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# Some Aspects of Friction Welding

By S. P. DASGUPTA, A. K. BANERJEE AND S. C. BASU*

**Introduction:**

Welding engineers are constantly presented with joining problems. The most difficult of these involve the junction of dissimilar or exotic metals in a minimum of time and low cost. In many cases, the engineers may be unaware of the rapid advancement of friction welding machine designs and techniques.

A large number of material combinations including dissimilar metals can be successfully welded by employing this process. Filler metal and flux are completely eliminated and excellent quality welds are readily available.

One American, J H Bavington developed a friction welding machine for joining wire rope end to a rod and patented it in 1891.

In Russia, a machinist named Chudikove foresaw the potentiality of the process and got a patent issued in 1965.

Later on the technology was developed by so many firms in U.K. and U.S.A. after 1959.

In India, Central Mechanical Engineering Research Institute, MERADO Welding situated at Durgapur, centering and the rotating chuck operates electrically welding machine in the year 1968. The machine has been completely designed and developed from indigenous resources. The paper describes some description with technical details as well as some experimental results based on the workings of developed friction welding machine.

The principle underlying friction welding machine is simple. It is a mechanical process in which the heat necessary to make the weld is provided by the friction caused by rubbing parts together (Fig. 1). In this process the one part to be joined is rotated and other is fixed and attached to a hydraulic piston ram to provide necessary pressure for welding as well as longitudinal movement.

**Objective:**

The main object was to design and develop a horizontal type friction welding machine which is more versatile than any type and can join a wide range of dissimilar metals.

**Design & Experimental set-up:**

A machine has been designed and developed Fig. 2(a), 2(b), 2(c) Two chucks which hold the job are self centering and the rotating chuck operates electrically whereas the fixed chuck operates both electrically and hydraulically. Automatic control completes the welding.

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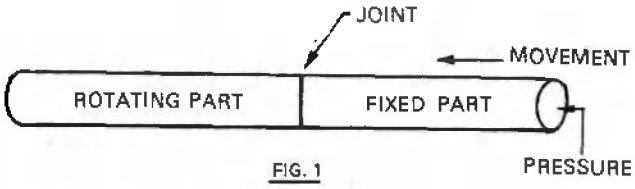


