FRICTION WELDING OF DIFFERENT MATERIALS

Mümin ŞAHİN
Trakya University Faculty of Eng. and Arch. Dept. Mech. Eng. 22180, Edirne-Turkey

Abstract

In general, any machine part can be produced by one of various manufacturing methods such as forging, machining, casting and welding. Determination of the manufacturing method depends on production costs of the alternatives for individual parts. Friction-welding which also is an alternative welding method, is widely used in production of machine parts having different cross-section or diameter in order to decrease manufacturing costs. For this reason, friction welding is getting higher share among the other welding methods. In the process, heat is generated by conversion of mechanical energy into thermal energy at the interface of the work pieces during rotation under pressure without use any energy from outside. Generally, friction-welding method is divided by as continuous drive and inertia friction welding. In the presented study, it was given the knowledge about friction welded different materials by the author.

Keywords: Friction Welding, Steel, Aluminium, Copper

INTRODUCTION

Friction welding can be achieved at high production rates and therefore is economical in operation. In applications where friction welding has replaced other joining processes, the production rate has been increased substantially.

When joining dissimilar metals such as copper and steel, friction welding is of great importance in applications. Welding is possible within the limited range of the welding conditions although problems for welding exist because of brittle intermetallic compounds and high thermal conductivity. To minimize the problems, the friction welding parameters must be taken into consideration for strong welds.

As it is known, friction welding is used extensively in various industries nowadays. Heat in friction welding is generated by conversion of mechanical energy into thermal energy at the interface of the work pieces during rotation under pressure. Various ferrous and non-ferrous alloys, which have circular or non-circular cross sections, having different thermal and mechanical properties can easily be joined by the friction welding method. Friction welding is classified as a solid-state welding process where metallic bonding is produced at temperatures lower than the melting point of the base metals. Friction time, friction pressure, forging time, forging pressure and rotation speed are the most interesting parameters in the friction welding method [1].

In practice, friction welding is classified in two ways as continuous drive friction welding and inertia friction welding [2-4]. In the continuous drive friction method shown in Figure 1, one of the components is held stationary while the other is rotated at a constant speed (s). The two components are brought together under axial pressure (P_f) for a certain friction time (t_f). Then, the clutch is separated from the drive, and the rotary component is brought to stop within the braking time while the axial pressure on the stationary part is increased to a higher upset pressure (P_u) for a predetermined upset time (t_u). Parameters of the method are shown in Figure 2.

FRICTION WELDED DIFFERENT MATERIALS

Surface cleanliness in terms of contaminants, especially grease, reduces the quality of joints. The cleanliness of the parts

must be considered as important as well. Therefore, the ends of the parts were cleaned prior to the welding process to minimize the effect of organic contamination in the welding zone by acetone [5-14].

- Friction Welded Stainless Steel and Aluminium Materials

Light non-ferrous metals such as aluminium and magnesium alloys have drawn much attention as regards application since they are energy-saving. Above all, aluminium alloys are used more due to their superior workability and less expensive cost. However, they are not entirely changed with stainless steel having superior strength and good weldability in various structures. Therefore, it is necessary to join stainless steel and aluminium materials [5-9, 11, 12]. Then, macrophoto and hardness distribution on the horizontal distance of joints are given in Figures 3 and 4, respectively.

The maximum strength obtained in the joints has about 94% that of aluminium parts having the weakest strength. Micro-hardness test results on the horizontal distance of joints are shown in Fig.4. As can be seen in Fig.4, the increase noted is the steel side.

- Friction Welded Stainless Steel and Copper Materials

When joining dissimilar metals such as copper and steel, friction welding is of great importance in applications. Welding is possible within the limited range of the welding conditions although problems for welding exist because of brittle intermetallic compounds and high thermal conductivity. To minimize the problems, the friction welding parameters must be taken into consideration for strong welds [5-9, 11, 13]. Then, macrophoto and hardness distribution on the horizontal distance of joints are given in Figures 5 and 6, respectively.

