Recent Industrial Scenario Of Rotary Friction Welding Technology and It's Applications - A Review

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ABSTRACT: Friction welding which was first applied to cutting tools in metal processing industry has found several applications. Friction welding obtained by frictional heat & it's a commercial process, friction welding has found several applications in different manufacturing processes with the advancement in technology. The first studies of friction welding in England were carried out by the Welding Institute in 1961.By modifying the friction welding; the Caterpillar Tractor Co. in the USA developed the method of inertia welding in 1962. Many researchers are still working on the thermal analysis and basic parameter, tool development of various types of friction welding processes. With these advances, it has found several applications in Engineering, Naval & offshore industry. Friction welding is used welding process in industries like automobile industries, aeronautical industries etc. and heavy duty industries. In this literature review paper the various processes and applications of friction welding has discussed theoretically.

Keywords: Rotary friction, linear friction, Inertia friction, Friction stirs welding.

I. INTRODUCTION

Friction welding is a solid state welding process or it is also called as a forge welding, where welding takes place by the friction between two mating surfaces of metal along with pressure, where no electric or other power sources are used, mechanical energy produced by friction in between two frictional mating parts to be welded. Using heat in the welding region is efficiently distributing on surfaces. The heat developed between two mating surfaces through a mechanically induced rubbing action and applied the force. This process is a collection of solid state welding processes, where heat is produced by means of mechanical friction between moving and stationary work pieces with the addition of an upsetting force to displace material plastically. The temperature in the welding region for steels is between 850°C and 1150°C approx. The heated material at the interface accumulates by increasing force after heating phase. Thus, a type of thermo-mechanical treatment occurs in the Heat Affected Zone (HAZ) and this region has stable particle structure. In order to obtain welding connection between two parts, untreated surfaces need to be contacted to one another this contact is efficient because friction corrects contacting problems. The melting process does not normally occur on contacted surfaces. Even though, a small amount of melting may occur, accumulation caused by post-welding process makes it invisible. In this process one of the specimen is stationary while the other one is rotating. When the rotational speed reaches to a certain level, the axial force is applied and vocational heating occurs in parts at the interface. Then, rotation is stopped heated material at the interface accumulates. Metals and alloys, and different types of dissimilar metals can be weld using friction welding. Applications of friction welding process are generally used in the welding of pipes and circular rods. Rotary friction welding is a type of friction welding in which one component is rotated against the other; it is the most commonly used process among the friction welding.

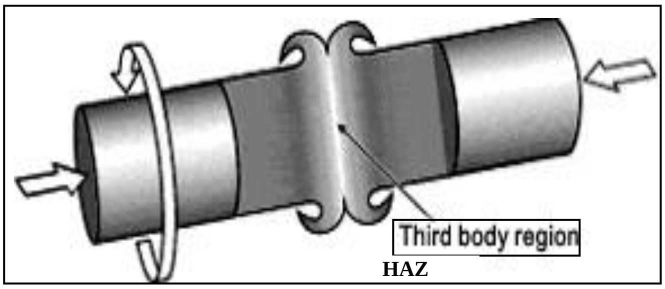

Fig.1: Rotary Friction Welding

OTHER TYPES OF FRICTION WELDING:

- Linear vibration welding.
- Inertia friction welding.
- Continuous drive friction welding.

Linear friction welding:

It is the relative motion across the interface is linear, rather than rotary. It is a process of producing high strength welds with non-melting fusion. It is also a solid-state joining process special application for aerospace industry. The method involves two parts being pushed together, one oscillating at a high frequency. This creates friction that heats the metals to a temperature at which they are able to join together. When the oscillation stops, the parts cool to form a forged-quality weld.

ISSN : 2454-9150 Special Issue - AMET-2019

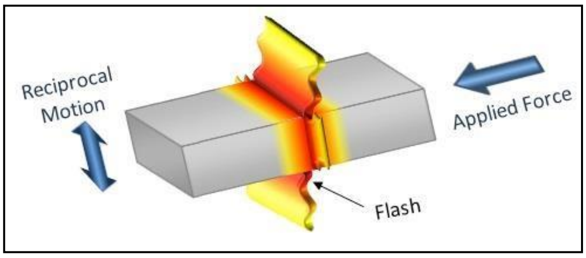

Fig. 2.Linear friction welding.

