A Review Paper on Rotary Friction Welding

Nisarg Shete[1], S. U. Deokar[2]

[1]*Undergraduate, Department of Mechanical Engineering,SKNCOE Vadgaon ,* **nisargshete@gmail.com**
[2]*Asst. Prof., Department of Mechanical Engineering, SKNCOE Vadgaon,* **swapnildeokar00@gmail.com**

ABSTRACT

Friction welding is a non-conventional pressure welding process It is considered most viable alternative to overcome the difficulties faced in conventional joining technique. Mostly used for joining material with varying physical and mechanical properties. We have mainly focused on Rotary Friction Welding (RFW). Our main objective is to understand the fundamental understanding of Friction Welding. In this process kinetic energy is converted into heat energy thereby producing high quality weld and unusually high efficiency coefficient.

Keywords*: Friction, Continuous-drive Friction Welding (CDFW), Inertial Friction Welding (IFW), Rotary Friction Welding (RFW)*

---

1. Introduction

Friction Welding is a variation of pressure welding method, in which the welded connection is formed without melting the metal, by joint plastic deformation of the pieces to be welded with the help of heat resulting from friction. Here we generate large amount of localised intense heat generation and deformation results in less energy consumption and highly strong weld. As it is a solid state welding process the process does not form molten pool thereby eliminating the solidification errors. FW can join two different materials having different thermal and mechanical properties without compromising the strength of weld. FW is preferred over conventional processes because of low cost, highly precise operations, repeatability and reliability. Rotary friction welding being the most popular variant it can be classified into Continuous Drive Friction welding and Inertial Drive Friction Welding.

The definition of friction welding process in the American Welding Society (AWS) C6?1-89 Standard is as follows:1 'Friction welding is a solid-state joining process that produces coalescence of materials under compressive force contact of workpieces rotating or moving relative to one another to produce heat and plastically displace material from the faying surfaces. Under normal conditions, the faying surfaces do not melt. Filler metal, flux, and shielding gas are not required with this process'.

2. Literature Survey:

From the literature survey following information has been found out. A non-uniform liberation of heat on the friction surfaces, conforming to general rules, as well as accidental phenomenon (different intensity of loading of some sections of the surface compared to others) is the basic cause for temperature difference at various points of friction surface. Measurements with thermocouples show that this difference could amount to several hundred degrees in the initial phase of welding process. But as the heating progresses, the temperature on the welding surfaces level off, primarily because of heat conduction and because of redistribution of heat liberation. Metal surface heated to a high temperature becomes plastic before other others and under the influence of axial force are deformed and flatten out. They cease to resist axial force and the latter is now transmitted by cooler portions of the friction surface where heat liberation is then increased, the temperature being continuously evened out across the specimen. This becomes evident while reviewing a micrographs of the cross-section of the samples where the duration of heating varies in the course of welding process.

If after a short heating period the heat-affected zone in the centre portion of the specimen does not extend into depth then, in sampling requires a long heating time the exterior boundary of the zone of thermal influence is located almost parallel to the surface of the weld. The self-levelling of the temperature towards the end of the welding process produces homogeneity of the physical and mechanical properties particularly the strength of the metal at the cross-section. Thus, plastic deformation of heated portion of the metal plays a important role in friction welding process, on other hand contribution to the destruction and elimination and destruction surface oxide films and the formation of seizure centres and on the other hand aiding the levelling-off of the temperature of the cross-section. In the end both are important in achieving the weld. The speed of relative motion and the value of the axial unit force determine the intensity of heat liberation and are the basic power parameters of the process. The plastic deformation of the heated metal is the basic technological parameter of the process. One can measure the amount of plastic deformation during welding by its axial component – the upset.

Sometimes, it is suggested that it would be better to select the duration of the heating period rather than the upset as the third basic parameter of the friction welding process. This suggestion is based on the fact that for a given heat power of the process (the speed and the pressure are given) the duration time fully determines the energy to be utilized for welding of given pair of materials and consequently to a certain extent determines the temperature conditions of the process, keeping in mind that the plastic deformation of the specimen is derived from the temperature conditions. However, this does not take into consideration the importance of secondary factors which can substantially alter the friction coefficient as well as the heat quantity introduced into the process at constant speed and pressure.

Experience shows that the selection of the process regulation method (by time or by upset) is important from practical standpoint. This is connected with local production conditions and to certain extent is also dependent on the selected values of the power parameters of the process. It is important to emphasize that, no matter which of the above factors is selected as the third parameter, its value must be maintained with sufficient accuracy. A decrease from the optimum value can result in following

1) Partial removal and destruction of oxide film;
2) Non-uniform heating of the cross-section of the welded specimen (insufficient plastic deformation)
3) An increase in the overheating of the metal;
4) Grain growth in the joint and heat affected zone

As a result, a decrease in the strength of the welded joint in both the cases will occur.

