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Thermomechanical processing of a twin-roll cast Al–1Fe–0.2Si alloy

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ABSTRACT

A sound homogenization practice is identified for a twin-roll cast Al–1Fe–0.2Si (AA8079) alloy, a popular foil stock with a higher Fe/Si ratio than most other AlFeSi commercial alloys. Homogenization below 793 K produces a very fine dispersion of α_c particles which in turn yields a very coarse and heterogeneous grain structure upon interannealing. When the Al–1Fe–0.2Si strip is homogenized above 833 K, α_c particles are replaced by relatively coarser Al_3Fe particles with a favorable effect on the recrystallized grain size. It is thus concluded that a homogenization temperature of at least 833 K must be employed to obtain a coarse particle dispersion which in turn would produce a fine grain size after interannealing.

1. Introduction

A number of alloys from the ternary Al–Fe–Si system have been traditionally used as foil stock (Vangala et al., 1992). The production cycle starts with either direct chill or twin-roll casting and almost always involves a recrystallization anneal at some intermediate gauge in order to restore the ductility to facilitate further rolling to foil gauges. Fe and Si are the main elements with an impact on grain size, texture or formability (Oscarsson et al., 1991; Moriyama et al., 1989; Marshall et al., 1991). High Fe contents are generally preferred in order to obtain a fine recrystallized grain structure for a superior stretch formability (Uchiyama and Sakaguchi, 1984). Design of the thermomechanical processing cycle is just as imporant in this respect (Sakaguchi et al., 1987).

AA8079 is a popular foil stock alloy with a higher Fe/Si ratio than most other commercial alloys in the Al–Fe–Si system (RRIA, 1989). Its Si content does not suffice to remove the solute Fe from the matrix. Supersaturation of the aluminium solid solution matrix with Fe may be substantial when twin-roll casting is employed owing to the high solidification rates encountered in this process. Hence, a significant portion of Fe may be in solution in the as-cast state and ought to be precipitated before further processing in order to ensure a fine recrystallized grain structure. This is often achieved via a high-temperature anneal referred to as the homogenization treatment. Homogenization treatment not only relieves the supersaturation of the matrix by allowing precipitation of secondary intermetallic particles, but also changes the primary phase features. It is thus of considerable technological interest to control the formation and transformation of intermetallic particles by employing a homogenization treatment at the cast gauge. The present work was undertaken to identify a sound homogenization practice for a twin-roll cast Al–1Fe–0.2Si strip and addresses the effect of homogenization treatment on the particle size and distribution and thus on interannealed grain structure.

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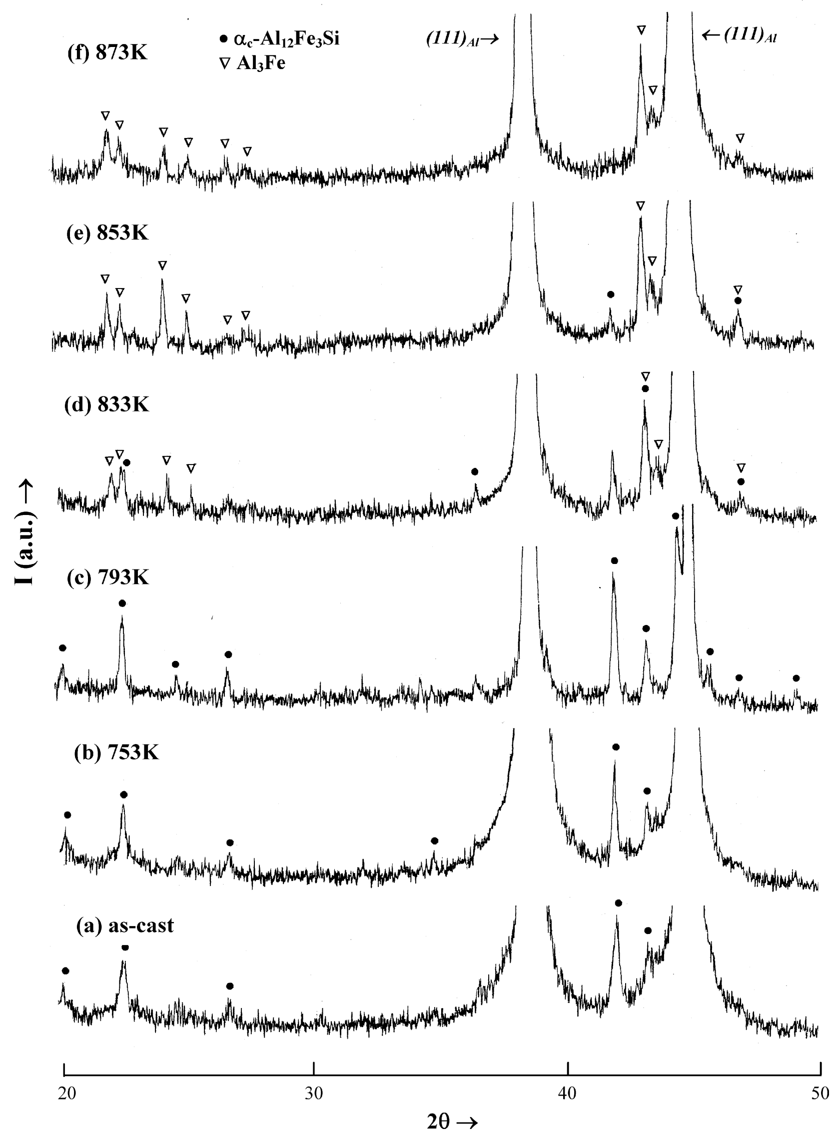

Fig. 1 – XRD patterns of (a) the cast AlFeSi strip and of the strip samples homogenized for 8 h at (b) 753 K, (c) 793 K, (d) 833 K, (e) 853 K and (f) 873 K. (●) α_c-$Al_{12}Fe_3Si$, (▽) Al_3Fe.

2. Experimental procedures

The present investigation was carried out on a 6 mm-thick twin-roll cast AA8079 alloy strip with 0.191 wt% Si and 0.966 wt% Fe. Samples for characterization studies in the as-cast state and for homogenization treatments were sectioned from the center of the strip. The homogenization treatments involved slow heating and a subsequent isothermal step where the samples were soaked between 753 K and 873 K for 8 h before they were finally furnace-cooled to room temperature. The homogenized samples were cold rolled in a fully instrumented laboratory rolling mill to a thickness reduction of 80% and were then interannealed at 698 K for 1 h.

The as-cast and heat-treated samples were polished using conventional metallographic techniques and were examined as polished, with an OLYMPUS BX51M model optical and a JEOL JSM 5400 Scanning Electron Microscope (SEM). X-ray diffraction (XRD) and energy-dispersive spectroscopy (EDS) were employed in a complementary fashion for the identification of intermetallic particles. XRD patterns of as-cast and heat-treated samples were recorded with a Shimadzu XRD 6000 diffractometer equipped with Cu Kα radiation. The diffractometer was operated at very low scanning rates (0.1–0.5° min^{-1}) in order to improve the counting accuracy. A Voyager 2110 model energy-dispersive X-ray analyzer (EDS) was also used for further identification of the intermetallic phases and a Sigma Test Unit to measure the electrical conductivity of the samples to find out about the solute levels in the matrix. The interannealed samples were etched and examined for their grain size.