Microstructure and Mechanical Characterization of Friction Welding Process - A Review

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***Abstract*:- Nowadays the industries are in huge demand of new materials essential for their requirements for different applications such as aerospace, railways and automobile Industry. Friction welding is a solid state welding processes in which the weld is obtained by the heat generated due to forging and friction. The advantages of friction welding process are reduction in production time and cost saving. The joining of metals, which are not possible to weld with fusion welding, can be done with this process. In this Technology, the required heat to fuse two metals to join with each other without melting is caused by means of rotary friction. In present study, the researches of previous years have been taken into review concerning the microstructure, strength of the joint and micro-harness of weld near the joint.**

Keywords: Friction welding, Mechanical properties, microstructure.

1. INTRODUCTION

Friction welding has great potentials in the field of aerospace and in other industrial applications specially in the production of steering shaft, tulip shaft, aluminum guide roller, track roller gear coupling body, flange gear and engine valve in automobile industry. In friction welding process, heat is generated by conversion of mechanical energy into thermal energy at the interfaces of the components during rotation under pressure without any energy from environment 1-3. In continuous-drive method, one of the components is rotated at a constant speed (s), while the other is pushed toward the rotated part by a sliding action under a predetermined pressure – friction pressure. Friction pressure is applied for a certain friction time. Then, the drive is released and the rotary component is quickly stopped while the axial pressure is being increased to a higher predetermined upset pressure for a predetermined upset time4. In the continuous drive friction welding process, one of the parts was held stationary while the other was rotated at a constant speed (n). The two parts were brought together under axial pressure (P1) for certain friction time (t1). Then the clutch was separated from the drive, and the rotary component was brought to stop within the braking time (t2) while the axial pressure on the stationary part was increased to a higher forging pressure (P2) for predetermined upset time (t4). Schematic diagram of the continuous drive friction welding weld cycle is presented in Figure1.

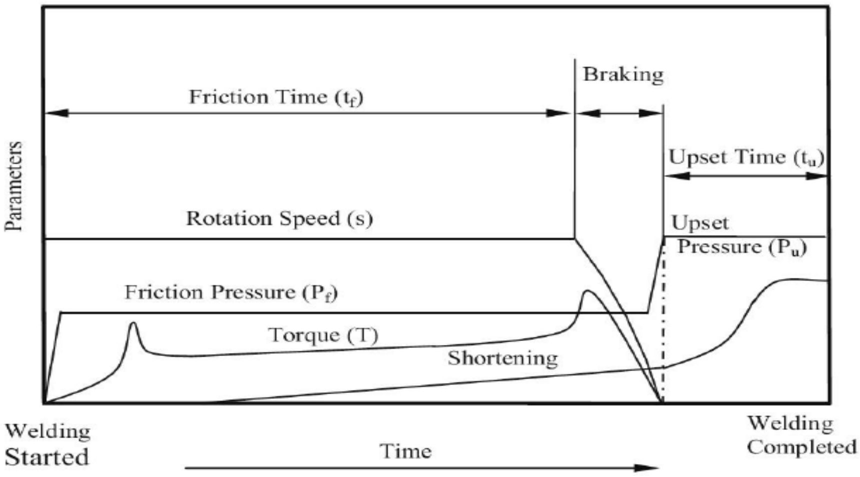

Figure 1. Friction weld cycle

2. LITREATURE REVIEW

Muralimohan et al. studied the microstructure and mechanical properties of dissimilar weld joints of aluminum alloy 6082 and copper alloys using continuous drive friction welding process. They observed that the tensile strength and impact strength of the weld joints gradually increased with increase in forging pressure over the 80MPa. At the conditions, tensile strength and impact strength was exhibited at 198MPa and 28J. It was higher than the base metal. The high level of forging pressure and longer friction time is directly proportional to the strength of the weld joints. The microstructure of the Al/Cu weld interface is shown in SEM micrograph. From the image, it is clearly indicates the deformation occurred on Al side due to the dislocation of atoms through weld interface.

Shanjeev et al. analyzed the dissimilar material of AISI 4140 steel and AISI 1050 steel and mechanical properties of all the samples made by friction welding, the sample S18 and S21 are obtained as lowest (157 MPa) and highest (238 MPa) of tensile strength values respectively. Low upset pressure results insufficient time for the material to heat up and bond strength is reduced. The bond strengths were comparable to that of parent material in copper. The highest tensile strength obtained in friction welded joint was 2.52% higher than parent material of copper whose tensile strength was 232 MPa. Topographic and phase images were obtained simultaneously using a resonance frequency of approximately 300 kHz for the probe oscillation and afree-oscillation amplitude of 62 nm ± 2 nm. The microstructure of inter phase layer in dissimilar material is seen in atomic force microscopy.

Efe et al. conducted on a twin head direct drive rotary friction welding machine which has an upset force capacity of 15 ton. The welding parameters used are as follows: friction pressure rate of 15 MPa per second, forging pressure rate of 37 MPa per second, and rotational speed of 900 rpm. The macrostructure properties in the welding interface of the welded samples were observed and the microstructure of the friction welding joints was investigated by using an optical microscope.

