Analysis of friction welding in conventional lathe machine

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Abstract—Conventional welding technique is used to weld only hard materials and also defects like porosity, alloy segregation, hot cracking, hydrogen embrittlement are encountered. To comprise this, friction welding has been employed which can weld soft materials and also it overcomes the defects of conventional welding techniques. The friction welding which welds both similar and dissimilar metals finds its applications in various fields like submarine industries, aerospace industries, automobile industries because of its simple, economical and high productive nature. Normally industries aims to earn more profits with their limited resources. Major problems investigated in small scale industries are cost and space requirement. To eliminate such problems we attempt an idea of employing welding on lathe machine so that the difficulty of welding on separate machine can be avoided. Our project describes the low cost method of frictional welding on conventional lathe machine and to analyse the welded parameters.

Keywords—Hydrogen embrittlement, High strength.

I. INTRODUCTION
Welding is a fabrication process that joins materials usually metals or thermoplastics by causing fusion which is somewhat different from low temperature metal joining techniques like brazing and soldering that doesn't melt the base metal. In addition to melting the base metal, a filler metal is typically added to the joint to form a pool of molten metal also called as weld pool which later cools to form a joint stronger than that of the base metal. Pressure may also be used in conjunction with heat to produce a weld.

Friction Welding (FRW) is a solid state welding process which produces welds due to the compressive force and the work pieces are either rotating or moving relative to one another. Heat is produced due to the friction which displaces material plastically from the faying surfaces. In friction welding the heat required to produce the joint is generated by friction heating at the interface. The components to be joined are first prepared to have smooth, square cut surfaces. One piece is held stationary while the other is mounted in a motor driven chuck or collets and rotated against it at high speed. A low contact pressure may be applied initially to permit cleaning of the surfaces by a burnishing action. This pressure is then increased and contacting friction quickly generates enough heat to raise the abutting surfaces to the welding temperature. As soon as this temperature is reached, rotation is stopped and the pressure is maintained or increased to complete the weld. The softened material is squeezed out to form a flash. A forged structure is formed in the joint. If desired, the flash can be removed by subsequent machining action. Friction welding has been used to join steel bars up to 100 mms in diameter and tubes with outer diameter up to 100 mm. Inertia welding is a modified form of friction welding, where the moving piece is attached to a rotating flywheel. Lathe allows one to produce cylindrical pieces by holding the work piece in the work holding device called chuck. When it is switched on, the chuck revolves and forces the metal to revolve with it. By using proper tools, the desired lathe operations can be performed. It is called Conventional because it might not be fully automated.

II. MATERIAL SELECTION
The material selected in this project is Mild steel and Aluminium alloy. Both the specimens are in the form of cylinder which is 12mm in diameter and 75mm in length. Conventional lathe is used to perform friction welding process. An aluminium alloy, with magnesium and silicon as the alloying elements. It has generally good mechanical properties and is heat treatable and weld able. It allows complex shapes to be formed with very smooth surfaces fit for anodizing. The alloy composition of AA is silicon minimum 0.2%, maximum 0.6% by weight. Magnesium minimum 0.45%, maximum 0.9% by weight. Mild steel is known for its good mix of strength, ductility and hardness. It has excellent weld ability and produces a uniform and harder case and it is considered as the best steel for carburized parts. Low carbon welding electrodes are to be used in welding procedure, and post-heating and pre-heating are not necessary. Pre-heating can be performed for sections over 50mm, post-weld stress relieving also has its own beneficial aspects like the pre-heating process.
III. EXPERIMENTAL WORK

A. Working process

Conventional lathe machine is used for the friction welding of two dissimilar metals. The setup is done by fixing one work piece to the chuck and the other work piece is fixed to the drill chuck. Here the chuck is rotated where other work piece on the drill chuck is kept stationary.

A drill chuck is fixed to the lathe machine and the two work pieces which are to be welded are inserted to the lathe chuck and the drill chuck. The chuck is rotated to maximum rpm(1440), where the work piece also rotates along with the chuck. The work piece in the drill chuck is pressurized over the fast rotating work piece. Friction is created and the temperature increases. Continuous increase in temperature creates a red hot zone. At this moment the reverse braking is applied to have a proper weld. If there is no proper braking system there will not be a proper weld formed.

B. Analysis of welded parts

1. Tensile strength

Tensile strength is a measurement of the force required to pull something such as rope, wire, or a structural beam to the point where it breaks. The tensile strength of a material is the maximum amount of tensile stress that it can take before failure, for example breaking.

There are three typical definitions of tensile strength:

Yield strength - The stress a material can withstand without permanent deformation. This is not a sharply defined point. Yield strength is the stress which will cause a permanent deformation of 0.2% of the original dimension.

Ultimate strength - The maximum stress a material can withstand.

Breaking strength - The stress coordinate on the stress-strain curve at the point of rupture.