In establishment welding procedure for friction welding of any specimen (the determination of the rotation speed, unit pressure, the duration of the process and the upset), one must proceed experimentally under the guidance of already available procedure.

3. Rotary Friction Welding:

Since the introduction of rotary friction welding during Second World War, it is by far the most popular of all friction welding processes which has been used extensively for joining of structural materials which are rotationally symmetrical. It is divided into two major process variations, depending on the manner by which rotational energy is converted into frictional heat. The first one is direct drive or continuous drive friction welding. The second is inertia friction welding. Our present study concerns with the development and experimental validation of Continuous Drive Friction Welding Technique

3.1 Continuous Drive Friction Welding (CDFW)

Continuous drive friction welding (CDFW) is a solid state joining process, in which one of the components to be welded is held stationary, while the other is rotated at a constant speed, and then the two parts are pushed against each other with an axial force. When sufficient temperature is reached at the friction surfaces, the rotating component is stopped rapidly and axial force is maintained at the same value or is increased for a short period of time. In this forging stage the hot metal cools under pressure and a weld is consolidated. During CDFW, temperature evolution and plastic deformation of joints are the dominant processes, which determine the removal of contaminants such as oxide debris from the weld region, and thus control the weld quality.

4. The Rotary Friction Welding Process:

RFW is the most common form of FW. Its basic principle is where one component is held stationary while forced to rub against another rotating part under normal pressure. There are two process variants: continuous drive

ISSN: 2321-8169
1557 – 1560

friction welding (CDFW, also termed direct-drive friction welding) and inertia friction welding (IFW, also termed inertia-drive or inertia welding). The biggest difference between these two methods is the means of supplying energy to the welding interface. In CDFW, the rotating part is attached to a motor driven unit which keeps a constant rotation speed during the whole welding process. The process runs until a braking force is applied or axial shortening (also known as burn-off or upset) is produced. While friction pressure can remain constant throughout the process, it can also be applied in two or more steps. In addition, both single-stage pressure and two-stage pressure processes are followed by forging at the end of welding, without altering the nature of the phases/physical processes of RFW. In general, RFW is composed of two phases: the friction phase where the material is heated up and necessary upset is formed, and the forging phase to consolidate the weld. Due to the different means of energy input, IFW can fulfil much higher input energy specifications compared to CDFW, and for this reason aero-engine manufacturers use IFW and the automotive industry CDFW.

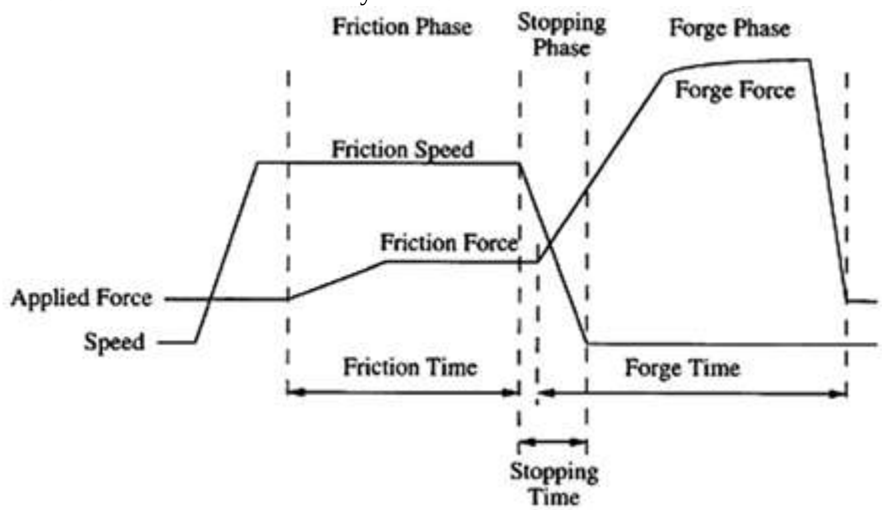

Fig. 1.2 A typical time-load curve used during the friction welding process [1]

5. Friction Welding Equipment

Friction welding process is involved with equipment, which is easy to construct. A schematic view of a typical friction welding apparatus (friction welder) is shown in Fig. 3.1, A friction welder can operate at different applied load conditions, which depend on the parts size and parts material. The maximum typical load for metallic parts is in the order of 120 KN. In general, the welder motor has variable speed, which could be controlled by a computer. A typical welder speed for metallic parts is in the order of 3500 rpm. The friction welder operating parameters include rotational speed, friction pressure, friction time, forging pressure, feed rate, brake delay time, upset delay time, and upsetting time. The operating parameters can be controlled by a computer for a desired end product quality.

