



Thermomechanical processing of an aluminium casting alloy for thixoforming

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ARTICLE INFO

Article history:

Received 30 June 2008

Received in revised form 14 December 2008

Accepted 15 December 2008

Available online 25 December 2008

Keywords:

Thixoforming

Thermomechanical processing

Aluminium alloys

ABSTRACT

Thermomechanical processing of Al–Si casting alloys may be attractive when the material of choice for a large number of small parts to be thixoformed is a higher silicon grade aluminium alloy. With particle dispersion characteristics unique to hot-worked metals and a matrix no longer dendritic owing to extensive plastic flow and welding of α -Al fibrous grains, the microstructure of the extruded AlSi8Cu3Fe stock is typical of particulate-reinforced wrought alloys. Its response to reheating in the semi-solid temperature range is also similar to that of wrought aluminium alloys processed thermomechanically. Of the three different extrusion temperatures employed in the present work, 420 °C produced, after reheating into the semi-solid temperature range, the best features for thixoformability, with nearly globular α -Al grains across much of the section. While the anisotropy of growth rates due to the abundance of Si particles aligned in the extrusion axis gives elongated grains in the interior of the slug, high aspect ratios are largely compensated for with increasing soaking time. α -Al grains tend to globularize and the difference in their size between the surface and the interior is also reduced with soaking time owing to the growth rates which become increasingly more uniform throughout the volume.

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1. Introduction

Semi-solid processing is a net shape process that combines the advantages of conventional forging and traditional casting and has already become the standard manufacturing route for a number of automotive parts [1]. The alloy is formed inside the solid–liquid binary phase field, either in closed dies as in forging or by injection into dies as in die-casting. Such a process offers to produce aluminium components free from porosity, with good surface finish, fine uniform microstructure and superior mechanical properties [2–4]. The key feature that permits the semi-solid forming of alloys is a dendrite-less microstructure, with α -Al globules suspended in a liquid matrix, which may be handled like a solid, but flows readily when sheared [5].

Among those methods used to produce aluminium alloy thixoforming stock [6–29], magneto hydro dynamic (MHD) casting is by far the most popular process to continuously cast billets for thixoforming and is thus widely commercialized. In MHD casting, liquid metal is subjected to simultaneous stirring and cooling while flowing through a conventional DC caster [6]. The resulting microstructure consists of ripened equiaxed dendrites which become globular upon isothermal holding in the semi-solid temperature range. Thermomechanical processing route, which involves, first recovery and recrystallization and then partial melt-

ing of a heavily deformed alloy [9–11], on the other hand, is almost invariably employed for wrought alloys. This process may be just as attractive when the material of choice for a large number of small parts to be thixoformed is a higher silicon grade aluminium casting alloy. Casting alloys additionally contain eutectic Si particles which are expected to have a big impact on microstructural evolution during reheating. Thermomechanical processing of casting alloys offers new applications for semi-solid processing route without the need for the costly MHD casting process to prepare the required feedstock. An attempt was made in the present work to explore the potential of thermomechanical processing to produce AlSi8Cu3Fe alloy feedstock for thixoforging. Extruded AlSi8Cu3Fe stock was isothermally held in the semi-solid temperature range and then quenched to freeze and then to identify the microstructural features thus obtained.

2. Experimental procedures

The aluminium casting alloy used in the present work was a commercial AlSi8Cu3Fe alloy with the chemical composition given in Table 1. The as-received ingot was first reshaped into a round billet for the laboratory press by remelting and casting. The molten alloy was inoculated with Al–5Ti–1B and Al–10Sr master alloys in accordance with the standard commercial practice. The 100 mm diameter billet thus obtained was heated to 420 °C, 440 °C and 480 °C and was subsequently extruded into 27 mm diameter bars (extrusion ratio 14:1) in a vertical hydraulic press. 35 mm long slugs sectioned from the extruded stock were submitted to reheating and quenching experiments, described in detail in Ref. [30].

3 mm diameter disc samples, weighing 30–40 mg were scanned in a differential scanning calorimetry (DSC) unit between 500 °C and 700 °C at 2.5 K min^{−1} under flowing argon. The heat flow vs. temperature curves thus obtained were used to calculate the change in solid fraction (F_s) with temperature. Temperatures for reheating