2. Hardness

Hardness is a measure of the resistance to localised plastic deformation induced by either mechanical indentation or abrasion. Some materials (e.g. metals) are harder than others (e.g. plastics). Macroscopic hardness is generally characterized by strong intermolecular bonds, but the behaviour of solid materials under force is complex; therefore, there are different measurements of hardness: scratch hardness, indentation hardness, and rebound hardness. It is dependent on ductility, elastic stiffness, plasticity, strain, strength, toughness, viscoelasticity, and viscosity.

Common examples of hard matter are ceramics, concrete, certain metals, and super hard materials, which can be contrasted with soft matter.

3. Dye penetrant inspection:

Dye penetrant inspection (DPI), also called liquid penetrate inspection (LPI) or penetrant testing (PT), is a widely applied and low-cost inspection method used to locate surface-breaking defects in all non-porous materials (metals, plastics, or ceramics). The penetrant may be applied to all non-ferrous materials and ferrous materials, although for ferrous components magnetic-particle inspection is often used instead for its subsurface detection capability. LPI is used to detect casting, forging and welding surface defects such as hairline cracks, surface porosity, leaks in new products, and fatigue cracks on in-service components.

4. Macrostructure

The quality of the joint profile of the welded material were assessed by an optical inspection employing a scanning electron microscope that provides a magnification factor in a range between M=5x and M=500x. The evaluation of welded profile can be made by providing micro structure of the welded joint.
6. Microstructure

Based on microstructure analysis of transverse cross section, characteristic zone of grains and precipitates were analyzed. Due to presence of inter mixture this area is mainly affected by precipitates or oxidation inclusions. Secondly thermodynamically affected zone, this zone between the mild steel and aluminium alloy is characterized by thermo mechanical forming which result in re crystallized fine grained microstructure. Thirdly, the heat affected zone which is located between the thermodynamically affected zone and parent material. This zone is exposed to a thermal treatment but does not experience any plastic deformation which leads to different micro structural properties.

IV. RESULTS

This chapter describes the results obtained after the experimental work and deals with the quality of the product by conducting of various test. It also deals with the mechanical properties for materials of mild steel and aluminium. Friction welding has been done for dissimilar material. It has been carried out in conventional lathe machine. The work piece which is welded is tested in laboratory. The purpose of the lab testing is to know the hardness, tensile strength and micro and macro structure of the welded piece.

1. Tensile test results

![Fig 3. Tensile test specimen](image)

<table>
<thead>
<tr>
<th>Test parameters</th>
<th>Observed value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultimate tensile strength</td>
<td>133</td>
</tr>
<tr>
<td>Fracture location</td>
<td>Weld</td>
</tr>
</tbody>
</table>

Table 1. Recorded value of tensile test

Tensile testing is done on universal testing machine of 400KN capacity. The geometry of the tensile test specimen in shown in fig 3. The mechanical property of the weld material is also considered. Tensile strength of aluminium alloy and mild steel at the joint of the specimen is found and the ultimate tensile strength is 133 MPa. Fracture location is at welded region.

2. Hardness test results

<table>
<thead>
<tr>
<th>Location</th>
<th>Observed Values Hv5kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base aluminium</td>
<td>48.6, 50.2, 48.8</td>
</tr>
<tr>
<td>Base steel</td>
<td>199, 195, 192</td>
</tr>
<tr>
<td>Weld</td>
<td>46.6, 48.8, 45.6</td>
</tr>
</tbody>
</table>

Table 2. Hardness test results

Micro hardness of aluminium alloy and mild steel was 49VHN and 192VHN respectively. Micro hardness data of fusion welding between aluminium alloy and mild steel was shown in table 2.

4. Dye Penetrant Test result

Dye Penetrant Test has been carried out in welded zone to know the surface defects. This is done by smearing penetrant and developer. After few minutes the defect area will be clearly visible. If there are no defects the material will not show any change. Our weld has no surface defects.

![Fig 4. DPT specimen](image)

3. Micro and Macro structure results

Both the micro and macrostructure has been analysed using scanning electron microscope. The heat affected zone of aluminium alloy is recorded. The studied structure of the mild steel and aluminium are shown below.

<table>
<thead>
<tr>
<th>Location</th>
<th>Observed values Hv5kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAZ aluminium side</td>
<td>45.8, 44.8, 44.0</td>
</tr>
<tr>
<td>HAZ steel side</td>
<td>178, 180, 178</td>
</tr>
</tbody>
</table>

Table 3. Heat affected zone of aluminium alloy and mild steel
V. CONCLUSION

The conventional lathe machine is better than friction welding machine and the conventional lathe machine is less expensive than the friction welding machine. There will not be any welding defects like porosity, hot cracking in other welding process. Very high static strength. Short welding time improves the efficiency. No filler material is used, thus minimize the total cost. The various tests has been applied to the welded part and the result were proven to be good.

REFERENCES


