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Design and Development of an Experimental Setup for Measuring Force Applied During Friction Welding on a Conventional Lathe Machine

Aishwarya Chaudhari, Deepak Gaikwad, Priyanka Chavan, Sarthak Bhokare,

Prof. Vaibhav .V .Kulkarni

Department of Mechanical Engineering, MITCOE, Savitribai Phule Pune University, Pune, India.

Abstract

The purpose of this paper is to design a special fixture for measuring the forge pressure on the conventional lathe machine during rotary friction welding of mild steel specimens. The fixture consisting of hydraulic jack with pressure gauge mounting was attached on the tail stock of machine. The pressure gauge shows the forge pressure and friction pressure applied. A fixture was designed to support the cantilever type section of the setup on tailstock and to stabilize the stationary job .Friction welding is a solid state welding process that generates heat through mechanical friction between a rotating/moving component and a stationary component. It is an important leap forward in manufacturing technology that will benefit a wide range of industries, including transportation electrical connections and aircraft industry. The principal advantage of frictional welding, being a solid state process, are low distortion, absence of melt-related defects and high joint strength, even in those alloys that are considered non-weldable by conventional welding techniques.

Keywords: *Rotary friction welding, forging force, Friction force, Force measurement, RPM, Lathe machine, Mild steel.*

1. Introduction

Today's manufacturing industries employ a variety of joining processes for metallic as well as non metallic joints. Depending on the types or combinations of energy input methods, these joining processes, also known as welding processes, can be divided into two major groups as follows:

Fusion welding: It is the process of melting together of filler metal and base metal (substrate), or of base metal only in order to produce coalescence between two specimens.

Solid-state welding: Solid state welding is a group of welding processes which produces coalescence at temperatures essentially below the melting point of the base materials being joined, without the help of brazing filler metal. In all of these processes time, temperature, and pressure individually or in combination produce coalescence of the base metal without significant melting of the base metals.

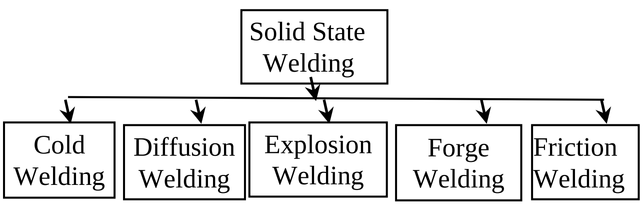

Fig.1 classification of solid state welding processes

2. Friction Welding (FRW)

Friction welding is a solid-state joining process that produces coalescence in materials, using the heat developed between surfaces through a combination of mechanically induced rubbing motion and applied load.

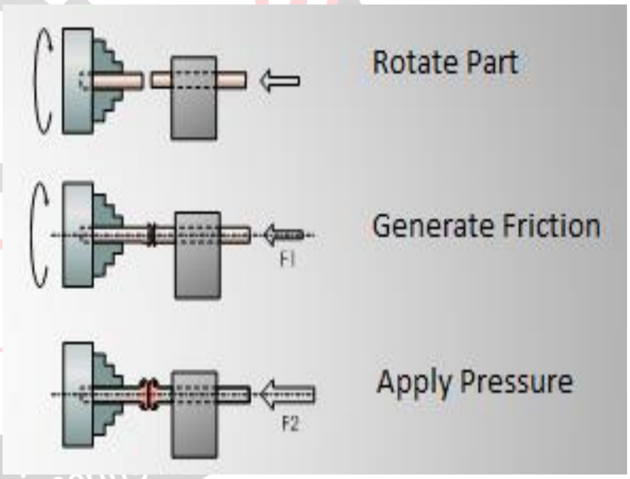

Fig.2 Working principle of Friction Welding

Friction welding is a commercial process which has developed through years with the advancement in technology. Preliminary trials were made using lathe machines for welding. However, they were considered impractical due to incorrect techniques. The first patent of friction welding process was granted to J.H. Belington. Studies on welding of plastic materials were carried out in the 1940s in USA and Germany. A Russian machinist named A. J. Chdikov has conducted experimental scientific studies and suggested the use of RFW as a commercial process. He patented this process in 1956. Researchers of American Machine and Foundry Corporation named Holland and Cheng have worked on thermal and parametrical analysis of friction welding. Studies of friction welding in England were carried out by The Welding Institute (TWI) in 1961.

