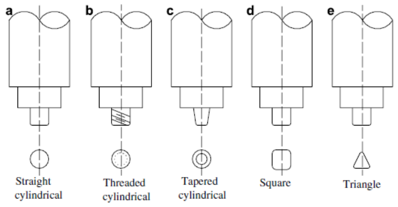

Fig. 5. FSW tool pin profiles.

2.6 MICROSTRUCTURAL EVOLUTION AND MECHANICAL PROPERTIES OF DISSIMILAR AL–CU JOINTS PRODUCED BY FRICTION STIR WELDING

C.W. TAN, Z.G. JIANG L.Q. LI 5A02 aluminum alloy and pure copper were joined by friction stir welding (FSW). A defect-free joint was obtained when one of process parameters, i.e. the traverse speed was lowered from 40 mm/min to 20 mm/min. A good mixing of Al and Cu was observed in the weld nugget zone (WNZ). A large amount of fine Cu particles were dispersed in the upper part of the WNZ producing a composite-like structure. In the lower part, nano-scaled intercalations were observed and identified by transmission electron microscopy (TEM).

2.7 INFLUENCES OF TOOL PIN PROFILE AND WELDING SPEED ON THE FORMATION OF FRICTION STIR PROCESSING ZONE IN AA2219 ALUMINIUM ALLOY

K. ELANGOVAN, V. BALASUBRAMANIAN AA2219 aluminum alloy has gathered wide acceptance in the fabrication of light weight structures requiring a high strength to weight ratio. Compared to the fusion welding processes that are routinely used for joining structural aluminum alloys, friction stir welding (FSW) process is an emerging solid state joining process in which the material that is being welded does not melt and recast. This process uses a non-consumable tool to generate frictional heat in the abutting surfaces. The welding parameters and tool pin profile play major roles in deciding the weld quality. In this investigation, an attempt has been made to understand the effect of welding speed and tool pin profile on FSP zone formation in AA2219 aluminum alloy. Five different tool pin profiles (straight cylindrical, tapered cylindrical, threaded cylindrical, triangular and square) have been used to fabricate the joints at three different welding speeds. The formation of FSP zone has been analyzed macroscopically. Tensile properties of the joints have been evaluated and correlated with the FSP zone formation.

2.8 OUTCOME OF THE LITERATURE SURVEY:

Understanding the principle working process of the friction stir welding and process parameters for the welding.
The dimension of the tool and plate were understand from the papers and according to the machine specification.
Understand the Inputs for the temperature distribution analysis is understand from the paper.
The hardness test is conducted in the Rockwell hardness machine to measure the hardness.
According to the ASTM, the standard dimension for the tensile specimen can be understand and the test performed.

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III. FRICTION STIR WELDING

FRICTION STIR WELDING was invented and experimentally proven by the Wayne Thomas and a team of his colleagues at the welding institution at UK in December 1991.

Friction-stir welding (FSW) is a solid-state joining process (the metal is not melted) that uses a third body tool to join two facing surfaces. Heat is generated between the tool and material which leads to a very soft region near the FSW tool. It then mechanically intermixes the two pieces of metal at the place of the join, then the softened metal (due to the elevated temperature) can be joined using mechanical pressure (which is applied by the tool), much like joining clay, or dough. It is primarily used on aluminium, and most often on extruded aluminum (non-heat treatable alloys), and on structures which need superior weld strength without a post weld heat treatment.

IV. PRINCIPLE OF OPERATION

A constantly rotated non consumable cylindrical-shouldered tool with a profiled probe is transversely fed at a constant rate into a butt joint between two clamped pieces of butted material. The probe is slightly shorter than the weld depth required, with the tool shoulder riding atop the work surface.

Frictional heat is generated between the wear-resistant welding components and the work pieces. This heat, along with that generated by the mechanical mixing process and the adiabatic heat within the material, cause the stirred materials to soften without melting. As the pin is moved forward, a special profile on its leading face forces plasticised material to the rear where clamping force assists in a forged consolidation of the weld.

This process of the tool traversing along the weld line in a plasticised tubular shaft of metal results in severe solid state deformation involving dynamic recrystallization of the base material.

V. EXPERIMENTAL WORK

ROCKWELL HARDNESS TEST

The inventor of the Rockwell hardness test is Stanley P. Rockwell. He was a metallurgist for a large ball bearing company and he wanted a fast non-destructive way to determine if the heat treatment process they were doing on the bearing races was successful. The Rockwell scale is a hardness scale based on indentation hardness of a material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload. There are different scales, denoted by a single letter, that use different loads or indenters. Rockwell and superficial Rockwell hardness are the two types of Rockwell hardness test.

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