EXPERIMENTAL WORK ON FRICTION WELDING OF SIMILAR AND DISSIMILAR METALS

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ABSTRACT-Friction welding method is one of the most simple, economical and highlyproductive methods in joining similar and dissimilar metals. It involves moving onecomponent relative to the other component to generate required amount of heat followedby application of lateral force (called upsetting force) to plastically displace and fusematerials. Technically, because no melt occurs, friction welding is not actually a weldingprocess in the traditional sense, but a forging technique. However, due to the similaritiesbetween these techniques and traditional welding, the term has become common.

Friction welding requires no filler materials. Hence, the properties won't bealtered to a great extent and the weld doesn't suffer from any inclusions and gas porosity as compared to any other type of welding. Also, it is a very fast process because of whichheat affected zone in the base metal is much less when compared to other weldingprocesses. The weld obtained will also have greater strength than that of the otherwelding process. 100% metal to metal contact can be achieved using friction welding.

This paper aims to first overcome the defects and increase the weld quality over the conventional welding. An attempt is made to extend the benefit of friction welding tosmall industries. A friction welding is attached to heavy duty engine lathe. Experiments areconducted on similar and dissimilar materials and the results are obtained.The mechanical properties obtained at different spindle speeds are recorded andhardness at the heat affected zone is measured. The experimental results prove that a heavy dutylathe can perform friction welding up to 20mm diameter. Investigations are carried onmild steel (AISI 1040), aluminium alloy (7075) and medium carbon steel (EN8) as similar combinations. For dissimilar experimentation, aluminium alloy (7050) and medium carbonsteel (EN8) are used.

1.INTRODUCTION

1.1 LATHE MACHINE

Lathe machine plays a very important role in manufacturing industry. Almost alloperations can be done on this versatile machine. However, accuracy will vary fromoperationseveral trials have been made to perform different types of welding on lathe.Weldingprocesses However, with proper attachments friction welding can be performed on lathe without any hassle. The main motto of the project is to perform rotary friction welding on a heavy duty Automatic Geared lathe Machine by modifying it to match the requiredrequirements.

1.2.FRICTION WELDING

Friction welding is a class of solid-state welding processes that generates heat through mechanical friction between a moving work-piece and a stationary component, with the addition of a lateral force called "upset" to plastically displace and fuse the materials. Technically, because no melt occurs, friction welding is not actually a welding process in the traditional sense, but a forging technique. However, due to the similarities between these techniques and traditional welding, the term has become common. Friction welding is used with metals and thermoplastics. Friction welding achieves 100 per cent metal-to-metal joints, giving parent metal properties. It is the only joining process to do this. No addition material or fillers are required and there are no emissions from the process. The process involves making welds in which one component is moved relative to, and in pressure contact, with the mating component to produce heat at the faying surfaces. Softened material begins to extrude in response to the applied pressure, creating an annular upset. Heat is conducted away from the interfacial area for forging to take place. The weld is completed by the application of a forge force during or after the cessation of Relative motion. The joint undergoes hot working to form a homogenous, full surface, high-integrity weld.

Principle of Friction Welding: Metals are made up of positive ions 'floating' in a 'sea' of electrons.

However, in a practical situation metal pieces do not spontaneously bond to each other and form 1 piece. This is because even polished metal surfaces have a layer of oxide and surface contamination. They are also not smooth enough for the atoms to be brought close enough to bond.In friction welding, the surfaces are rubbed together to burn off the oxide and surface contamination layers and bring the atoms in close enough proximity to bond.

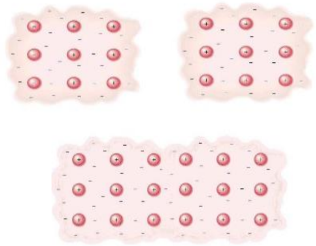

Fig 1: Electrons when both metals are combined

1.3 ROTARY FRICTION WELDING

The rotary friction welding process is inherently flexible, robust and tolerant to different qualities of materials. The parameters involved are the rotational speed, time and force applied. There are optimum parameters for each particular weld that Thompson Friction Welding has calculated through years of experience. However, as the process is inherently robust and flexible, deviations on these parameters can still give a good weld.