Friction welding requires relatively expensive apparatus similar to a machine tool. There are three important factors involved in making a friction weld:

The rotational speed which is related to the material to be welded and the diameter of the weld at the interface. The pressure between the two parts to be welded. Pressure changes during the weld sequence. At the start it is very low, but it is increased to create the frictional heat. When the rotation is stopped pressure is rapidly increased so that forging takes place immediately before or after rotation is stopped. The welding time is related to the shape and the type of metal and the surface area. It is normally a matter of a few seconds. The actual operation of the machine is automatic and is controlled by a sequence controller which can be set according to the weld schedule established for the parts to be joined. Hence the process is easy to automate.

3. DESIGN AND ASSEMBLY OF SETUP AND FIXTURE

For performing friction welding on conventional lathe machine few issues encountered were difficult to measure the force applied on the non-rotating specimen and swiveling of specimen of longer length. These issues further lead to few unwanted phenomena like uneven flow of material, defective distribution of HAZ and imperfect coalescence.

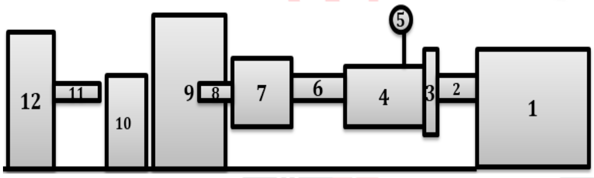

Fig.3 Block Diagram of fixture and setup

Sr. no.	Component
1.	Tail stock
2.	Dead centre
3.	Plate holding hydraulic jack
4.	Hydraulic jack cylinder
5.	Pressure gauge
6.	Piston
7.	Drill chuck
8.	Stationary Specimen
9.	Fixture for supporting and guiding drill chuck
10.	Fixture for stabilization of stationary specimen
11.	Rotary Specimen
12.	Three jaw chuck

Table1. Components of the block diagram

To overcome the problems mentioned above a special setup and a fixture was designed and assembled. The setup for force measurement consists of a hydraulic jack with a pressure gauge mounted on it. The base of this jack is bolted to a plate which is further welded to a dead center which has a Morse taper on other end to fit into the tailstock assembly. The top end of jack is fitted with a drill chuck using a threaded joint. This drill chuck holds the stationary specimen. The hydraulic jack is mounted in vertical direction as shown in the figure 4.

