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INVESTIGATION OF THE STRENGTH OF A FRICTION-WELDED ALUMINIUM ALLOY

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ABSTRACT

Friction welding is a solid state welding technique in which coalescence is produced by frictional heat generated by rotating one workpiece against another. It is a simple process that is readily adaptable to automatic control. It is tolerant to surface preparation, economical due to high production rate reduced with less occurrence of porosity in the weld zone.

In this work, friction welding of Aluminium alloy rod was carried out at various rotating speeds - 1200,696 and 504 revolution per minute and at various welding duration. The parameters that produces the strongest weld was established and compared with strength of gas-welded and arc-welded specimens. The strongest weld obtained at a speed of 1200 rpm has the U.T.S equals to 16.578 N/mm^2. The U.T.S for flame and arc welded specimens are 38.68 and 27.63 N/mm^2 respectively.

INTRODUCTION

Friction welding is a solid state welding technique grouped under mechanical welding. It is a process in which the heat for welding is produced by direct conversion of mechanical energy to thermal energy at the interface of the workpieces without the application of electrical energy, or heat from other sources, to the workpieces. Friction welds are made by holding non rotating workpieces in contact with rotating workpieces under constant or gradually increasing pressures until the interfaces reach the welding temperatures and then the rotation is halted to complete the welding.[1]

Friction welding as a production process was introduced about 1957 and has attracted a great amount of research interest. Most of the research efforts have focused on the establishment of various welding parameters for different metals. Replacement of the traditional welding with friction welding has substantially increased production rates and considerably reduced the length of the heat-affected zone.[2]

In this work, friction welding of aluminium rod was carried out at various rotating speeds - 1200,696 and 504 rpm and at various welding durations on an adapted lathe machine. The parameters that produce the stongest weld were established and this strength was compared with the strength of gas - welded and electric arc - welded samples.

1.0. WELDING OF ALUMINIUM

Aluminium and its alloys require strong and high concentration of heat sources for successful welding due to high thermal conductivity, heat capacity and latent heat of fussion. The high thermal expansivity promotes distortion and warping in welded aluminium.

The difficulty experienced in welding aluminium is attributable to the disparity in the density and melting point of the alloy as compared to the oxide layer (2.7g/cm^3 and 660^{0}C respectively for aluminium as compared to 3.85g/cm^3 and 2050^{0}C for Al_2O_3). The refractory and the heavy aluminium oxide often remain in the weld metal and impair the efficiency of the weld.[3]

1.1 Friction Welding.

Friction Welding is a pressure welding process in which a coalescence is produced by frictional heat generated by a rotating workpiece against another under controlled axial pressure.

In the preparation of the workpieces, reasonably good alignment between the workpieces, leaving adequate tolerance is very vital. Friction welding is tolerant to pre-weld interface condition. Frictional wear breaks the protective refractory oxide layer, removing the irregularities and leaving a clear smooth surface adequately prepared for the subsequent welding process.[4]

The principal welding variables are the welding speed, the applied pressure and the heating duration. For any particular joint configuration, selection of the optimum welding condition is primarily dependent on material strength and thermal conductivity. Although, with dissimilar metal joints, such conditions that minimise the formation of brittle phases at the interface should be adopted.

The friction welding process is simple and readily adaptable to automatic control. It is tolerant with respect to surface preparation and finds applications in a wide range of geometrical sections such as bar to bar, or tube to plate welds. The absence of the liquid phase reduces the problem of porousity and cracking associated with fussion processes. The process is economical due to high production rates. In application, production rates have been substantially increased by replacing other welding processes with friction welding.[5]

2.0 EXPERIMENTS

A lathe machine with a maximum rotational speed of 1200 rpm was adapted for use as a friction welding machine. The specimen used is a 12mm aluminium rod freshly machined and degreased prior to welding.

With a portion of the rod fixed in the chuck and the other in the tailstock of the converted lathe machine, a speed of 1200 rpm was initially chosen and the machine switched on. The tailstock was then fed until it made contact with the rotating specimen and a moderate axial thrust was exerted. The duration of the welding was noted and the set-up was allowed time to cool after the was stopped. Two other speeds, 696 and 504 rpms, were chosen and two welded samples were produced at each of the speeds.