Linear friction welding material having a many advantages. It is a very consistent and fast process, taking only few seconds to create a weld. Very little preparation of the surfaces to be joined is required: any imperfections and impurities are removed along with a layer of surface metal as requires specific parameters of mass/weight, speed, and pressure to meet the requirements of the weld union. When the desired rotational speed is achieved, kinetic energy is transferred into the freely rotating part. Constant forge pressure is applied until a plastic state is reached. Rotation stops due to controlled pressure as the desired total displacement length of material (upset) are met. Rotational speeds are normally higher than direct drive friction welding. The majority of the total displacement comes at the very end of the weld cycle as compared to being spread out over the middle to end of the cycle. Following (fig.4) shows the Inertia welding Phases and the results shows on a graph. The end result is the same but the major difference between the two techniques is the energy source, rpm, timing and distance as pressure is applied flash. It requires no consumables, produces no harmful fumes, and because of a solid-state welding process, no potential issues occurs with solidification e.g. segregation or porosity. There are some other potential applications of linear friction welding has established itself as the primary method of fabrication of bladed disk assemblies for aircraft turbine engines. It has great potential for other aerospace applications like manufacturing of aircraft structural components. Linear friction welding has the potential applications are automotive, shipbuilding, rail, oil and gas, energy and construction etc.

Inertia friction welding:

Inertia friction welding or direct drive rotary friction welding, the part of rotation under pressure to heat the faying surfaces. A flywheel to generate the rotational motion in the part holding chuck. The flywheel driven chuck rotates and stops when the weld zone seizes. This inertia method is also sometimes known as a spin welding.

Energy is provided by the machine's kinetic energy that is stored in a rotating system or mass. This requires specific parameters of mass/weight, speed, and pressure to meet the requirements of the weld union. When the desired rotational speed is achieved, kinetic energy is transferred into the freely rotating component. Continuous forge pressure is applied until a plastic state is reached. Rotation stops due to controlled pressure as the desired total displacement length of material (upset) are met. Rotational speeds are normally higher than direct drive friction welding. The majority of the total displacement comes at the very end of the weld cycle as compared to being spread out over the middle to end of the cycle.

RPMs, and timing/distance as pressure is applied.

Stage 1: One component is inserted into a rotating chuck and the other component is inserted into a fixed tail clamp. The head is then accelerated to a preset speed.

Stage 2: The rotating component or the fixed tailpiece is then forced against the remaining component.

Stage 3: Rotation stops under its own kinetic mass and then a forge pressure completes the welding cycle.

Energy is provided by the machine's kinetic energy that is stored in a rotating system or mass. In this instance the energy available in a stored energy system is finite. This

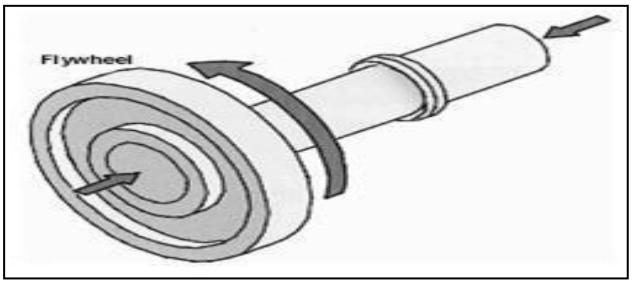

Fig. 3.Inertia Welding.

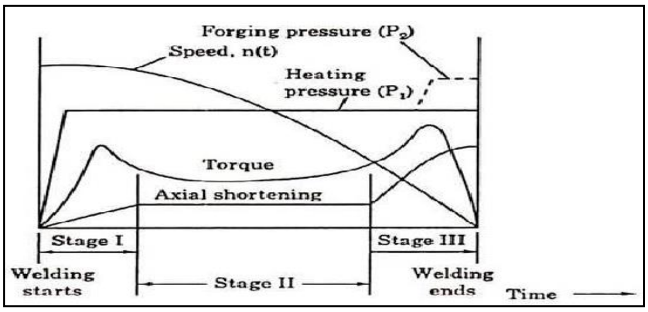

Fig. 4: Characteristics of Inertia Friction.

