

## THIXOTROPIC PROCESSING OF A6061: A STUDY ON MICROSTRUCTURE REFINEMENT AND HARDNESS IMPROVEMENT

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### ABSTRACT

Aluminum alloy A6061, known for its excellent strength-to-weight ratio, corrosion resistance, and extrudability, is widely used in structural and transportation applications. This study investigates the influence of semi-solid extrusion temperatures on the microstructural and mechanical behavior of A6061 alloy. Bar stock of A6061 was machined into desired geometries and subjected to semi-solid extrusion at three processing temperatures: 630 °C, 635 °C, and 640 °C, which fall within the alloy's solid-liquid coexistence range, helping in facilitating thixotropic flow and grain refinement during extrusion. After extrusion, the cast samples were examined using optical microscopy, Vickers hardness testing, and X-ray diffraction (XRD) analysis. The observations showed that higher extrusion temperatures promoted the formation of a more uniform, globular microstructure, thereby improving hardness and overall phase stability. The XRD results verified the presence of the primary alloying phases and also indicated partial dissolution of certain precipitates as a result of the semi-solid processing conditions. The findings suggest that carefully controlled semi-solid processing can significantly improve the structural integrity of A6061 alloy, making it a promising approach for manufacturing high-performance components with refined microstructures and enhanced resistance to impact loading.

**Keywords:** A6061 alloy, Thixotropic processing, Semi-solid extrusion, Microstructure refinement, Hardness

### 1. INTRODUCTION

Aluminum alloy A6061, which belongs to the precipitation-hardenable 6xxx series, is widely used because of its favorable combination of high strength-to-weight ratio, good corrosion resistance, excellent weldability, and ease of extrusion. Owing to these advantages, it has become a commonly selected material for aerospace, automotive, and load-bearing structural components [1–3]. Despite these benefits, parts produced through conventional casting and extrusion often contain coarse-grain structures, internal porosity, and directional variations in mechanical properties. Such microstructural limitations can reduce the reliability and performance of the alloy when used in demanding service conditions [4].

To address these drawbacks, semisolid metal (SSM) processing has been explored as an effective alternative manufacturing route. This technique enables the production of near-net-shape components while promoting microstructural refinement and improving overall mechanical performance [5–8]. SSM processing utilizes the thixotropic nature of alloys within the temperature range where solid and liquid phases coexist. In this state, the material exhibits reduced viscosity under shear, which improves its flow behavior and formability during shaping operations. Among the different SSM routes, semi-solid extrusion has gained particular interest because it lowers forming forces, encourages grain refinement, and helps suppress common casting defects such as porosity and chemical segregation [9–10]. This approach is especially beneficial for high-strength aluminium alloys