

Tensile Strength of Friction-Welded Joints of Copper Alloys to Steels

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ABSTRACT

Friction welding of copper alloys (C4641 naval brass, C6191 aluminum bronze) to steels (S25C carbon steel, SUS304 and SUS304L stainless steels) was carried out. In all combinations, a stable tensile strength could be obtained under the wide range of welding conditions. Maximum joint efficiencies of C4641/S25C, C4641/SUS304, C6191/S25C and C6191/SUS304L were 73%, 61%, 78% and 77%, respectively. In C4641 to steels joints, there was no reaction layer at the weld interface with the exception of a small area at the peripheral region. In C6191 to steels joints, there were reaction layers which consisted of component elements of the base metals.

KEY WORDS: Friction welding; naval brass; aluminum bronze; carbon steel; stainless steel; tensile strength.

INTRODUCTION

Friction welding is used in many fields because the procedure is easily automated and it is possible to weld dissimilar materials. Recently, various industrial fields have seen an increased demand for dissimilar material joints due to the reduction of weight, resource conservation and energy saving. Joints of pure copper to steels have been used for the electrode for electrical discharge machines and the pipe joint for low temperature. Joints of copper alloys, which are a higher-performance material in terms of corrosion-resistant and strength than pure copper, to steels will be of wide application. An arc welding, an electron beam welding, a laser welding, a brazing and a diffusion welding are used for the joining of coppers to steels (Asai et al., 2003). However, there are issues with the fusion welding, such as the necessity of the preheating and the weld crack (Japan Copper and Brass Assoc., 1997). In the present study, the authors examined the joining of copper alloys to steels using a friction welding method, which is used for the joining of dissimilar materials which is difficult to be welded by the fusion welding.

EXPERIMENTAL PROCEDURE

The materials used in this study were C4641-F naval brass (C4641-JIS), C6191-F aluminum bronze (C6191-JIS), S25C carbon steel (S25C-JIS),

SUS304 austenitic stainless steel (SUS304-JIS) and SUS304L austenitic stainless steel (SUS304L-JIS) with 471 MPa, 813 MPa, 495 MPa, 641 MPa and 567 MPa tensile strength, respectively. A cylindrical bar of 20 mm in diameter of each metal was cut to 100 mm in length, and a 25 mm length of bar on the welding end was machined down to 14 mm in diameter. Friction welding was conducted using a brake-type friction welding machine. The friction welding factors used are shown in Table 1. The joint strength of friction-welded joints was evaluated by tensile testing using the test specimens without a burr.

The hardness distribution, the reaction layers at the weld interface of the joint welded under the optimum welding condition was examined. Moreover, the tensile strength distribution of 30 pieces of the joint welded under the optimum welding condition was statistically analyzed.

Table 1. Friction-welding factors used.

Friction pressure P_1 , MPa	30, 40
Upset pressure P_2 , MPa	70, 90, 110, 130, 150
Friction time t_f , s	1.0, 2.0, 3.0
Stopping time t_B , s	0.2
Friction speed N, s^{-1}	50.0

RESULTS AND DISCUSSION

Appropriate Welding Condition of Brass to Steels

The relationship between tensile strength and upset pressure in the C4641/S25C is shown in Fig. 1. In friction pressure 30 MPa, tensile strength increased with a friction time and a consistently tensile strength of 330-350 MPa was obtained under friction time 3.0 s and upset pressure 70-130 MPa. In friction pressure 40 MPa, joints having tensile strength of 310-340 MPa were obtained under friction time 2.0 s and upset pressure 110-150 MPa.

The relationship between tensile strength and upset pressure in the C4641/SUS304 is shown in Fig. 2. In both cases of 30 MPa and 40