2. PROBLEM DEFINITION

The inability of fusion welding to produce good weld quality in welding the circular parts paved way for development of newer welding techniques. Also welding of light weight metals like aluminium was being a matter of concern. Above all the conventional welding has defects like porosity, slag inclusion, incomplete fusion and penetration, weld profile, cracks and surface damage.

The main short comings of conventional welding are listed below

1. Fusion welding processes generates fumes, gases or smoke which maycause harmful effects on operators.
2. Infusion welding process, possibility of porosity and slag inclusions aremore.
3. Less process efficiency with high energy consumption.
4. Welding of dissimilar alloys and complex shapes is difficult.
5. Heat affected zone is more.
6. Distortion of work pieces and spatter is the most common problem infusion welding.

Above discussed welding defects and disadvantages in conventional weldingprocesses canbe effectively overcome by adopting new solid state welding techniquecalled Inertia or “Friction Welding” that is being developed.Now In developing this project many problems have been encountered in manyphase before it got completed. Since friction welding was being aimed to performwelding on higher diameters the first and foremost task was to increase the speed ofconventional lathe from 1440 rpm. Next immediate task was to modify the spindle rod soas to hold the specimens in order to perform the welding.

3. OBJECTIVE OF THE EXPERIMENT WORK

The following are the main objectives of the work

1. To develop the Rotary Friction welding setup on the lathe machine.
2. To perform Friction welding on similar metals.
3. To perform Friction welding on dissimilar metals.
4. To perform Friction welding on varying diameters.
5. To test the tensile strength of the weld joint.
6. To check the hardness of the welded material.
7. To compare the tensile strength results with the strength of the base metal.

4. EXPERIMENTATION

4.1 SPECIMENS

We have performed rotary friction welding on variety of specimens with varying diameter. Different materials of specimens that are taken up are mild steel (MS), medium carbon steel (EN8) and aluminium (Al). We have performed welding with similar and dissimilar combinations of materials. Combinations taken up are as follows

1. MS-MS
2. Al-Al
3. EN8-Al

The different diameters of the specimens taken were

MILD STEEL (MS)	16MM
MEDUIM CARBON STEEL(EN8)	16MM
ALUMINIUM (7075)	12MM

4.2 PARAMETERS CONSIDERED

The important parameters that influence the weld formation while performing welding are

- Speed of rotation in rpm
- Diameter of specimens

4.3 EXPERIMENT SETUP ON LATHE MACHINE

The tool in the tool post have been replaced with the required rode of certain diameter as per the need. Then the tool post is moved near the other rod which is to be welded which is placed in the three jaw chuck attached to the spindle of the lathe machine.Then the machine is turned on and the operation of friction welding takes place on the lathe machine.

In order for a join to be successful the following process in terms of phases must take place:

