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Joining of aluminium matrix composites using friction stir welding: A review

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Abstract

Aluminium matrix composites are one of the most important classes of materials and have become a major focus of attention in aerospace, aeronautical, defense, and automotive industries. Aluminium matrix composites when compared to conventional alloys offer various promising properties like excellent strength-to-weight ratio, higher stiffness, lower coefficient of thermal expansion, better dimensional stability, and tribological behavior. The properties of aluminium matrix composites are highly influenced by the appropriate selection of metal matrix, processing routes, and reinforcement. Various ceramic particles (oxides, carbides, nitrides, borides, etc.) are used as reinforcements for aluminium matrix composites. Significantly different properties may be obtained using various reinforced particles and matrix material, which makes it difficult for the traditional fusion welding techniques to meet the joining requirements of these composites and is restricted to certain grades of materials. Solid-state welding process offers greater advantages over the conventional fusion welding. As a solid-state joining process, friction stir welding has proven to be a better and promising technique for joining aluminium matrix composites. However, it is still subjected to various challenges to join aluminium matrix composites even with considerable progress has been made in recent years. The current review provides an overview of state-of-the-art of friction stir welding of aluminium matrix composite materials. Specific attention and critical assessment have been given to weldability, the macrostructure and microstructure of aluminium matrix composite joints, mechanical properties of joints, fractography, and the wear of friction stir welding tool during welding of aluminium matrix composite. Furthermore, the various existing challenges of friction stir welding of aluminium matrix composites are summarized and the recommendations for future research are proposed.

Keywords

Friction stir welding, aluminium matrix composites, macrostructure, microstructure, weldability, mechanical properties

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Introduction

The current situation of evolving trends and varying technology makes a need for introducing novel materials with the essential properties at low cost The promising mechanical and thermophysical properties (e.g. excellent strength-to-weight ratio, lower density, higher stiffness, lower coefficient of thermal expansion, better dimensional stability, and tribological behavior) of metal matrix composites (MMCs) have gained significant attention.[1] MMCs are the composites that are usually based on two parts namely matrix and the reinforcement. The matrix part is based on the metals or alloys, while as reinforced phase is based on different metals, organic compounds, or ceramics. Particulate MMC is mostly used and it consists of lightweight alloys like aluminium, titanium, magnesium, etc. and is reinforced with oxides, carbides, nitrides, boorides, etc. Among the various MMCs, aluminium matrix composites (AMCs) draw the considerable attention of aerospace, aeronautical, automotive, defense, nuclear energy, and marine industries[2–4] Despite such promising properties, the industrial application of these composites is restricted. The industry-ready composite must have maximum wettability, minimum porosity, uniform distribution of reinforcement, and must avoid the chemical reaction. Various studies have also stated that using the conventional process for the joining of composites is not reliable due to mismatch in various thermal, physical, and mechanical properties between base matrix and reinforcement phase and an undesirable reaction between reinforcements and matrix results in brittle phase formation and makes it difficult to obtain desired joint properties.[5] Melting of these composites must be

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