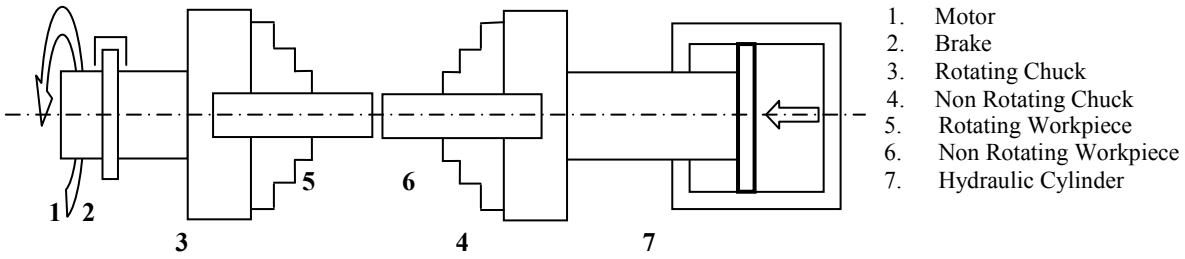


Fig. 1. *Layout of Continuous Drive Friction Welding*

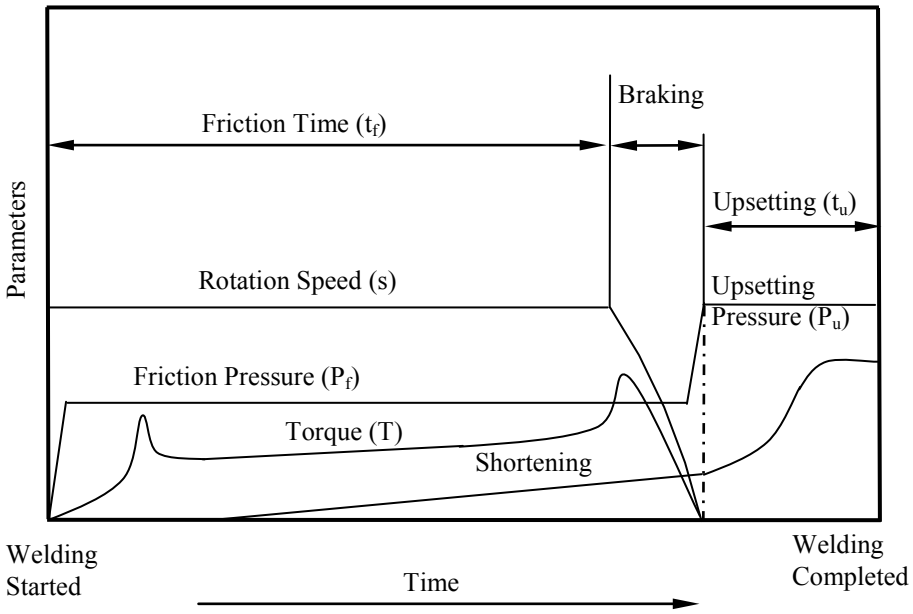


Fig. 2. *Parameters for Continuous Drive Friction Welding*

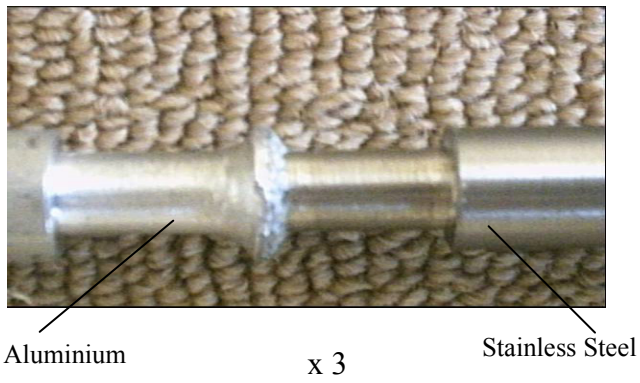


Fig. 3. *Photo of joint*

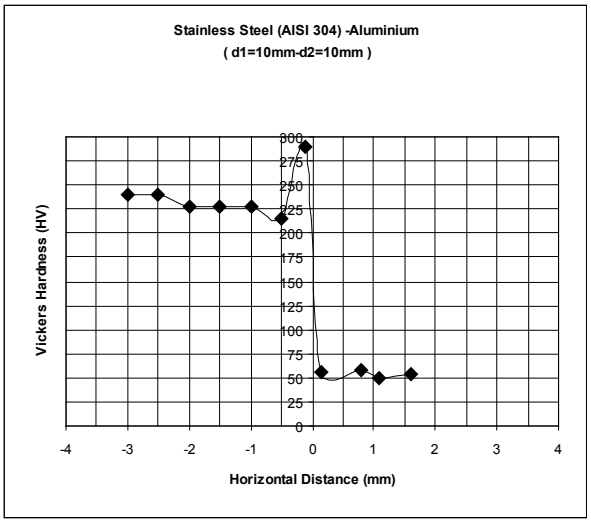


Fig. 4. *Hardness Distribution on the Horizontal Distance of Joints*

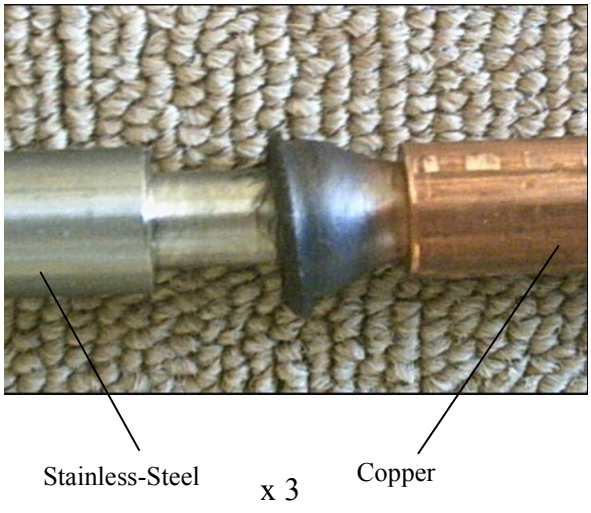


Fig. 5. *Photo of Joint*

It was found that the maximum strength obtained in the joints is about 75% that of copper parts having the weakest strength.

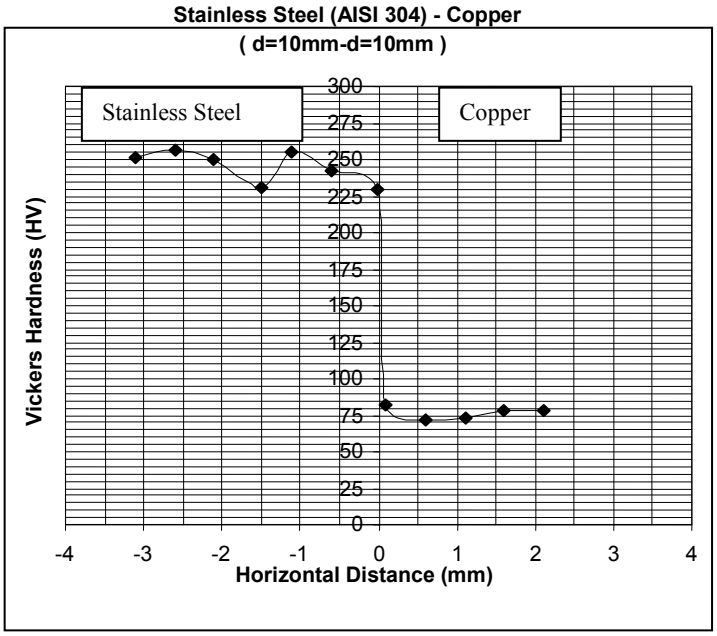


Fig. 6. *Hardness Distribution on the Horizontal Distance of Joints*

Micro-hardness test results on the horizontal distance of joints are shown in Fig.6. It can be seen that around the interface, the hardness of the copper increases slightly.

- Friction Welded Aluminium and Copper Materials

Aluminium and copper are continually replacing steels in electricity supply systems to reduce cost. However, welding of copper and aluminium are usually difficult by conventional fusion welding processes because those have the high thermal diffusivity higher than in many steels alloys. To overcome the problem the friction welding which is one of the solid state welding techniques is applied to the joining of copper and aluminium material [5-9, 11, 14]. Then, macrophoto and hardness distribution on the horizontal distance of joints are given in Figures 7 and 8, respectively.

