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To Study the Mechanical behaviour of Friction Welding of Similar and Dissimilar Material

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Abstract—Friction welding (FW) is a fairly recent technique that utilizes a non-consumable welding tool to generate frictional heat and plastic deformation at the welding location, there by affecting the formation of a joint while the material is in solid state. The principal advantage of frictional welding, being a solid state process, low distortion, absence of melt-related defects and high joint strength, even in those alloys that are that are considered non-weld able by conventional welding techniques. Furthermore, friction welded joints are characterized by the absence of filler-induced problems or defects, since the technique requires no filler, and by the low hydrogen contents in the joints, an important consideration in welding steel and other alloys susceptible to hydrogen damage. The technique can produce joints utilizing equipment based on traditional machine tool technologies, and it has been used to weld a variety of similar and dissimilar alloys as well as for welding metal matrix composites and for repairing the existing joints. Replacement of fastened joints with FW welded joints can lead to significant weight and cost savings, attractive propositions for many industries. FW is a leap forward in manufacturing technology, a leap that will benefit a wide range of industries, including transportation industry in general and the airframe industry in particular.

Keywords*: *Friction welding, welding parameters, mechanical characterization, metallographic

I. Introduction

Welding technology is used in manufacturing development of New welding method. Welding of different metal and their alloys is a common application in engineering. A method of operating on a work piece comprises offering a probe of material harder than the work piece material to a continuous surface of the work piece causing relative cyclic movement between the probe and the work piece while urging the probe and work piece together whereby frictional heat is generated as the probe enters the work piece so as to create a plasticized region in the work piece material around the probe, stopping the relative cyclic movement, and allowing the plasticized material to solidify around the probe. This technique, which we refer to as "friction welding" provides a very simple method of joining a probe to a work piece. Friction welding is a type of forge welding, i.e. welding is done by the application of pressure. Friction generates heat, if two surfaces are rubbed together, enough heat can be generated and the temperature can be raised to the level where the parts subjected to the friction may be fused together.

Types of Friction Welding:

- CONTINUOUS DRIVE FRICTION WELDING
- ROTATIONAL WELDING
- ORBITAL FRICTION WELDING
- LINEAR VIBRATION WELDING

CONTINUOUS DRIVE FRICTION WELDING:

The present study utilized a continuous drive friction welding machine. In continuous drive friction welding one work piece is rotated at nominal constant speed in action alignment with the second part under an applied pressure. The rotation and pressure are maintained for the specific period to ensure adequate thermal and mechanical conditioning of the interface region. Thereafter, the rotation is stopped often with forced braking and at the same time pressure is increased to upset parts together. The application of an axial force maintains intimate contact between the parts and causes plastic deformation of the material near the weld interface.

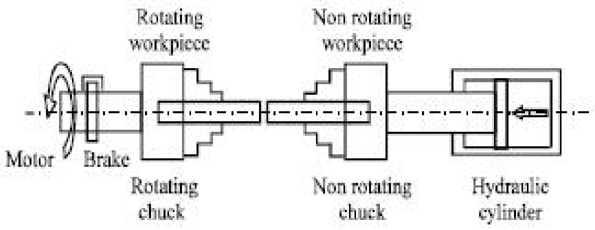

Fig.1

MACHINE PARAMETERS:

The controlled variables also called machine parameters in friction welding are the speed of rotation, the amount of axial shortening or burn off length and weld time.

PERIPHERAL SPEED: The most widely used speed cycle is one where a constant speed is maintained during the friction heating phase followed by rapid heating. The rotation speed is often specified in terms of sliding speed at two third of the radius at the faying surface. In the welding of solid specimen, although the speed of rotation is kept constant, the rubbing speed across the interface varies linearly from zero at the centre to a maximum value at the outer radius. It is an important parameter in determining the maximum interface temperature and hence the final joint metallurgy. High speeds produce overheated structures whereas low speeds can produce insufficient heating.

WELD TIME: Weld time is calculated with the help of stop watch during the joint of the two metals. Duration of heating welding of material is noted in sec.

BURN OFF LENGTH: Burn off length is the overall length loss of the components during the application of friction force & forge force. The duration of the heating (Burn off) is selected so as to ensure that the faying surfaces are cleaned by friction and the weld zone temperature is raised to achieve the required plasticity for solid state pressure welding.

Materials that can be friction welded are listed below:

- Aluminium and its alloys
- Stainless steel
- Tantalum
- Tungsten
- Zirconium alloys
- Nickel alloys
- Brass and Bronze
- Alloy steels
- Titanium alloys
- Magnesium alloys
- Carbon steel
- Alloy steel to Carbon steel
- Copper to Carbon steel
- Aluminium to Stainless steel
- Copper to Aluminium
- Super alloys to Carbon steel
- Stainless steel to Carbon steel
- Sintered steel to Carbon steel

EXPERIMENTAL WORK:

In this experiment of friction welding, one end of the job is fixed with the help of chuck and one end of the job is welded to dead centre of tail stock. Then the plate attached to the chuck is rotated and the other plate is pushed towards it by applying pressure manually. The various experimental process of friction welding is described in detail.