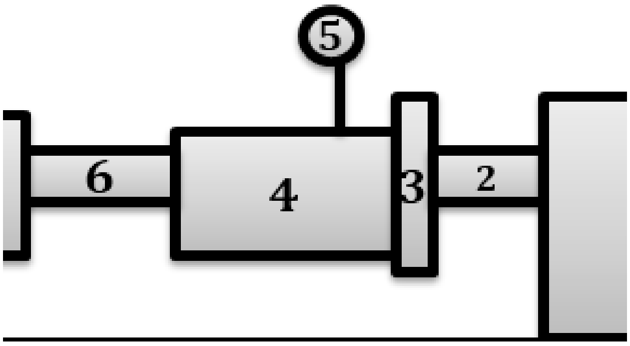

Fig.4a Block diagram of the setup

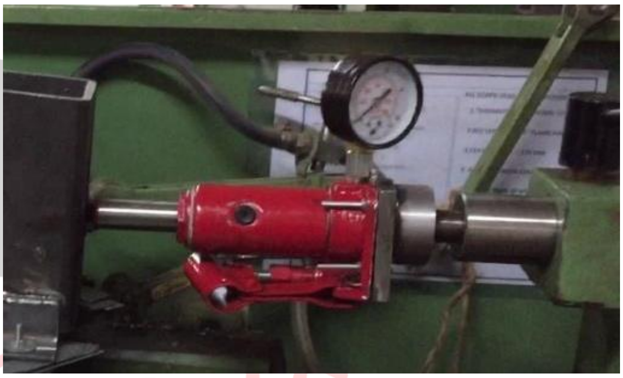

Fig.4b Actual picture of the setup

After the final assembly of the setup (Fig.4) it was observed that a considerable overhang is produced in it leading to an error in centering of specimens which results in formation of joints with high axial misalignment as shown in figure 5a. To overcome this, a fixture was developed which reduces deflection of stationary specimen by supporting and guiding the drill chuck.

Fig5a. Axial Misalignment without Use of Fixture

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Fig5b. Axial alignment using fixture

A part of setup was also specially made so as to avoid swiveling of stationary specimen which further enhanced the axial alignment as shown in figure 5b.

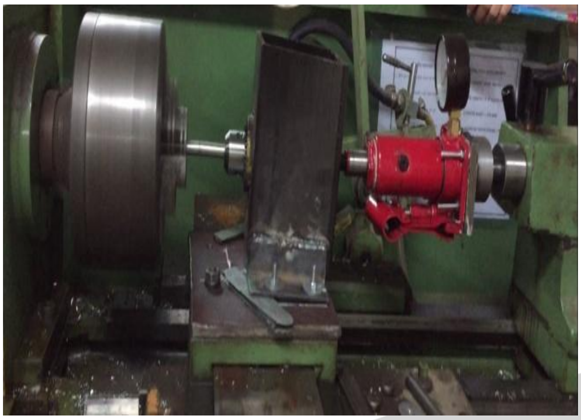

Fig.6 fixture attached during experimental run

Bill of material

S. no.	Component	Quantity
1.	Hydraulic jack	1
2.	Pressure gauge	1
3.	Drill chuck	1
4.	Base plate	1
5.	Chuck support and guide	1
6.	Stationary rod stabilizer	1
7.	Dead center	1

Table no. 2 bill of material

1. Hydraulic jack

Hydraulic jack used for applying pressure on the stationary sample. The max capacity to lift load of the jack used is 3 tons. The pressure applied is transferred to the piston through the oil present in the jack. This in turn increases the pressure of the contained oil and by measuring this pressure the applied force on the stationary specimen can be easily calculated.

2. Pressure gauge

The pressure developed in the jack can be easily measured by using the scale given on the pressure gauge. The body of gauge was made of mild steel having a bottom mounting of Ø 1/4th inch BSP. Due to different constrains, internal threading of Ø 1/8th inch BSP was taped on the jack and a connector was used to connect gauge with the jack. Range of jack is 0-106 kg/cm^2

3. Drill chuck

A drill chuck with max capacity to hold rods up toØ14 mm was used in this particular setup. The max diameter capacity of the setup depends on the chuck. The chuck used has an internal threading to fit to the holding device used in a drill machine. With help of this threading the chuck was fitted on the jack.

4. Base plate

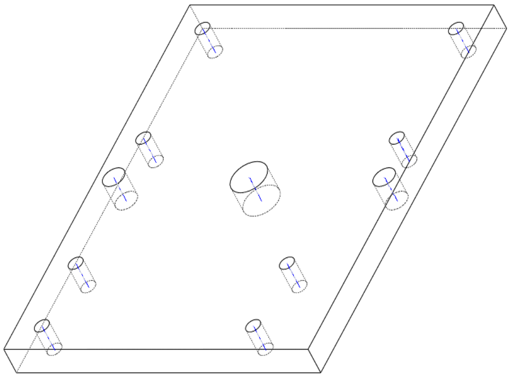

Fig.7 Base Plate with holes for mounting

The chuck support and stabilized is mounted on this plate, with help of bolts, which is in turn mounted on the saddle of the lathe machine. This plate helps in adjusting angular deflection or error if present in the setup it also facilitates for height adjustment and positioning of the chuck support and stabilized in axial direction with respect to each other. The plate was welded with bolts in order to mount the stabilizer and chuck support.