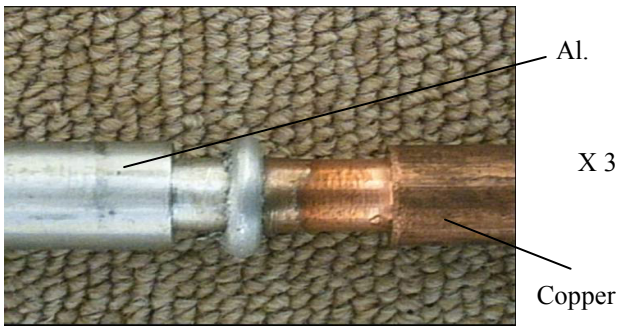


Fig. 7. *Macro-photo of joint*

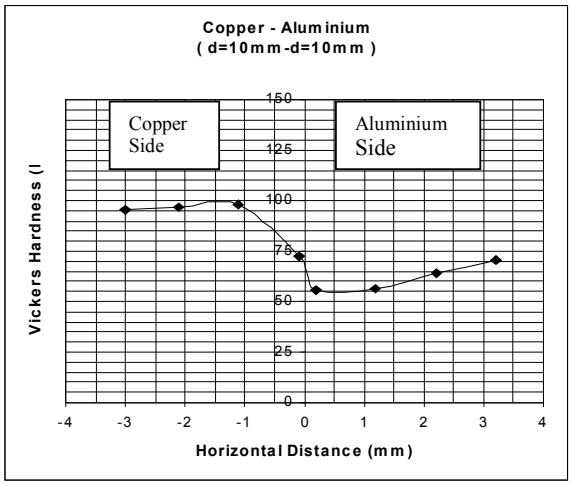


Fig. 8. *Hardness Results on Horizontal Distance of the Joints*

As it is shown in Figure 8, the hardness variations on the copper side are more than those on the aluminium side. This variation is possible due to comparatively high thermal conductivity of copper material.

CONCLUSIONS

- Because of the existence of intermetallic phase, the welding of non-ferrous metals is very hard. But, continuous drive friction welding method can suitably be adopted for welding of different ferrous and non-ferrous materials.
- Tensile strengths for joints were considered as positive result when compared with those of the base metals. But, some of the welds show poor strength depending on some accumulation of alloying elements at the interface result of temperature rise and the existence of a grey layer.
- The hardness variations are harmonious with previous works.

REFERENCES

[1] Vill, V.I., Friction Welding of Metals, *AWS*, Newyork, (1962).

[2] Kinley, W., Inertia Welding: Simple in Principle and Application, *Welding and Metal Fabrication*, (1979), Oct., pp. 585-589,

[3] Fomichev, N. I., The Friction Welding of New High Speed Tool Steels to Structural Steels, *Welding Production*, (1980), pp. 35-38.

[4] Murti, K. G. K., Sundaresan, S., Parameter Optimisation in Friction Welding Dissimilar Materials, *Metal Construction*, June, 1983, pp. 331-335.

[5] Yılbas, B. S., Şahin, A. Z., Kahraman, N., Al – Garni, Friction Welding of St - Al and Al- Cu Materials, *Journal of Materials Processing Tecnology*, (1995), v 49 n 3-4 Feb15., pp. 431-443.

[6] Yılbas, B. S., Şahin, A. Z., Çoban, A., Abdul Aleem, B. J., Investigation into the Properties of Friction –Welded Aluminium Bars, *Journal of Materials Processing Tecnology*, (1995), v 54, pp. 76-81.

[7] Rhodes, C. G., Mahoney, M. W., Bingel, W. H., Spurling, R. A., Bampton, C. C., Effects of Friction Stir Welding on Microstructure of 7075 Aluminium, *Scripta Materialia*, (1997), v 36 n 1, pp. 69-75.

[8] Fukumoto S, Tsubakino H, Okita K, Aritoshi M, Tomita T., Amorphization by Friction Welding between 5052 Aluminum Alloy and 304 Stainless Steel. Scripta Materialia, (2000), V 42, pp 807-812.

[9] Fukumoto S, Tsubakino H, Okita K, Aritoshi M, Tomita T., Friction Welding Process of 5052 Aluminium Alloy to 304 Stainless Steel. Materials Science and Technology, September, (1999), Vol. 15, pp 1080-1086.

[10] Şahin, A. Z., Yılbaş, B. S., Ahmed, M., Nickel, J., Analysis of The Friction Welding Process in Relation to The Welding of Copper and Steel Bars, Journal of Materials Processing Technology, v 82, (1998), 127-136.

[11] ASM, Welding And Brazing, *Metals Handbook*, ASM, Metals Park. Ohio: 507-518, 8th Edition.

[12] Sahin, M., Joining of stainless-steel and aluminium materials by friction welding, The International Journal of Advanced Manufacturing Technology, Volume 41, Issue 5, 2009, pp: 487-497.

[13] Sahin, M., Joining of stainless steel and copper materials with friction welding, Industrial Lubrication and Tribology, Volume: 61, Issue: 6, 2009, pp: 319-324.

[14] Sahin, M., Joining of aluminium and copper materials with friction welding, The International Journal of Advanced Manufacturing Technology, Volume: 49, Issue 5-8, 2010, pp: 527-534.