FIG. 1

SCHEMATIC LAYOUT OF FRICTION WELDING

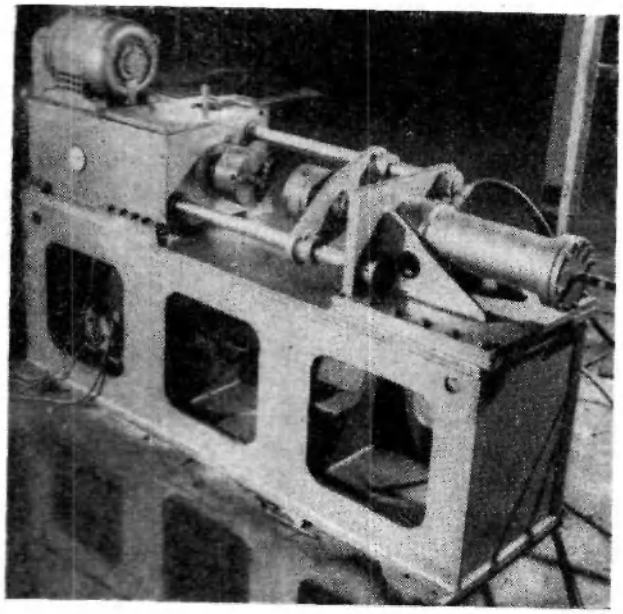

*Fig.—2(a) Main Machine Tool*

*Fig.—2(b) Electrical Control Panel*

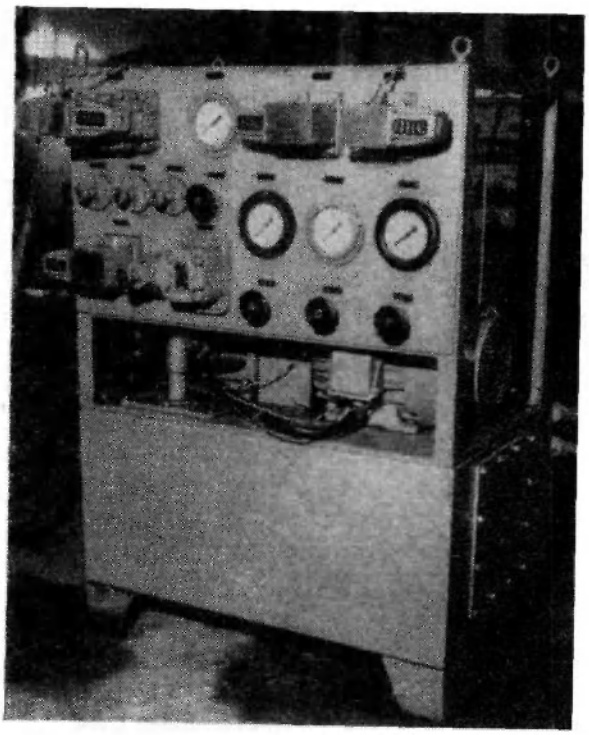

*Fig.—2(c) Hydraulic Power Pack*

The main assembly can be divided into three parts:

(i) Headstock.
(ii) Tailstock,
(iii) Body or bed.

The drive transmission systems are extremely simple and provided on the headstock side. The head is of fabricated construction. It carries the electrical motor on the top surface complete with pulley and belt which supplies the main drive to the main spindle. The main spindle is carried on roller bearings and has a self centering chuck mounted at the welding end. At the rear end a pulley, an electromagnetic clutch and a twin callipered disc brake are provided. Both brake and clutch may be switched in or out of automatic sequence as required.

Lubrication is provided for the main bearing. In operation, the motor is running continuously and it clutches in and out as and when required for friction welding.

**Tailstock:**

This part consists of a cylinder, slider and holding chuck. The axial movement of the chuck is actuated by the hydraulic cylinders. The slider is connected with ram. Hydraulic cylinder is placed at one end and holding chuck at the other end. The slider is placed along the tie rods.

The headstock and tailstock are placed on bed for support, which is of mild steel construction.

**Hydraulic Power Pack:**

This installation consists of a free standing hydraulic tank, carrying the pump, motor and all control valves associated with the machine.

**Electric Control Panel:**

A free standing electrical control panel is connected with the machine and provided with timers which makes operation of the machine automatic.

**Capacity:**

| | | |
|---|---|---|
| 1. | Drive motor | 10 h.p. |
| 2. | Spindle speed (range rpm) ... | 1500 to 3000 (pre selected) |
| 3. | Maximum forge (force at 3000 lb/sq. inch) ... | 14 tons |
| 4. | Hydraulic unit motor ... | 10 h.p. |
| 5. | Total weight of the machine including hydraulic power pack and control panel ... | 5 tons |
| 6. | Minimum diameter solid bar | 6 mm |
| 7. | Maximum diameter solid bar | 10 mm |
| 8. | Diameter of the hydraulic cylinder piston ram ... | 60 mm |

Besides, pulley and belt of various sizes may be used.

**Friction Welding Theory:**

It can be mentioned here that no surface is extremely smooth; it contains some hills and valleys and also some oxide films which prevent two surfaces coming in close contact for the intermolecular cohesive forces to join them together. The purpose of friction welding is to remove the surface unevenness and to apply the requisite amount of pressure to form the joint.

When two surfaces are rubbed together under considerable pressure as applied in friction welding machine, uneven surface points collide with each other, all the oxide films are ruptured and metallic or intermetallic bonds are formed. In this process, the mechanical energy is transformed to heat energy. As the friction temperature increases, the forging surfaces deform. When the increased friction heat is about to make the interface of the two surfaces plastic, with a final application of forge pressure, the joint is made. It should be kept in mind that the machine is stopped immediately the joint forms, otherwise a small amount of movement will rupture the welded joint. The surface which will be under pressure will obviously increase and the metal will upset and be forced out of joint area forming a collar. The displacement of the metal carries away oxides and other contaminants out of the weld zone.

The photographs illustrate some of the welded samples made by friction welding machine developed at MERADO. Welding (Fig. 3a & 3b).

