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Fatigue behaviour of friction welded medium carbon steel and austenitic stainless steel dissimilar joints

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ABSTRACT

This paper reports the fatigue behaviour of friction welded medium carbon steel–austenitic stainless steel (MCS–ASS) dissimilar joints. Commercial grade medium carbon steel rods of 12 mm diameter and AISI 304 grade austenitic stainless steel rods of 12 mm diameter were used to fabricate the joints. A constant speed, continuous drive friction welding machine was used to fabricate the joints. Fatigue life of the joints was evaluated conducting the experiments using rotary bending fatigue testing machine ($R = -1$). Applied stress vs. number of cycles to failure (S–N) curve was plotted for unnotched and notched specimens. Basquin constants, fatigue strength, fatigue notch factor and notch sensitivity factor were evaluated for the dissimilar joints. Fatigue strength of the joints is correlated with microstructure, microhardness and tensile properties of the joints.

1. Introduction

Joints of dissimilar metal combinations are employed in different applications requiring certain special combination of properties as well as to save cost incurred towards costly and scarce materials [1]. Conventional fusion welding of many such dissimilar metal combinations is not feasible owing to the formation of brittle and low melting intermetallics due to metallurgical incompatibility, wide difference in melting point, thermal mismatch, etc. Solid-state welding processes that limit extent of intermixing are generally employed in such situations. Friction welding is one such solid-state welding process widely employed in such situations [2].

Dobrovidov [3] investigated selection of optimum conditions for the friction welding of high speed steel to carbon steel. Ishibashi et al. [4] chose stainless steel and high speed steel as representative materials with an appreciably difficult weldability, and their adequate welding conditions were established. The distributions of the alloying elements at and near the weld interface with sufficient strength were analysed using X-ray microanalyser. Sahin [5] has analysed the variations in hardness and microstructure at the interfaces of friction welded steel joints. While using austenitic stainless steel, negative metallurgical changes like delta ferrite formation and chromium carbide precipitation between grain boundaries took place during fusion welding. These changes are eliminated by friction welding. The effect of friction time on the fully plastically deformed region in the vicinity of the weld has been investigated by Sathiya et al. [6].

Ananthapadmanaban et al. [7] have reported the effect of friction welding parameters on tensile properties of steel. Satyanarayana et al. [8] joined austenitic–ferritic stainless steel (AISI 304 and AISI 430) using continuous drive friction welding and investigated optimum parameters, microstructures-mechanical property and fracture behaviours. Yılmaz [9] investigated variations in hardness and microstructures in the welding zone of friction welded dissimilar materials The effect of friction pressure on the properties of hot rolled iron based super alloy has been investigated by Afes et al. [10]. Meshram et al. [11] investigated the influence of interaction time on microstructure and tensile properties of the friction welding of dissimilar metal combinations.

Hiizu et al. [12] evaluated tensile and fatigue behaviour of friction welded SUS304 stainless steel joints. They found that the fatigue strength of sound joints was higher than that of SUS304 base material. This is probably because the material near the weld interface was hardened due to the work hardening. Lee et al. [13] investigated the fatigue crack propagation characteristics of dissimilar friction welding zone of two kinds of heat-resisting steels, STR3 and STR35, commonly used as valve materials for vehicles. A small circular artificial defect was machined to induce fatigue crack on weld interface, heat affected zone and base metal to compare fatigue lives according to the notch position. Sahin [14] investigated fatigue properties of friction welded austenitic stainless steel (AISI 304) joints. The fatigue strength of welded joints is close to those of base metal.

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