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# Pre-strain rolling as an effective tool for suppression of abnormal grain growth in friction-stir welded 6061 aluminum alloy

ACCEPTED MANUSCRIPT

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*In this work, pre-strain rolling to a small thickness reduction was applied to friction-stir welded 6061 aluminum alloy to suppress abnormal grain growth during post-weld heat treatment. This approach enabled to produce nearly homogeneous microstructure distribution across the weld and thus to avoid strain localization during transverse tensile tests.*

**Keywords:** Aluminium alloys; Plasticity methods; Grains and interfaces

## 1. Introduction

Friction-stir welding (FSW) is an innovative solid-state joining technology which enables to produce high-quality welds with excellent service properties in various structural materials [1-3]. Due to numerous advantages, FSW has great industrial potential and sometimes even considered as one of the most significant recent achievements in materials joining. However, the essential drawback of this technique is the relatively low stability of the welded material against *abnormal grain growth* at elevated temperatures [e.g. 4-6]. This phenomenon involves catastrophic growth of few grains which may eventually consume the entire material and thus substantially degrade its mechanical characteristics. The abnormal annealing behavior of friction-stir welded material is often explained in terms of Humphreys's cellular model [7,8], i.e. local imbalance between the pressure for the grain growth and pinning pressure of low-angle boundaries and/or second-phase particles. It should be emphasized, however, that the above model was elaborated for macro-scale homogeneous material whereas the friction-stir welds are characterized by extremely sharp microstructural gradient. The theory of the annealing behavior of such heterogeneous materials has not elaborated yet and therefore the genesis of the abnormal grain growth in friction-stir welds is still not completely clear. Accordingly, there is no clear understanding of how to avoid or inhibit this undesirable effect.

It is worth noting in this regard that ~50 years ago a simple but effective approach for suppression of abnormal grain growth was proposed [9]. This method involved a pre-strain rolling and was based on the idea of randomization of crystallographic texture which was believed to be responsible for the abnormal grain growth [9]. This old technique appears to be very promising for improvement of thermal stability of friction-stir welds, but, to the best of the authors' knowledge, it has never been

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