Martin Charles et al. Friction welding is used extensively in joining of similar and dissimilar materials for the many engineering applications. The base material EN 24(AISI 4340) steel is used in this investigation as circular form with dimension of 16 mm diameter and 100 mm length. the S/N ratio for the axial shortening, heating time plays major role in axial shortening. The optimum values are 25 Bar of heating pressure, 35 Bar of upset pressure, 5 sec of heating time and 3 sec of upset time. During friction welding, the softness of material begins to extrude with upsetting time due to excessive heat generation. The optimum parameters of friction welding are 19 Bar for heating pressure and 29 Bar for upset pressure and 7 sec for heating time and 3 sec for upset time. Increase in heating pressure results an increase in hardness values. This may be attributed to the predominant plastic deformation.

Mumim Sahin et al. investigated the hardness variations and microstructure at the interfaces of steel welded joints .micro hardness test was used and the hardness measurements and micro examination were done in accordance with ASTM E384-01 and ASTM E407-01 standards respectively. The hardness of the samples increased at the welding interface. Joining of high tensile strength steel (728 MPa) to lower tensile strength steel (622 MPa).

Amit Handa et al. studied the mechanical properties of friction welded AISI 304 with AISI 1021 steels, produced by mechanical joining, have been investigated. Samples were welded under different axial pressures ranging from 75 to 135MPa, at constant speed of 1250rpm. The existing lathe machine model “Kirloskar [MK 1675]”, speed range 30–1600 rpm, was used for this experimentation work. the variation of stress vs. strain behavior at different axial pressures, it depicts that with the increase in stress the strain increases. During tensile testing, brittle fracture appeared at 75 and 90MPa axial pressures and the joint failed on the weld interface without showing any necking; whereas, at an axial pressure of 105MPa, the joint also failed from the weld interface but little necking appeared at the interfaces; whereas, cup and cone fractures observed at pressures of 120 and 135MPa.

Rajesh Jesudoss Hynes et al. analyzed the welding process of AA6061-T6 alloy and another specimen having f 20 mm × 70 mm made of AZ31B alloy were used. To attain a good bonding mechanism and to improve the strength of dissimilar weld, the process parameters play a vital role in friction welding process. . It was found that, by increasing the value of friction time, the value of the tensile strength increases and the result of tensile strength is found to be 120 MPa at a friction time of 10 s. h results in the occurrence of maximum displacement at the interface of the welded joint on the AZ31B alloy side. It was also observed that, the weakest point existed at the interface of the welded joints. The maximum strength of 120 MPa was achieved at a rotational speed, friction pressure and friction time of 1200 rpm, 10 bar and 10 s respectively. the Micro structural examination of the parent metal, the etchant used was 2% Nital and a magnification of 100 µm is used. The micro structural examination revealed that there were three distinct zones namely AA6061-T6 alloy parent metal, a plastically deformed interface and the AZ31B alloy parent metal.

Amit Handa et al. analyzed the welding process of Austenitic stainless steel AISI 304 and low alloy steel AISI 1021 specimens having diameter of 20 mm and 100 mm length were joined together by friction welding. The chemical composition of austenitic stainless steel and low alloy steel is presented. . The required rotational speeds of 800, 1000, 1250, 1430 and 1600 rpm were set by the levers attached on this machine. Within a fraction of seconds. The welds were prepared at different axial pressures in the steps of 15 MPa starting from 75 MPa to 135 MPa to form different welds for the study. , the specimens were prepared at 1250 rpm, tensile tested and it was observed that the specimens welded at 75 MPa, 90 MPa and 105 MPa were failed at the weld interface but they show necking behavior before getting failed at the interfaces. The welded specimens at 120 MPa and 135 MPa. The maximum strain obtained here was 0.37 and maximum stress was observed to be 467 MPa.

Sathiya et al. investigated the welding process parameters in friction welding of stainless steel (AISI 304) by using non conventional techniques. A continuous drive friction welding machine (KUKA, Germany) with a maximum 150 kN load was used for welding. The friction and forge pressures are in the range of 15–25 bar and 35–45 bar respectively. The spindle rotating speed was kept constant at 1125 rpm and the welding was performed under the specified friction upset distance. Austenitic stainless steel (AISI 304) specimens of size 16mm diameters and a length of 160mm were used as parent materials in this study. The chemical composition of the specimen material is presented.

Pandiarajan et al. carried out to weld two dissimilar materials of SA 213 tube to SA 387 tube plate using an external tungsten carbide tool to enhance and validate the mechanical and metallurgical properties. The joint strength for the welded work piece was maximum at the rotational speed 1320 rpm, depth 1.0 mm and projection was 0 mm. The maximum compressive strength for without hole is 3062.25 MPa and corresponding values for each factor speed, projection, depth are 1320 rpm, 0 mm and 0.2 mm respectively. the microstructure sample of the optimal joint strength of the work piece with various zones with input parameters as speed, projection and depth of cut was 1320 rpm, 0 mm and 0.2 mm respectively.

3. CONCLUSIONS

In present paper stated in above studies, it can be concluded that friction welding is appropriate technology for joining of aluminium, copper, their alloys and other hard materials such as stainless steel efficiently. It was observed that the friction time has maximum influences on weld strength. Moreover, hardness of the weld is particularly affected by friction pressure. With increase in pressure, hardness in the vicinity of the weld area increases. Microstructure at the weld zone can be controlled with key parameters such as friction time, friction pressure and rotational speed of the metal piece.

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