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Technical Report

Investigations on the mechanical properties and microstructure of dissimilar cp-titanium and AISI 316L austenitic stainless steel continuous friction welds

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ABSTRACT

Friction welding process is a solid state joining process that produces a weld under the compressive force contact of one rotating and one stationary work piece. In this study, the friction welding of dissimilar joints of AISI 316L stainless steel and cp-titanium is considered. The optical, scanning electron microscopy studies of the weld were carried out. Moreover, the X-ray diffraction analysis was performed. The integrity of welds was achieved by the micro hardness and tensile tests. The fracture surface was examined by the scanning electron microscopy. The study showed that the magnitude of tensile strength of the dissimilar welded specimen was below that of the titanium base material if preheating was not applied at the interface. The high weld tensile strength was achieved by preheating the 316L stainless steel material to 700 °C, smoothing and cleaning of the contact surfaces. Results illustrated that in dissimilar joints, different phases and intermetallic compounds such as FeTi, Fe_2Ti, Fe_2Ti_4O, Cr_2Ti and sigma titanium phase were produced at the interface. The presence of brittle intermetallic compounds at the interface resulted in degradation of mechanical strength which in turn led to premature failure of joint interface in the service condition. Preheating caused to produce oxide layer at the interface which was harmful for bonding. The oxide layer could be eliminated by applying pressure and smoothing the surface. Results of hardness tests illustrated that the high hardness was occurred in the titanium side adjacent to the joint interface. Moreover, the optimum operational parameters were obtained in order to achieve the weld tensile strength greater than the weak titanium material.

1. Introduction

Friction welding process is a solid state joining process that produces a weld under the compressive force contact of one rotating and one stationary work piece. The heat is generated at the weld interface because of the continuous rubbing of contact surfaces, which, in turn, causes a temperature rise and subsequent softening of material. Eventually, the material at the interface starts to flow plastically and forms an upsetting. When a certain amount of upsetting has occurred, the rotation stopped and the compressive force is maintained or slightly increases to consolidate the weld. Fig. 1 shows the schematic of continuous friction welding process. Essential parameters of friction welding process (FRW) are friction pressure and time, forging pressure and time, and rotating speed. Friction time, friction pressure, forging time, upset time, forging pressure and rotation speed are the most important operational parameters in the friction welding process. Fig. 2 shows the relations between different parameters of continuous friction welding process [1].

Materials have different chemical, physical and metallurgical properties. Some materials have high corrosion resistance, some are light and some materials have high strength. However, sometimes combinations of various materials with various properties are required. Therefore, joining of dissimilar materials is necessary. Joining of various combinations of different materials can lead to reduce costs and increase efficiencies. Nowadays, several joining processes are used for joining of dissimilar materials such as explosion welding, pressure welding, friction welding and soldering and brazing [1–3].

Titanium and its alloys are suitable for chemical and aerospace industries, because of their special mechanical and metallurgical properties. However, their applications are restricted because of their high cost and problems in joining to other materials such as stainless steel [4].

Few investigations were carried out on the influence of continuous friction welding parameters on mechanical properties of titanium and AISI 304L stainless steel joints [5–7]. However, no research was found to report any success about dissimilar joining of titanium and AISI 316L stainless steel. Explosive welding of Ti and AISI 304 stainless steel sheets was studied by various investigators [8–11]. Explosive claddings of cp-titanium–stainless steel have especial properties, such as good corrosion resistance and

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