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Multi-Response Optimization of Burnishing of Friction Welded Al6082-T6 Using Grey Relation Analysis

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Abstract

Ball burnishing is an effective post-weld and post machining process to enhance surface finish and surface properties. Al6082 -T6 used in aerospace, marine and automobile are difficult to join by fusion welding can be joined by friction (solid state) welding. Burnishing was used a post weld treatment to enhanced the surface roughness, surface hardness and tensile strength. This paper optimizes the burnishing process for friction welded Al6082-T6 part using grey relation analysis. Four controllable factors of the burnishing process were studied at five levels each. Grey relation analysis was employed for multi-response optimization. Twenty five experimental runs based on an orthogonal array of Taguchi method were performed to derive objective functions to be optimized within experimental domain. The objective functions have been selected in relation of burnishing parameters; burnishing speed, burnishing feed rate, burnishing force and number of passes. Grey relational analysis was applied to solve the multi-response optimization problem. The significance of the factors on overall quality characteristics of the burnishing process has also been evaluated quantitatively with the variance method (ANOVA). Optimal results were verified through confirmation experiments. This shows application feasibility of the Grey relation analysis in combination with Taguchi technique for continuous improvement in product quality in manufacturing industry.

Keywords: Friction welding; Ball burnishing; Multi-response optimization; Grey relation analysis; Analysis of variance

1. INTRODUCTION

Ferrous and non-ferrous alloys having circular or non-circular cross sections and that have different thermal and mechanical properties can easily be joined by 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 important parameters in the friction welding method [1-4]. Experimental study and parametric optimization of friction welding [5-9] of similar and dissimilar metals are helped in deciding the control factor to weld of AA6082-T6 part by friction welding. Friction welding offers several advantages over conventional fusion welding processes, due to its low heat

input and absence of melting. However, the local heating produced by friction can leave a fusion zone with reduced mechanical properties and a heat-affected zone with tensile residual stresses that can be deleterious to fatigue performance [10]. Controlled plasticity burnishing (CPB) and low plasticity burnishing (LPB) are an established post weld surface treatment technology that has been investigated and described extensively for the improvement of surface finish and produces deep compressive residual stress that improves fatigue and corrosion fatigue performance of friction welded aluminum alloy [10,11]. Burnishing can be readily adapted to industrial FSW and FSP fabrication of components, either simultaneously or as a post weld process with