5. Chuck Support and Guide

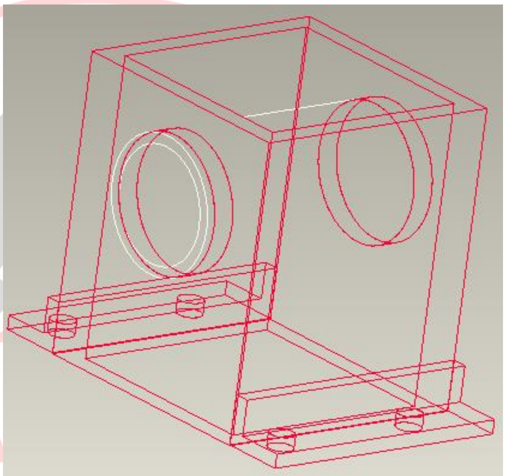

Fig.8 Chuck support and guide

This part of the fixture is used to guide and support the drill chuck fastened at top end of hydraulic jack. With help of this setup the axial misalignment of centers of stationary and rotating work piece.

6. Stationary rod stabilizer

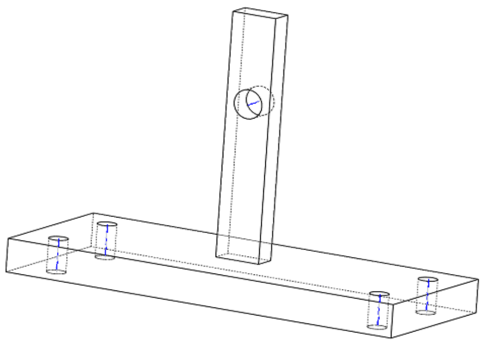

Fig.9 Stationary rod stabilizer

When the welding process is started, due to rotation of work piece, the stationary work piece also tends to rotate and gets displaced from its position leading to axial misalignment. To avoid this a stabilizer is used which restricts displacement of stationary work piece leading to better weld joints.

7. Dead center

A dead center having Morse taper to fit in tailstock assembly was used. This was welded on to the plate with a intermediate bush to ensure orthogonal welding of the square plate. This plate was bolted to the base of the hydraulic jack.

4. Experimental readings

Different experimental runs were performed using rods made of mild steel samples with Ø12 mm. Following table shows the variations of different parameters during the experiments welding conducted.

Sr. no.	Sample Name	Time (sec)	Friction Pressure	Forging Pressure	Speed RPM
1.	A2	65	30	60	1500
2.	A3	56	30	60	975
3.	A4	116	25	50	1500
4.	A5	85	25	50	975

Table no. 3 Experimental trials variation of parameters

5. Conclusion

- With help of setup mentioned above rods up to Ø14 mm can be effectively friction welded. This limit can be increased by using drill chuck with higher capacity or also by using a three jaw chuck.
- The force measurement becomes a convenient job without executing complex calculations.
- Optimum parameters like friction and forging force can be calculated.
- Vibrations and axial misalignment were partially eliminated.
- An economical alternative to costly friction welding machines can be made available with research on similar type of setup.

6. Future scope

The setup mentioned in present paper solves the issue of force measurement during friction welding process but other issues that can be solved with certain modification in the present setup are as follows:-

Strain gauges can be used at appropriate locations so as to measure torque applied on the work piece and they can also be used to measure friction and forging forces applied if properly mounted on the assembly thus replacing the jack and gauge. Thermocouples can be incorporated to measure temperature with better accuracy than non-contact type thermometers.

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