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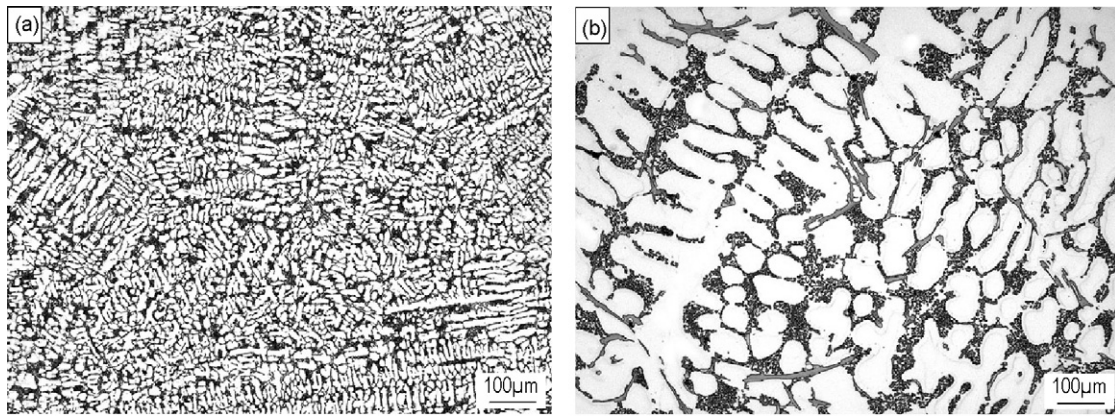


Fig. 1. Microstructure of the AlSi8Cu3Fe billet.

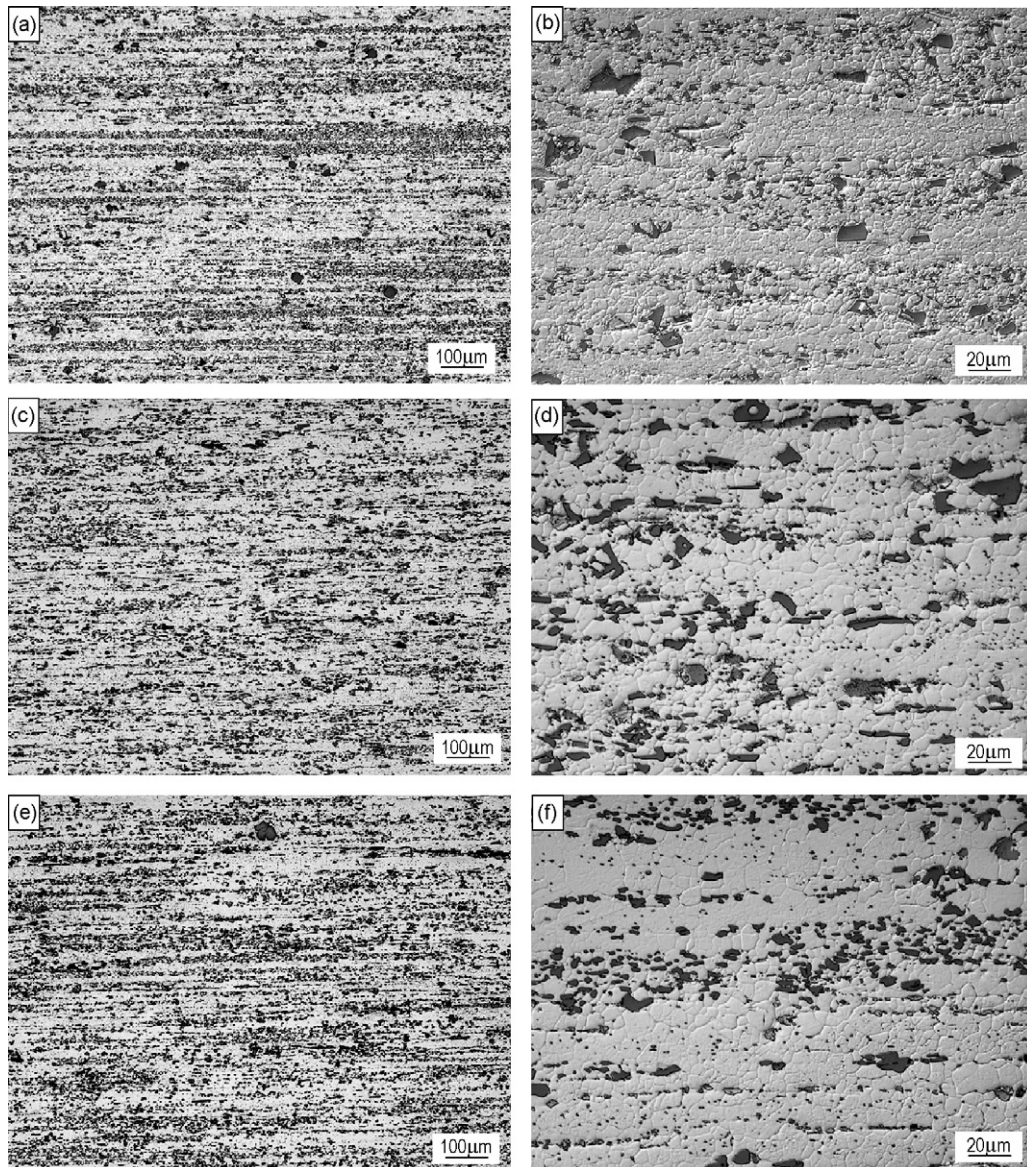


Fig. 2. Microstructure of the AlSi8Cu3Fe bars extruded at (a and b) 420 °C, (c and d) 440 °C and (e and f) 480 °C.

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