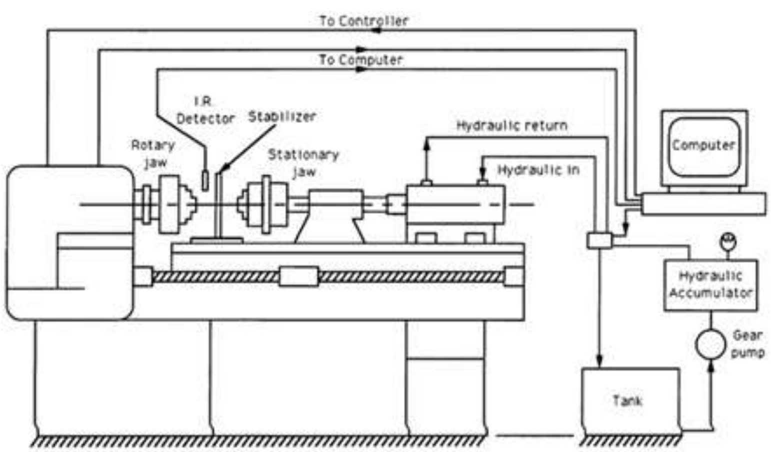

Fig. 1.1 Shows a schematic view of friction welding equipment (friction welder) [1]

6. CONCLUSION:

Friction welding has immensely high potential in the field of thermomechanical processing of various alloys. This thesis presents experimental investigation of friction welding. The mechanical properties and the resultant microstructure for friction weld were presented for different combinations of axial force, rotational and translational speeds.

The correlation of mechanical properties and microstructure with the process parameters for the optimization of process is a unique approach which has been the main motivation behind this project.

From the present experimental investigation, the following conclusions are derived:

- Material showing different mechanical and thermal properties can be welded. This is particularly useful in aerospace, where it is used to join lightweight aluminum stock to high-strength steels.
- Welded bond is stronger than the parent metal itself.
- Friction welding is also used with thermoplastics, which act in a fashion analogous to metals under heat and pressure. The heat and pressure used on these materials is much lower than metals, but the technique can be used to join metals to plastics with the metal interface being machined. For instance, the technique can be used to join eyeglass frames to the pins in their hinges. The lower energies and pressures used allows for a wider variety of techniques to be used.
- A very efficient and economic utilization of heat is possible because of strictly localized heat generation. This heat generation eliminates the oxide films and levels of the surface.

7. ACKNOWLEDGEMENT

The author gratefully acknowledge the guidance of Prof. S. U Deokar for his valuable technical support to encourage newer ideas. He was a constant source of inspiration and was of great help throughout the paper.

We also thank SKNCOE, HOD Dr Amar Pandhare, Department of Mechanical Engineering for his continuous encouragement and valuable support as well as our classmates.

8. REFERENCES

[1] Yilbas BS (2006) Improved formulation of electron kinetic theory approach for laser short- pulse heating. Int J Heat Mass Transfer 49(13–14):2227–2238

[2] Eesley GL (1986) Generation of non-equilibrium electron and lattice temperatures in copper by picosecond laser pulses. Phys Rev B Condens Matter 33:2144–2151

[3] Yilbas BS, Dweik A (2014) Short-pulse laser heating and incorporating thermomechanical coupling: closed form. J Thermophys Heat Transf28:142–149

[4] Yilbas BS, Dweikh A (2012) Laser short pulse heating of metal nano-wires. Phys B 407(22):4473–4477

[5] Tzou DY (1997) Macro-to-microscale heat transfer. Taylor and Francis, Newyork, Washington

[6] Kovalenko A (1969) Thermoelasticity (basic theory and applications). Wolters-Noordhoff, Publishing,Groningen

[7] Debnath L, Bhatta D (2007) Integral transforms and their applications, 2nd edn. Chapman & Hall/CRC, New York, p 93

[8] Shampine LF (2008) Vectorized adaptive quadrature in MATLAB. J Comput Appl Math 211:131–140

[9] Yilbas BS, Sahin AZ, Coban A, Abdul Aleem BJ (1995) Investigation into the properties of friction-welded aluminum bars. J Mater Process Technol54:76

[10] Sahin AZ, Yilbas BS, Ahmed M, Nickel J (1998) Analysis of the friction welding process in relation to the welding of copper and steel bars. JMaterProcessTechnol82:127–136