Frictions stir welding:

Friction stir welding is also produces a required plasticized state of material and a non-consumable rotating tool is held under the pressure against the materials to be joined. This tool is like a pin at the center also known probe or shoulder as shows in Fig. 5. FSW is a solid-state joining process with many advantages, such as sound mechanical and metallurgical properties and a narrow heat-affected zone compared with conventional fusion welding. This joining technique is energy efficient, environment friendly, and versatile. It can be used to join high-strength aerospace aluminum alloys and other metallic alloys that are hard to weld. A plastic state material is generated the heat resulted from friction between tool and materials when it comes in contact with. As the tool moves along the joint line, material from the front of the tool is cleaned around this plasticized circular region to the rear, so reducing.

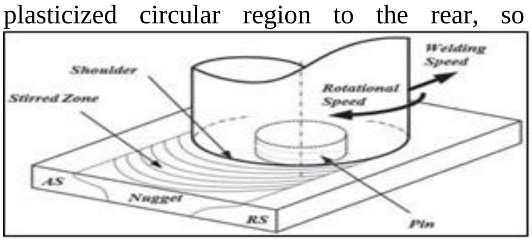

Fig.5.F SW Pin shoulder.

ISSN : 2454-9150 Special Issue - AMET-2019

Properties of Friction Welding Machine:

Phase 1: Low temp interface heat cycle by spinning one component against another stationary component.

Phase 2: Solid forging cycle showing displaced plastic state material when final axial forging force is applied.

Phase 3: Plastic state flashing is removed easily, even for harden able materials that would otherwise require grinding.

A friction welding machine has the main body, joining parts, rotate and accumulate mechanisms, brake system, power supply, control unit and control panel. Friction welding machines are all-mechanized machines. Joining and releasing of parts, turning of copular produced due to accumulation after welding is automatically accomplished. The main functions in friction welding are joining, compressing and releasing of parts, rotation and friction under pressure, braking, accumulation and precise adjustments of required processing times. Simple joining apparatus needs to have certain rigidity, must resist increased moments, and must eliminate vibrations and leaks. Especially, possible vibrations during welding process need

It is an ideal process for the automotive manufacturing industry with the ability to create highly durable, customized automotive parts for everything from commercial to personal use vehicles, friction welding helps to design flexible solutions to ever-changing challenges of the automotive industry. Automotive manufacturers have used this technology to save money and improving quality of products like piston rods, hydraulic cylinders, radial pump Pistons, shaft with worm screw, crankshafts, drill bits, valves. Following pictures shows the various industrial applications in automobile industry.

Some other automobile industry applications:

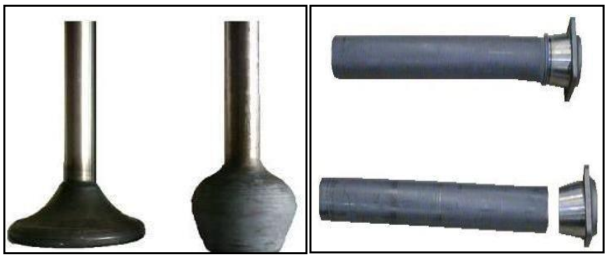

Fig. no 6.b. Applications

Truck banjo axle, Gear cluster, valves, drive shafts, gear levers, axle fasteners, break spindles, transmission Mechanisms, preheat rooms, pipe spindles, banjo axles, Mono steel piston, Brake calipers, Transmission shafts & gears.

Aviation and space industry: Repulsion jets, combustion chambers, spindles, turbines, rotors, pipes, fittings, flanges.