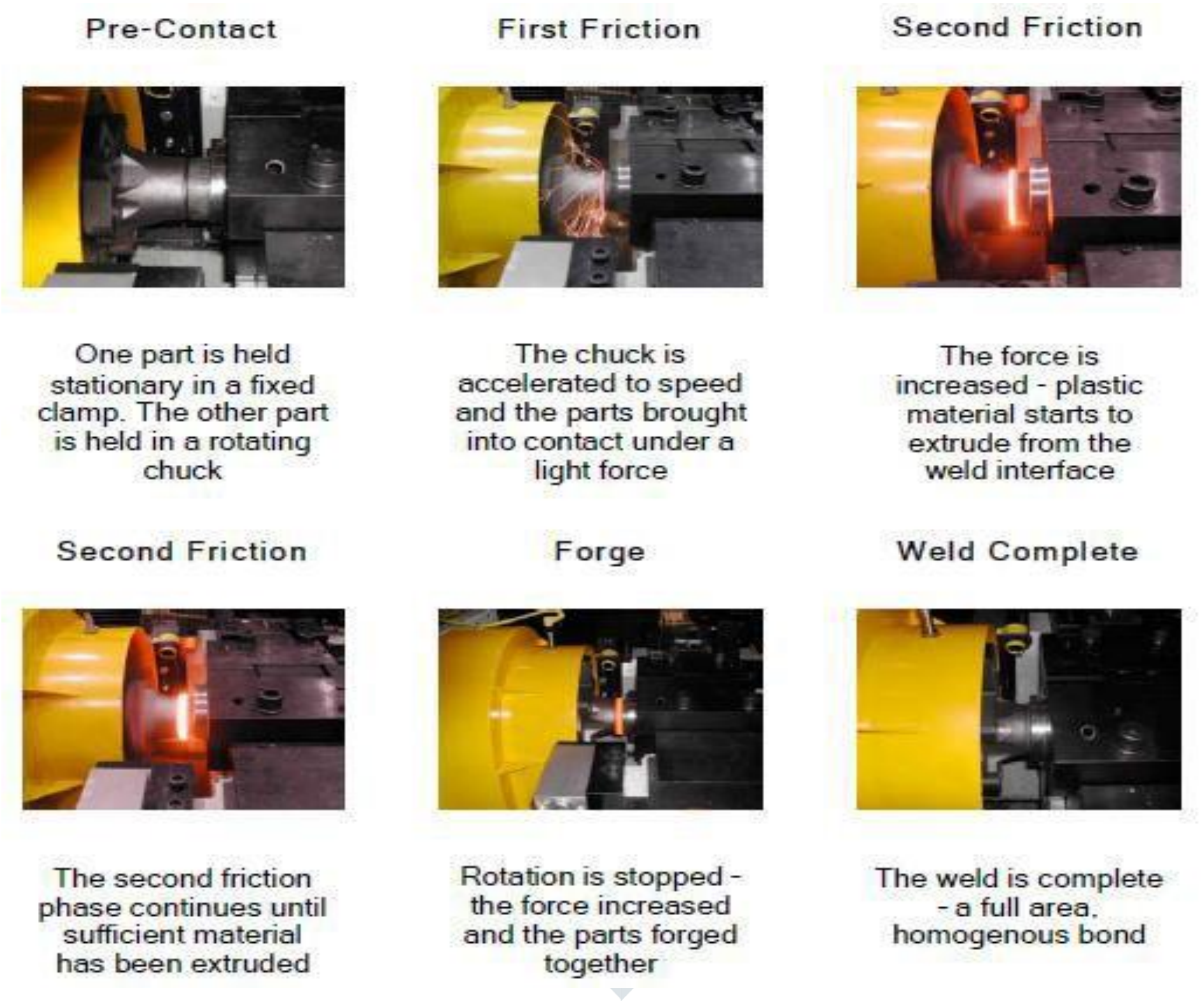

Fig: Steps involved in rotary friction welding

4.4 STEPS INVOLVED IN PERFORMING ROTARY FRICTIONWELDING ON LATHE

The following steps are involved in performing rotary friction welding

- First, measure the diameters of the two jobs using vernier callipers and fix them in the two chucks firmly using key.
- Move the tool post closer to the main chuck till the two work pieces are just apart.
- Make sure that the shaft is stationary, 3 jaw chuck is locked using the locking lever so that the work piece won't move.
- Now, turn the lathe so as to rotate the 1st work piece at required speed.
- Check the speed using tachometer.
- Now start applying pressure using the tool post.
- Slowly increase the pressure until the required amount of heat is generatedand molten state is reached.
- Once the bur formation starts taking place, stop the lathe machine and start giving maximum feed to the joint.
- Turn off the lathe and wait till the rod cools down.
- Use gloves carefully to take out the welded job out of chuck.
- The friction weld joint is completed.

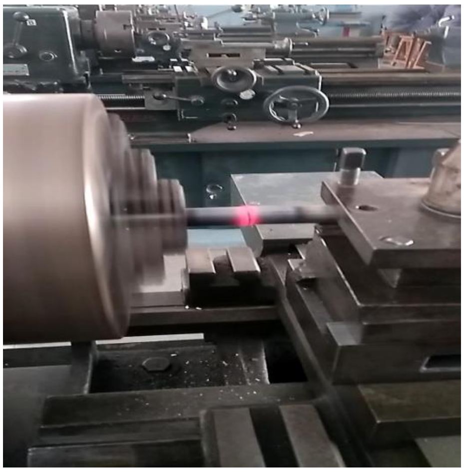

Fig: Friction welding phase-4

Fig: Friction welding phase-5

5. TESTING OF WELDED SPECIMENS

5.1 LOAD TEST ON UNIVERSAL TESTING MACHINE

5.1.1 UTM and Its Specifications

Various machine and structure components are subjected to tensile loading innumerous applications. For safe design of these components, their ultimate tensile strength and ductility one to be determine before actual use. Tensile test can be conductedon UTM.

