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Effect of speed on tensile strength and hardness of friction welded joint

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***Abstract**:*

Welding of dissimilar metals take place due to uneven heating in the outide and inside zones of materials. This paper discusses, the Joining of two non-metals like copper, aluminium & brass using friction welding method by varying the different speeds like 1800,1400,1120,960 rpm's to analyse the hardness and strength of a material by conducting Brinell Hardness test hydraulic load test and also studied the effect of time on speed.

Keywords: **friction welding; hardness; tensile strength;**

1. Introduction

The similar or dissimilar metallic or polymer based materials can be joined by solid state process is known as friction welding. In the Bronze age, the gold coins and complex structures were formed through the application of pressure welding. Therefore, the friction welding place a vital role in welding of the similar or dissimilar materials whether it concerns the classical friction welding or the friction welding with mixing. The reason for that are the various advantages of the friction welding procedure, with respect to other welding procedures, primarily in regards with environmental protection and human health [1]. Simultaneously one can obtain the outstanding mechanical properties using friction welding [2-5].

In the past, Sathiya et al. [6] optimized the friction welding process parameters using artificial neural networks and different optimization algorithms. They illustrated the correlation between the input and output responses of the friction welding of incoloy 800H. They also optimized the strength and hardenss of joints with minimum burn off length. They showed that genetic algorithms with artificial neural networks outperform the other four approaches in most of the cases but not in all. Nada Ratković et al. [7] presented the review and analysis of microstructure of the characteristic joint zones in the friction plane of the high-speed steel and carbon steel for tempering. They welded these two metals by varying the friction welding parameters like friction pressure and friction time and monitored the micro structure in the joint zone and its immediate vicinity, both from the side of the tempering steel and the H S steel, as well as defining the present phases and compounds. Senkov et al.[8] determined the relationship between the inertia friction welding process parameters line initial angular velocity, and moment of inertia of the flywheel and axial compression force and welding behaviour like welding time, sample upset and flash formation, efficiency and kinetics of friction-induced sample heating of dissimilar super alloys. They concluded that the initial Kinetic energy of the flywheel should not be considered as a key parameter for the design of the inertia friction welding process. Kimura et al. [9] described the effect of the friction welding condition on joining phenomena, tensile strength, and bend ductility of friction welded joints between pure Al (CPAl) and austenitic stainless steel (AISI 304).They investigated the joining phenomena during the friction process such as joining behavior, friction torque, temperature changes at the weld interface, and transitional changes of the weld interface. They were also investigated the effects of friction time and forge pressure on the tensile strength and bend ductility of joints and also observed the and the metallurgical characteristics. They concluded that the joint, which had high joint efficiency, the fracture on the CP-Al side with no crack at the weld interface, and no IMC inter layer on the weld interface, could be successfully achieved. They suggested that the joint should be made with a high forge pressure of 150 MPa, the opportune friction time at which the temperature on the weld interface reached about 573 K or higher, and those friction welding conditions for obtaining good joints with high joint efficiency and the bend ductility of 90degrees. RadosławWiniczenko et al.[10] studied the mechanical properties and microstructure of a friction welded coupe of weight heavy alloy with aluminium alloy.They investigated the fracture morphology and phase transformations taken place using Scanning electron microscopy. They were used energy dispersive spectroscopy to deremine the chemical compositions of the interfaces of the welded joints.They also studied the effection

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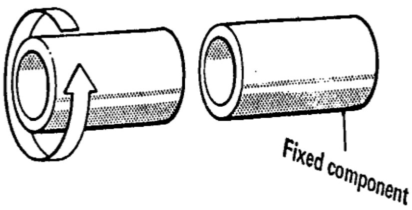
of friction time and friction pressure on the ultimate tensile strength. FurkanSarsilmaz et al. [11]studied the properties of joint made by friction welding process. The materials used to joining were Armor 500 steel and duplex (ferritic/austenitic) steel AISI 2205. They also compared the properties of weld at friction pressure and friction time. Their experimental results indicates that armor 500 steel could be joined to AISI 2205 steel using the traditional friction welding technique. They also the welded joints were tested using axial tension test. They obtained the highest tensile strength, as 1020 MPa when friction time is 8 s and friction pressure is 80 MPa. The microstructures of the alloys and fracture surfaces were also examined by optical and scanning electron microscopy. The results indicate that microstructural and mechanical properties are significantly affected by changing welding parameters within the chosen range of conditions. Prashanth et al.[12] fabricated the Ti6Al4V alloy samples by selective laser melting (SLM). These were subjected to-state welding friction welding (FW). They observed that the welded alloy exhibits a α′-martensitic microstructure in the form of platelets with dimensions in the submicron regime. The base alloy has a relatively coarser microstructure consisting of both α′ and β-phases, as compared to the as-prepared SLM microstructure (single-phase α′martensite). They were also conducted the hardness and tensile tests on the fabricated specimen. Hardness increases in the weld zone due to the refined α′platelets. Their tensile tests reveal an improved ductility for the FW samples at the expense of a marginal drop in strength, compared to the as-prepared SLM samples. Ranvijay Kumar et al. [13] joined the PA6 matrix reinforced with metal powder (Fe) by friction welding with ABS matrix reinforced with Fe powder for structural applications (like : joining of pavement sheets, assembly of pipe lines etc.). They put the melt flow index (MFI) of PA6+Fe powers approximately equal to MFI of ABS+Fe powder by varying the proportion of Fe powder in PA6 and ABS matrix. After mixing the prepared the functional prototypes of circular cross section on fused deposition modeling machine.

The present work deals with the Joining of two non-metals like copper, aluminium & brass using friction welding method by varying the different speeds like 1800,1400,1120,960 rpm's and to analyse the hardness and strength of a materials by conducting Brinell Hardness test hydraulic load test and also studied the effect of time on speed.