Material Selection: One is stainless steel rod and high speed steel rod of same dimension:

The following are the specifications which will be used:

Length of specimen: 90mm (each)

Diameter of specimen: 15mm

Welding operation:

The chosen experiments were conducted on friction welding machine which works on the principles of continuous drive-mechanism. The friction and upset pressures used are in the range of 1-3 tonnes and 3-5 tonnes, respectively. Rotational speed was kept constant at 1500 rpm and upset time was set constant for 5 sec. Burn-off lengths were in range of 1-3 mm. There are two sets of experiments conducted, one holding austenitic stainless steel specimens stationary and High speed steel specimens rotating and another keeping High speed steel specimens stationary and austenitic stainless steel specimens rotating.

Test Performed:

Metallographic examination

Tensile Test

Hardness test

Micro structure test

What the Future Holds:

Given the challenges facing the manufacturing sector, friction welding, on the strength of its unique advantages, is a process that makes increasing sense. Providing advantages that manufacturing companies can readily leverage, friction welding machinery has seen an astounding rise in inquiries from China and southern Asia over the last year. As engineers and product designers delve deeper into this process, they will come away convinced that friction welding can serve to optimize and perfect both the design of heretofore unrealized components, and their cost of production. If, indeed, necessity is the mother of invention, then friction welding has a substantive role to play in the future of global manufacturing.

Such has been the interest in friction stir welding, which was patented no so long ago, that considerable effort is being made in transferring the technological benefits from aluminum and magnesium to higher temperature materials such as copper, titanium and steels. TWI has two projects in conjunction with several industrial users to develop the friction stir welding of titanium and steels.

Friction welding can also assume the role of "assembling" prefabricated components and materials in a variety of creative configurations in a more economic method, as per a particular client's needs and specifications. Importantly, according to metallurgical testing, the friction welding process is solid state, and no welding rods or filler materials are used. Only base metal material exists up to and across the faying surfaces. This is significant because no material has melted.

When looking at the broader scope of what the process offers, without question, friction welding produces a full cross-sectional porosity-free bond, reduces material waste and enhances productivity by limiting time-consuming labor associated with pre-machining," says Stuart Carlson, a metallurgist with over 30 years' experience in the field. "These factors are especially vital to manufacturers in today's economic environment," he says, "considering the current dramatic rise in the prices of aluminum, copper, steel, stainless steel, titanium and inconel." The friction welding process is completely automated via PLC and PC control, and includes monitoring, testing and recording of process parameters to guarantee quality. The universally accepted standards of friction welding are defined according to ISO 1562.

Advantages:

Weld heat affected zone (HAZ) has a fine grain hot-worked structure, not a cast

Structure found with conventional welding

Material and machining cost savings

100% Bond of full cross section

Similar and dissimilar material joined with no added fluxes or filler metals.

Joint strength equal or greater than that of parent material

Disadvantages:

The disadvantage of friction welding are that not every configuration is feasible that a machine of sufficient power is needed and that for short runs the process may not be economical. Apart from the cost of equipment, which must be suitable for the intended joints, the friction welding process has some costs in tooling and set up that must be taken into account when calculating the costs per weld. Tight concentricity requirements, when needed, may be difficult to meet. Also finishing operations may be requested which sum up to the total cost.

Application of friction welding:

Commercial

Aerospace

Hydraulic

Automotive

Bi-metal

Agricultural field

Drill rods

Conclusion: In general terms, the present invention is dependent on relative motion where both faces of the weld joint are in motion during the heating phase of the operation, which motions are brought into phase when the conditions of the joint are appropriate. While both will continue in motion, at least for a brief period, the relative motion between the parts is stopped by virtue of synchronizing the motions so they are in phase and identical. The change of phase of the motions of the mating parts can be accomplished with far greater precision and speed than are possible when alignment of the parts is dependent on stopping the motion of one or both the parts. In general terms, the present invention is applicable to all wieldable materials, and includes a few materials not ordinarily joined by welding techniques. These materials include aluminum and a broad variety of aluminum alloys, brass, bronze, metallic carbides, such as tungsten and titanium carbides, cobalt based alloys, columbium, copper, cupronickel alloys, lead, magnesium alloys, molybdenum, nickel alloys, mild steel, stainless steel, tool steel, sintered steel, tantalum, titanium and titanium alloys, tungsten and zirconium, as well as more complex alloys of many of the foregoing elements and metals.

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