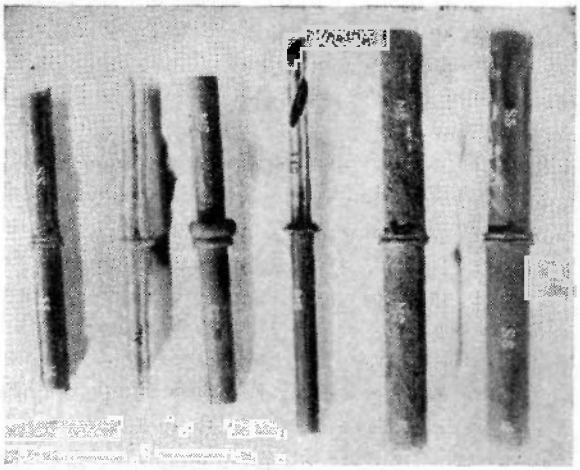

*Fig.*—(3*a*)

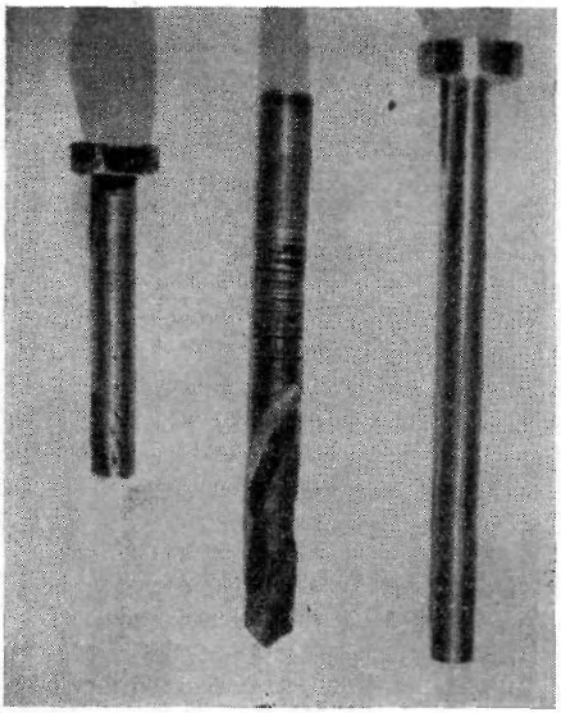

*Fig.*—(3*b*)

EXPERIMENTS :

Experiments have been carried out by the machine designed and developed at CMERI welding MERADO. Some of the results are presented below :

| Sl. No. | Material combination. | Dia of rod to be welded (mm) | Friction force (tons) | Friction time (sec) | Forge force (tons) | Forge time (sec) | Speed r.p.m. | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1. | Al to Al | 12 | 0.2 | 4 | 0.36 | 1 | 1500 | |
| 2. | MS to MS | 12 | 0.2 | 4 | 0.40 | 2 | 1500 | |
| 3. | MS to MS | 16 | 0.54 | 5 | 0.80 | 2 | 1500 | |
| 4. | MS to SS | 12 | 0.3 | 6 | 0.40 | 2 | 3000 | |
| 5. | MS to SS | 12 | 0.2 | 6 | 0.40 | 2 | 1500 | |
| 6. | MS to HMS | 18 | 1.2 | 6 | 1.80 | 2 | 1500 | |
| 7. | MS to HSS | 14 | 0.54 | 5 | 0.80 | 1 | 1500 | |
| 8. | MS to Al | 12 | 0.2 | 6 | 0.40 | 1 | 3000— | Welding is not up to the mark. Further study needed. |
| 9. | MS to Cu | 12 | 0.2 | 4 | 0.50 | 2 | 3000 | |
| 10. | Al to Cu | 12 | 0.2 | 2 | 0.50 | 3 | 3000— | Further study needed |

The process is unaffected by voltage fluctuations.

No spatter takes place during welding. A neat and smooth weld flash is produced.

**Application:**

Application of friction welding is found in the welding of engine valves with dissimilar metals (EN 56 and MS); drills, reamers whose shank can be of somewhat cheaper material such as mild steel and the usable portion which may be of costly material. All these will appreciably reduce the cost of production because of less requirement of costly material and also saving of material in welding two different diameters. A series of plants like tractor, electric tool manufacturing plants etc. in Russia, have already introduced friction welding machine in their production line.