The elecric arc-welded specimen was prepared with a chamfer
and the welding was carried out using a gauge 10 flux-coated aluminium electrode and a current of 65 amperes.

The gas-welded specimen was also prepared in a way similar to the elecric arc-welded sample. Oxy-acetylene gas welding, using a large torch tip to produce a neutral or reducing flame was carried out on the sample using fluxing materials from chloride of alkali metals.

The welded samples were all tested for strength on the Timus Olisen Model 200 Universal Testing Machine. Hardness tests were also carried out at different points of the heat affected zones using the Frank Rockwell Hardness Tester with a load of 2450N.

3.0 RESULTS AND DISCUSSIONS

3.1 Results.

The results of the tensile tests carried out on the friction - welded samples are shown in Table I. Failure in each case occurs at the weld interface. The results of the hardness tests carried out at the interval of 1mm, 2mm, 3mm, and 4mm away from the friction - welded interface are shown in fig.1. The results of the strength tests carried out on flame-welded specimen `B' and arc – welded specimen `C' are compared with the strongest weld obtained from friction welding `A1' in fig. 2.

The hardness of flame - welded (B) and Arc - welded (C) samples compared to the hardness of the strongest friction-welded sample A1 are presented in fig. 3.

Table I: Tensile Strength of the Friction - Welded Sample.

Specimen A	Time (sec)	Tensile Load (KN)	U.T.S. (N/mm^2)	Extension(mm)	Elongation (%)
A1 (1200rpm)	45	1.875	16.578	2.50	0.65
A2 (696rpm)	90	1.375	12.157	1.60	0.50
A3 (504rpm)	180	0.875	7.737	0.80	0.39

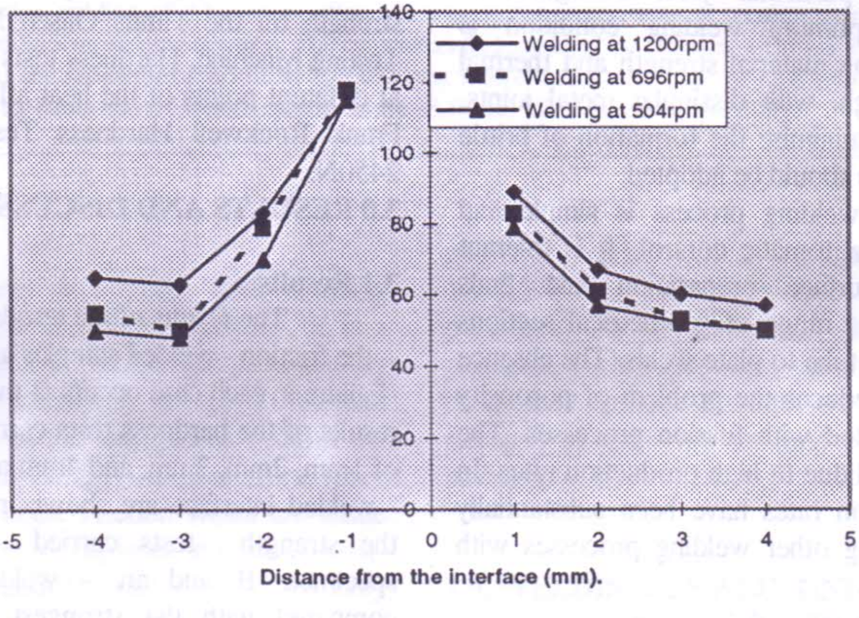

Figure 1: Hardness test result for Friction-welded Aluminium bars.

