# Chapter 14
# Process Evaluation and Numerical Optimization in Friction Stir Welding of Dissimilar AMCs

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## ABSTRACT

*In recent times, any engineering material is deemed worthwhile only if it satisfies functional characteristics such as weldability, formability, machinability, etc. Aluminum-based metal matrix composites have extensive usage in modern automobile parts, aircraft components, and ship structures, mainly due to their attractive properties such as low cost, high strength-to-weight ratio, excellent corrosion and wear resistance. Friction stir welding is one of the most versatile solid-state joining processes to ensure weldability between two AMC plates. In this research work, an analysis of FSW process through parameters (e.g., composition of alumina, spindle speed, feed, etc.) in joining Alumina reinforced aluminum alloy composites Al 6061 and Al 2024 together at various proportions by analyzing properties like impact strength, hardness, flatness, and ultimate tensile strength has been done. Finally, optimization is carried out to select the best possible combination using a multi-attribute decision-making technique called the complex proportional assessment of alternatives.*

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## INTRODUCTION

A composite is a heterogeneous combination of different engineering materials joined together at various proportions. It has two distinctive phases: matrix and reinforcements. Matrix is the major constituent and reinforcements are minor constituents, which are added, mixed or embedded into the matrix. Composites are classified based on either the type of matrix material such as metal, ceramic, polymer, etc. or the shape and size of reinforcements like continuous fibres, whiskers, particulates, etc. (Bodunrin, M. O., Alaneme, K. K., & Chown, L. H., 2015). When more than one reinforcement is added to the matrix, the resultant material is called hybrid composite (Krishna, S. M., Shridhar, T. N., & Krishnamurthy, L., 2015). Composites are used almost everywhere in the world, rather unknowingly. They may be natural or synthetic. Their applications are immense ranging from structural components, aerospace materials, marine parts, common houseware, accessories used in elevated or cryogenic temperatures (Vengatesh, D. & Chandramohan, V., 2014). Composites are having an edge over metal alloys, owing to their improved hardness, high impact strength and superior wear resistance.

Metal Matrix Composites or simply MMCs, as they are often called are most popular and widely used among composites. They derive their name from the fact that the matrix material is usually a metal alloy. In Aluminium Matrix Composites (AMCs), the metallic matrix comprises of an aluminium alloy and reinforcements are generally non-metallic particles. In the modern era, reinforcements from diverse sources such as natural and synthetic ceramic powders like alumina and silicon carbide, agricultural wastes like Rice Husk Ash, industrial wastes like fly ash are used for strengthening the composite (Bodunrin, M.O., et al., 2015). Aluminium, the most abundant material in Earth's crust is the most preferred choice for matrix, owing to its low price, high strength-to-weight ratio, good heat withstanding capacity and excellent corrosion resistance (Pradeepkumar, J., Robinson Smart, D.S., & John Alexis, S., 2018).

Casting is one of the oldest traditional methods used for fabricating sand cast and chill cast Aluminium alloys Aluminium Metal Matrix Composites (AMMCs). It is commonly prevalent even now due to its robustness, flexibility and inexpensiveness. In this method, metal alloy to be moulded is heated till it attains semi-solid or molten state (at a temperature above its melting point) and is poured into mould cavity of required shape and dimension. In conventional casting process, a moulding box filled with green sand is used to prepare mould cavity. In recent times, mould cavity (die) made up of mild steel is used for both gravity and pressurized die casting. Stir casting is one of the categories in casting that derived its name from the process of stirring the molten metal thoroughly with propeller after the addition of reinforcement powder. This activity ensures the uniform distribution of reinforcement within the matrix (Bhandare, R.G., & Sonawane, P.M., 2013).

Welding is a metal joining process, in which two or more metal pieces are joined with the application of enormous amount of heat. The application of pressure is optional. The choice and cross section of metals may be similar or different (Wang, D., Xiao, B. L., Ni, D. R., & Ma, Z. Y., 2014). Friction Stir Welding (FSW), sometimes called as Friction Stir Processing (FSP) is the most appropriate welding technique used for Aluminium and its allied composites (Subramanya, P., Amar, M., Arun, S., Mervin, H., & Shrikantha, R., 2018). In FSW, two plates of AMCs with rectangular cross section are welded together as butt joints by means of exerting force through a rotating Stainless-Steel tool (Verma, S. & Misra, J.P., 2021). Based on the size of composite specimens, their composition, physical and mechanical properties, parameters such as welding speed, traverse feed, type and dimensional attributes of the tool material are chosen. FSW is one of the very few welding techniques that offer excellent binding strength and microstructural stability at the weldment area with relatively small Heat Affected Zone (HAZ). This