**Testing:**

Destructive, non-destructive and metallurgical tests have been carried out on the welded samples made by friction welding machine and successful results have been achieved. Some microphotographs of the friction welded joints of similar and dissimilar metals are presented (Fig. 4a, 4b, 4c).

**Advantages:**

Besides its importance in joining dissimilar metals, friction welding can show a few other advantages that conventional welding methods do not have.

Time, speed and pressure can be correctly controlled according to the requirement by timers and regulators. The preparation of faces to be joined is not necessary.

The absence of fumes and radiation and minimum time required for welding are some of the other advantages of friction welding machine.

**Conclusion:**

From the above work, it can be concluded that friction welding can be applied to various similar and dissimilar metals. The results obtained are also encouraging. The friction welded joints are as strong as conventionally welded ones. As regards fatigue,

friction welds are generally found superior to other welds owing to the exclusion of foreign matter.

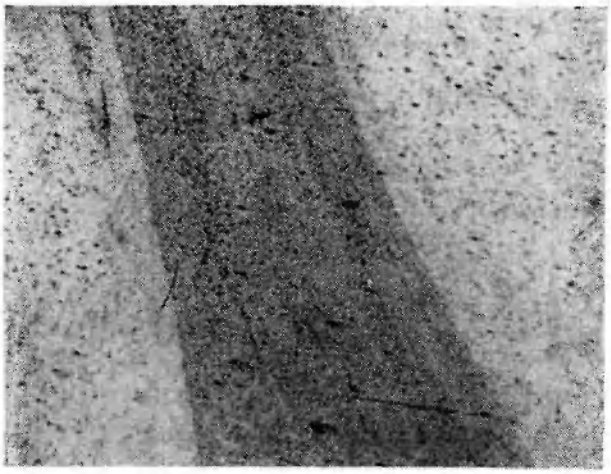

*Fig.—4a (Microphoto shows the complete bonding Al-Al).*

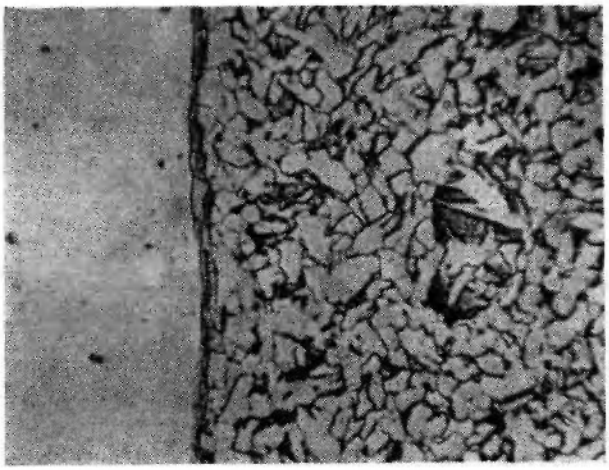

*Fig.—4b (Microphoto shows the complete bonding of mild steel to stainless steel. Unetched portion is stainless steel side, etched portion is mild steel).*

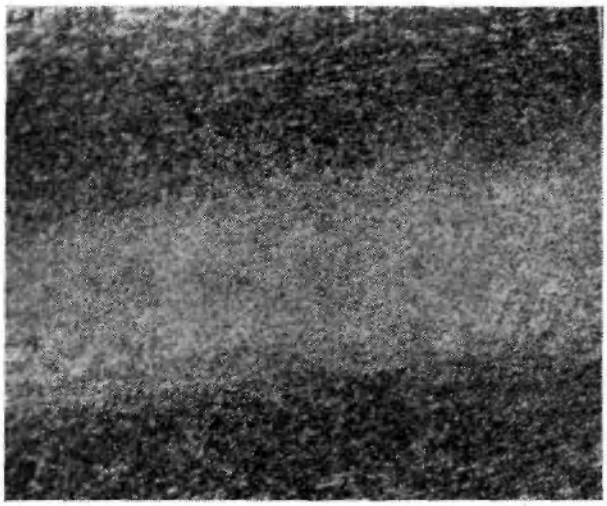

*Fig.—4c (Microphoto shows the complete bonding of stainless steel to stainless steel).*

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