Optimization of friction stir welding AA6082-T6 parameters using analysis of variance and grey relational analysis.

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Abstract. Friction stir welding (FSW) is a solid-state welding process, which plays a significant role in solid-state welding processes for nonferrous alloys. Conventional arc welding processes for aluminum alloys such as tungsten inert gas (TIG) and metal inert gas (MIG) are replaced by FSW. The effect of process parameters such as tool rotational and traverse speeds, tool geometry, plunge depth, tilt angle, etc., on weld quality were considered in several optimization studies. Multi-criteria decision-making (MDCM) techniques such as grey relational analysis (GRA) were used to determine the optimal condition among experimental runs designed using response surface methodology (RSM). The Taguchi method was widely applied with MCDM techniques. Therefore, the experiments were conducted according to response surface methodology. Input parameters were (14, 16 and 18) mm for shoulder diameter (SD), (0.0, 0.2 and 0.4) mm for plunge depth (PD), and (30, 60 and 90) mm for fixture position (FP), which is the distance between fixture bolts used to fix the welded plate. The results obtained by GRA were similar to the ANOVA optimizer, and the optimum process conditions are shoulder diameter of 14 mm, plunge depth of 0.2 mm, and fixture position of 60 mm.

1. Introduction

Four decades ago in the United Kingdom, the welding institute (TWI) developed the friction stir welding process, a solid-state welding process that overcomes many problems of conventional welding methods. Welding of workpieces by FSW can be performed without melting the workpiece material or using filler wires. Heat is generated due to friction between a rotating tool and a workpiece, causing a soft area around the tool. When the tool moves transversely, it mechanically mixes the softened metal and forges it by mechanical pressure applied by the tool [1]. Particularly, it can be used for welding aerospace aluminum alloys and other materials like stainless steel, titanium, and high-strength steel, which are difficult to weld by conventional fusion welding processes. FSW prevents melting, cast microstructure formation, and solidifying weld shrink zone found in traditional fusion welding [2]. A schematic diagram of the FSW process is shown in Figure 1.

FSW process is attractive, unique, and reliable due to its advantages such as lower power consumption, good quality joint without defects, no gas shielding required, improved mechanical properties, reduced distortion, cracks elimination, and reduced residual stresses [3]. The solid-state FSW technique can successfully join various aluminum alloy grades [4]. FSW process still has some defects such as pinholes, tunnel defects, voids, etc., that affect welding quality. Figure 2 shows FSW defects, [5], [6] provide more information on these defects. Tensile strength, surface roughness,