Utilising friction spot joining for dissimilar joint between aluminium alloy (A5052) and polyethylene terephthalate

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The weld strength of thermoplastics with aluminium alloy, such as high density polyethylene and polypropylene sheets, is influenced by friction stir welding parameters. This paper focuses on the preliminary investigation of joining parameter at various levels as well as the mechanical properties of friction spot joining (FSJ) of aluminium alloy (A5052) to polyethylene terephthalate (PET). A number of FSJ experiments were carried out to obtain optimum mechanical properties by adjusting the plunge speed and plunge depth in the ranges of 5–40 mm min−1 and 0.4–0.7 mm respectively, while spindle speed remains constant at 3000 rev min−1. The results indicated that A5052 and PET successfully joined with the aid of frictional heat energy originated from the friction spot welding process. The effect of plunge speed on the joined area and the effect of formation of bubbles at the interface of joints on the shear strength of joint are discussed.

Keywords: Friction spot joining, Aluminium alloy, Thermoplastic, Dissimilar materials, Bubble formation

Introduction

The rate of usage of light material aluminium and magnesium alloys as well as thermoplastic materials in engineering applications especially in the field of automotive industry is in an expanding range due to their enhanced stress/weight ratios and toughness. Even though plastics offer a high degree of design freedom and processing ability, the fabrication of larger and complex parts usually requires joining technologies, such as friction stir welding (FSW). Friction stir welding is a rapidly maturing solid state joining process that appears as a promisingly ecologic weld method that enables to diminish material waste and to avoid radiation and harmful gas emissions usually associated with the fusion welding techniques. The main process parameters affecting material flow and weld quality contain the tool rotation speed, tool traverse speed, vertical pressure on the tool, tilt angle of the tool and tool geometry. During processing, a non-consumable tool attached with a specially designed pin was inserted to the mating edges of the plates to be joined. The tool shoulder had to touch the plate surface. Under this condition, the tool was rotated and traversed along the bond line. Thus, frictional heat was generated. The tool rotation and traverse expedite material flow from the front to the back of the pin, and welded joints were produced. The process was suitable for joining the plates and sheets; however, it can be employed for pipes and the hollow sections and positional welding. Friction stir welding aims for structural demanding applications to provide high performance benefits in industry.

Although the FSW process was initially developed for aluminium alloys, it also has a great potential for the welding of copper, titanium, steel, magnesium, and metal matrix composites as well as different materials. Recently, some researchers have studied the application of FSW and friction stir spot welding (FSSW) to thermoplastics. There are very few publications on polymer friction stir spot joining applications. Thus, this study was intended to join dissimilar materials between aluminium alloy (A5052) and polyethylene terephthalate (PET) using the friction spot joining (FSJ) method, which mimicked the FSSW process. Although the technique has been used for the joining of dissimilar metals, the study on the joining of metal to polymer using friction stir joining is fairly a recent innovation in modern manufacturing process. The resultant joint has been evaluated in terms of joining strength by measuring the shear loading and also by microscopic observation of the cross-sections of the specimens.

Experimental

Experimental set-up

Aluminium alloy (A5052) and PET sheet specimens with dimensions of 40 × 100 × 3 mm thickness were prepared. The chemical composition of A5052 is shown in Table 1,