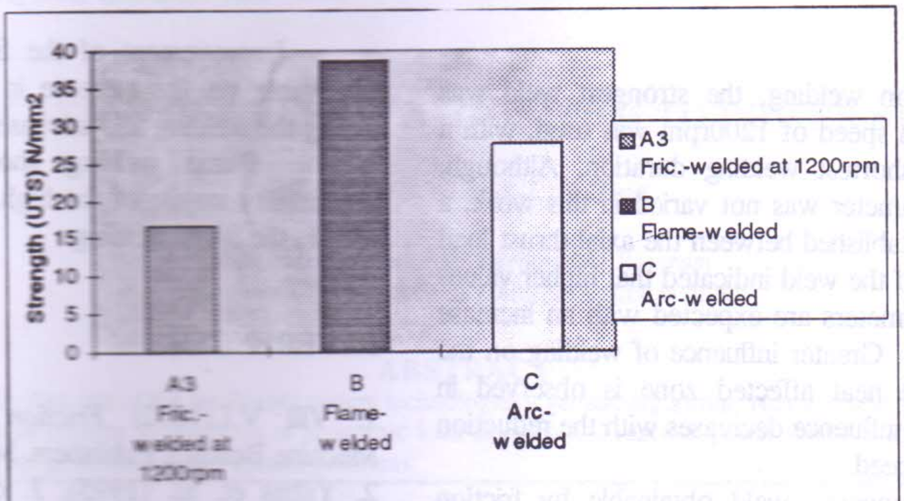

Fig 2: Strength of Joints obtained by Friction, Flame and Arc Welding.

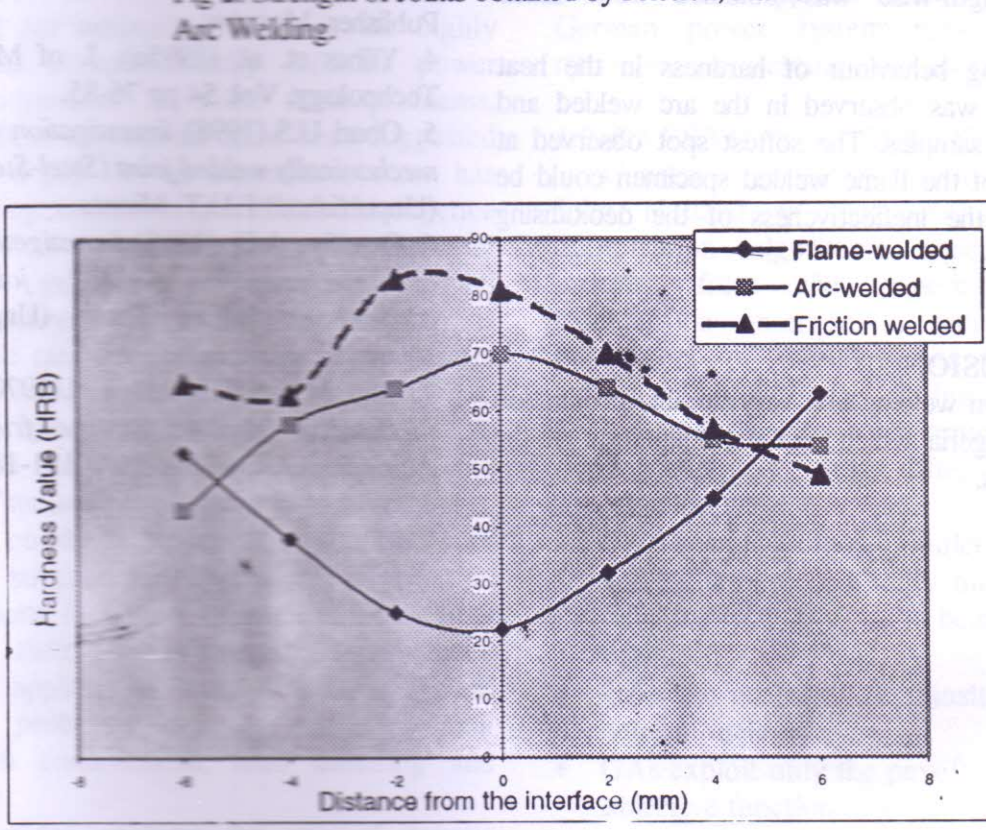

Figure 3: Hardness test for the flame-, arc- and friction-welded samples.