2. PRINCIPLE: (INERTIA FRICTION WELDING)

Traditionally, friction welding is carried out by moving one component relative to the other along a common interface, while applying a compressive force across the joint. The friction heating generated at the interface softens both components, and when they become plasticised the interface material is extruded out of the edges of the joint so that clean material from each component is left along the original interface. The relative motion is then stopped, and a higher final compressive force may be applied before the joint is allowed to cool. The key to friction welding is that no molten material is generated, the weld being formed in the solid state.
The principle of this process is the changing of mechanical energy into heat energy. One component is gripped and rotated about its axis while the other component to be welded to it is gripped and does not rotate but can be moved axially to make contact with the rotating component. At a point fusion temperature is reached, then rotation is

Fig 1: One component rotated rapidly, the other is stationary



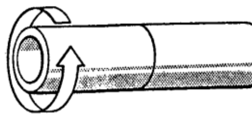


Fig 2:Rotating and stationary components brought together into contact and force applied

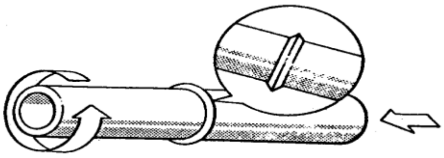


Fig 3:Axial force is increased to bring components into a plastic state at interface

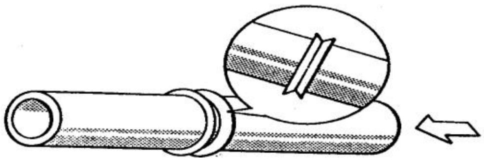


Fig 4: Rotation is stopped and more axial force is applied

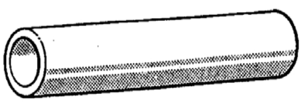


Fig 5: Result - A full cross sectional weld in the parent materials

3. Experimental Details

The materials used and its dimensions are shown below.
Material type : Aluminum-Copper-Brass
Diameters : 20 mm each
Length : 100 mm each

The step by step procedure is presented through Fig 6-9.

Fig 6. FIXING THE RODS

Fig 7. APPLYING AXIAL FORCE

Fig 8. PLASTIC STATE OF RODS

Fig 9. AFTER SOLDIFICATION

Fig 10. Welded components

Fig 10 shows the completed welded materials of Brass, Aluminium, and Copper rods after solidification.

3. Mechanical Characterization

The friction welded materials are finished and then used for mechanical characterization. The steps involved in characterizing are in Fig. 11 through 14.

Fig 11. Removing excess material at the weld joint.

Fig 12: Testing hardness by Brinell hardness tester.

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Fig 13: Testing the weld strength by applying hydraulic load

Fig 14: Gauge to show applied load

Fig 15: Tested samples under tension

Fig 15 shows after applying the load the material undergoes continues deformation up to its elastic state again increasing load gradually it reaches the plastic state and breaks at after exceeds its ultimate stress.

4. Results

The two parts are properly welded. The two non-metals are welded because sufficient amount of heat is produced during the experiment. The experiment was performed for one hour duration as a result welding effect could be produced between the rods. The welding process can be performed by increasing the time required for producing sufficient amount of heat and by affecting the rotation speed of spindle and by applying sufficient pressure to the work table end manually or by some other means. Table 1 and 2 shows the results of hardness and tensile strength of aluminum and brass against speed.

Table 1: variation of hardness and strength of Aluminum material.

S. No	Speed (rpm)	Surface-1 (left side of weld)	Surface-2 (right side of weld)	At joint HRB	Yield strength (MPa)	Ultimate strength (MPa)
1	1800	57	57	34	400	455
2	1400	55	56	36		
3	1120	58	58	32		
4	960	57	56	32		

Table 2:Brass

S. No	Speed (rpm)	Surface -1 (left side of weld)	Surface -2 (right side of weld)	At joint HRB	Yield strength (MPa)
1	1400	45	36	27	250
2	1800	39	42	34	

The relationship between friction time and speed graph is shown in Fig 16.

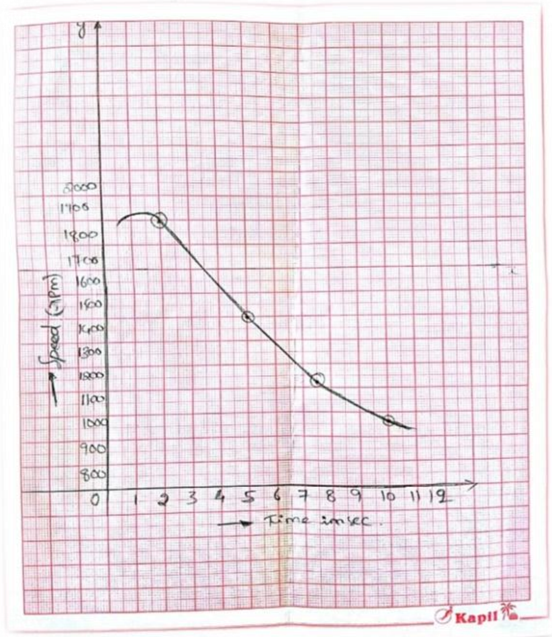

Fig 16:Variation of Speed with friction time

5. Conclusions

Arc welding is only suitable for ferrous metals and not suitable for non-ferrous metals. It is difficult to join two non-ferrous metals, so friction welding method is useful for joining two nonferrous metals and soft materials like aluminum copper brass.

This is the advanced method for joining the two non-ferrous metals. By observing the experimental graph if speed increases time taken for weld is decreases, hardness of the weld portion is increases and also weld strength is increases. Weld parameters are mainly depending upon the speed and time.

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