Machine tool industry: Spiral drills, milling cutters, borers, Reamers, cutting tools.

to be taken into account while designing the friction welding machine. In addition to vibrations, other radial and axial forces have to be accounted for design consideration. Friction welding machines have certain particle size and material limitations. For example, a machine having 120KN compressed force and 15KW electric engine can be used in the welding of steels with cross sectional areas of 130-800 mm^2. All machines can be adjusted to meet certain specifications and can automatically be controlled. This process is sometimes done by just manually turning off the switch or protectors. The friction welding also used for underwater repair of cracks to marine structures and pipelines.

Applications of Rotary Friction Welding: Manufacturing and Automotive accessories industry:

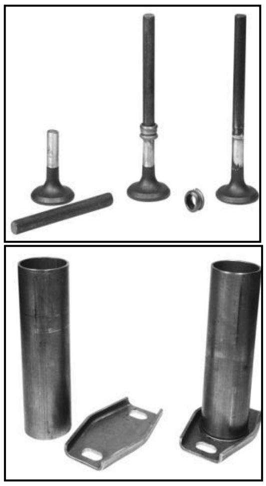

Fig no. 6.a. Applications

Electrical, electronics, and chemical industry: Electrical connectors, Receiver camera for gas analysis, swing Contacts segregation columns for chromatograph, Electrical connectors, continuous solder top.

Friction-welded parts are always produce the same high quality component and friction welding machines are more reliable than conventional welding techniques, And the automated nature of a friction welding machine takes individual operator skill out of the equation to deliver durable, defect-free parts.

When two dissimilar metals welding together with friction welding process like aluminum with copper or steel with low-carbon alloys, the solid state bond quality gets always strong and always consistent.

Advantages of RFW:

- No filler metal is needed. Flux and shielding gas arc are not required. The process is environmentally clean; no arcs, sparks, smokes or fumes are generated.
- Surface cleanliness is not significant, compared with other welding processes, since friction welding tends to disrupt and displace surface films.
- Creates narrow, heat-affected zone & Consistent and repetitive process. It produces a fine-grained forged weld without any weld dilution, or weld inclusions. Solid state process – no possibility of porosity or slag inclusions
- Friction welding is suitable for welding most engineering materials and is well suited for joining many dissimilar metal combinations.
- The weld strength is stronger than the weaker of the

two materials being joined.

- Operators are not required to have manual welding skills. The process is easily automated for mass production.
- It is a fast welding process as compared to other welding processes. It has the ability to produce high quality welds in a short cycle time.
- Plant requirement (space, power, special foundations, etc) are minimal.
- Creates cast or forge-like blanks – without expensive tooling or minimum quantity requirements.
- Full surface weld gives superior strength in critical areas.
- Reduces machining labor, thereby reducing perishable tooling costs while increasing capacity.
- Reduces raw material costs in bi-metal applications.
- Joint preparation is minimal saw cut surface used most commonly.
- Faster Turn-around Times compared to the long lead time of forgings.
- Greatly increases design flexibility chooses appropriate material for each area of a blank.
- Suitable for diverse quantities from single prototypes to high-volume production.

Limitation of RFW:

- The process is restricted to joining round bars or tubes of same diameter (or bars, tubes to the flat surfaces), i.e. capable of being rotated about the axis.
- Dry bearing and non-forgeable material cannot be welded, i.e. one of the components must be ductile when hot to permit deformations.
- Preparation and alignment of the work pieces may be critical for developing uniform rubbing and heating, particularly for pieces having diameters larger than 50 mm.
- Capital equipment and tooling costs are high and free-machining alloys are difficult to weld.

II. Conclusion

The Rotary friction welding method is successfully used to join the different materials which are not weld-able by the convention welding processes. RFW provides the manufacturing flexibility for manufacturing of the bimetallic parts. As the cost of tooling and machinery is quite high it is only used in mass production. Rotational friction welding was successfully used to join stainless steel tubes of small dimensions. Rotational friction welding can be a very beneficial process when properly integrated into a design, but the parameter effects and system capabilities need to be understood in order to be effective. The solid state welding method viz. the friction welding is also discussed. The need for innovative and cost effective welding methodologies to meet the growing requirement and the technological advancement in the metal joining in the context of auto industry is discussed.

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