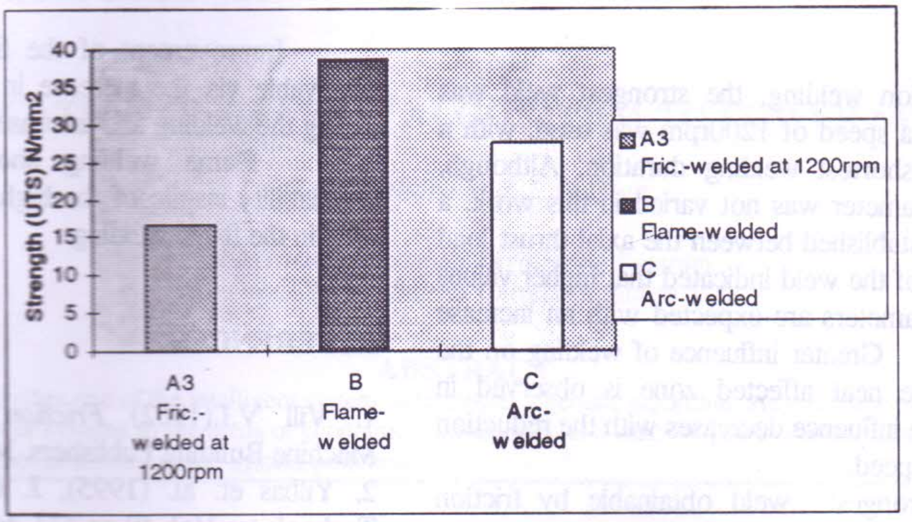

Fig 2: Strength of Joints obtained by Friction, Flame and Arc Welding.

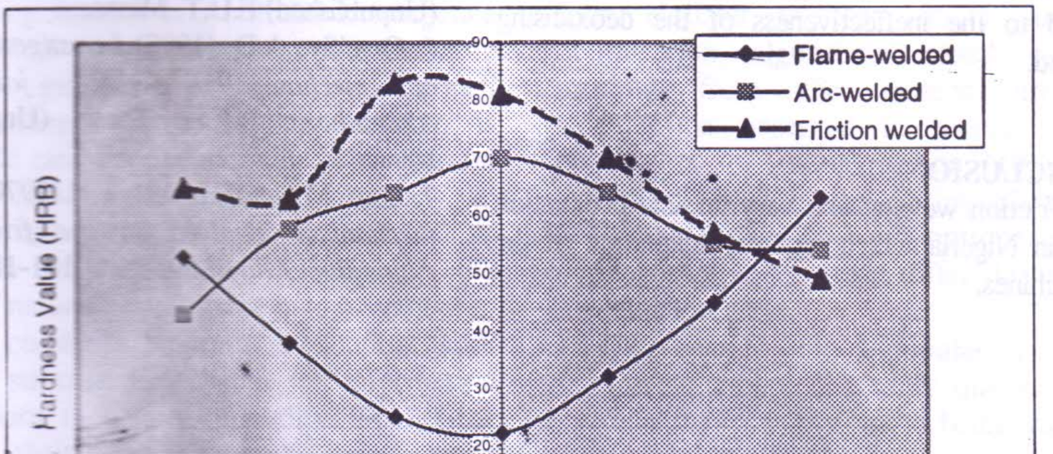

Figure 3: Hardness test for the flame-, arc- and friction-welded samples.

3.2 Discussion.

In friction welding, the strongest weld was obtained when a speed of 1200rpm was used, with a corresponding shortest welding duration. Although, the loading parameter was not varied in this work, a general trend established between the axial thrust load and the tensile of the weld indicated that higher values of strength parameters are expected with an increase in axial thrust.[3] Greater influence of welding on the hardness of the heat affected zone is observed in sample A3. The influence decreases with the reduction in the welding speed.

The strongest weld obtainable by friction welding is inferior to the arc welded joint. The best welding strength-wise was obtained from flame welding.

A contrasting behaviour of hardness in the heat affected zone was observed in the arc welded and flame welded samples. The softest spot observed at the interface of the flame welded specimen could be attributed to the ineffectiveness of the deoxidising agent used.

4.0 CONCLUSION

Friction welding is a very feasible production process in Nigeria which requires adaptation of the lathe machines.

Improvement of the friction welded joint is achievable via the increase in the speed of rotation during the welding and increase in the axial load.

Flame welding shows some degree of unreliability inspite of the high skill of the manpower used in the flame welding.

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