A material when subjected to a tensile load resists the applied load by developing internal resisting force. These resistances come due to atomic bonding between atoms of the material. The resisting force for unit normal cross-section area is known as stress.The value of stress in material goes on increasing with an increase in applied tensile load, but it has a certain maximum (finite) limit too. The minimum stress, at which a material fails, is called ultimate tensile strength. The end of elastic limit is indicated by yield point (load). This can be seen during experiment with increase in loading beyond elastic limit original cross-sectional area (A) goes on decreasing and finally reduces to its minimum value when the specimen breaks.

The tensile test is conducted on UTM. It hydraulically operates a pump, oil in oil sump, load dial indicator and central buttons. The left has upper, middle and lower cross heads i.e., specimen grips (or jaws).Idle cross head can be moved up and down for adjustment .The pipes connecting the left and right parts are oil pipes through which the pumped oil under pressure flows on left parts to move the cross-heads.

SPECIFICATIONS:

1. Load capacity =0-60000kg
2. Least count =20kg

Table1.Complete Tensile Test report of various Friction Welded specimens

S.NO.	Specimen	Specimen Diameter (mm)	Final Diameter (mm)	Ultimate Load (kg)	Ultimate Tensile Strength (N/mm^2)	Cross section Area (mm^2)	Surface Hardness	Final Gauge Length (mm)
1	MS-MS	16	0	97.640	486.837	200.56	93.00	0
2	AL-AL	12	0	3.240	28.364	114.231	54.33	0
3	MS-AL	16	0	5.28	38.24	110	64	0

5.2 HARDNESS TEST

Hardness of the specimens can be found by using any of the two tests, BRINELL HARDNESS TEST and ROCKWELL HARDNESS TEST.Hardness represents the resistance of material surface to abrasion, scratching and cutting, hardness after gives clear identification of strength. In all hardness tests, a define force is mechanically applied on the test piece for about 15 seconds. The indenter, which transmits the load to the test piece, varies in size and shape for different tests.Common indenters are made of hardened steel or diamond

Brinell Hardness Test:

In Brinell hardness testing, steel balls are used as indenter. Diameter of the indicator and the applied force depend upon the thickness of the test specimen, because for accurate measures depth of indentation should be less than 1/8th of the thickness of the test pieces. According to the thickness of the test piece increase, the diameter of the indicator and force are changed.

Rockwell Hardness Test:

Rockwell hardness tester presents direct reading of hardness number on a dial provided with the machine. Principally this testing is similar to Brinell hardness testing. It differs only in diameter and material of the indenter and the applied force. Although there are many scales having different combinations of load and size of indenter but commonly 'C' scale is used and hardness is presented as HRC . Here the indenter has a diamond cone at the tip and applied force is of 150kgf. Soft materials are often tested in 'B' scale with a 1.6mm diameter Steel indenter at 60kgf. Since Rockwell hardness number is directly displayed and also it is easy to perform the Rockwell hardness test, we are conducting Rockwell hardness test to know the hardness values at different locations on the welded specimens.

Specifications of a Brinell cum Rockwell hardness testing machine are as follows

1. Diameter of ball (as indicator) used D=2.5mm, 5mm, 10mm.
2. Maximum application Load =2000kgf
3. Method of load application = Lever type
4. Capability of testing the lower hardness range= 1BHN on application of 0.5D load.

Table2.Complete Hardness Test report of various Friction Welded specimens

S.No.	Specimen Material	Location	Observed values in HRB			
			Impression 1	Impression 2	Impression 3	Average
1	Mild Steel	On Surface	92	93	94	93
2	Aluminium	On Surface	54	55	54	54.33

CONCLUSION

The paper presents the complete planning, implementation and testing in the friction welding process. Starting from how to modify the lathe machine for enabling it to perform the friction welding to final phase of testing the weld profile. Carrying out the experimental work at 3600rpm has proved to provide excellent results in the weld quality and the strength of the weld. Although the strength was high in weld joints of similar specimens compared to dissimilar ones, the overall strength is good in both the cases. The findings of the microstructural analysis has also proved that the grain structure has not changed much and the heat affected zone was also very less compared to that obtained in conventional welding.Concluding the overall analysis has proved that friction welding is the most cost effective, efficient and is with minimum defects.

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