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Effect of calcium addition on the microstructure and compressive deformation behaviour of 7178 aluminium alloy

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ABSTRACT

Aluminium 7178 alloys containing 1% calcium are used to study the effect of calcium addition on their microstructure and compressive deformation behaviour. The compressive deformation behaviour of aluminium alloy containing 1% calcium is studied at varying strain rates (10^{-2}–10/s). The material is prepared using stir casting technique. The yield stress, flow stress and elastic limit are measured from the true stress–strain graph. The strain rate sensitivity and strain-hardening exponent was also determined for each material at different strain rates. Its microstructural characterization reveals that Ca particles act as grain refiners for primary base alloy and helps in improving the strength of the virgin alloy. An empirical relationship has been proposed to predict the flow curve of the alloys as a function of strain and strain rate.

1. Introduction

Aluminium and its alloys have potential applications in aerospace and automotive industry because of its higher specific strength and stiffness [1–3]. Pure aluminium is relatively a soft material. For applications requiring greater mechanical strength, it is generally alloyed with other elements such as copper, magnesium, manganese, iron, silicon and zinc. Strake [4] reviewed in detail the effect of different alloying elements on the microstructure and mechanical behaviour of aluminium and its alloys. Zhongxia et al. [5] reported that addition of rare earth metals like Sc, Zr and Ti, in small quantities refined the microstructure and thus improved the strength of Al–5Mg alloy significantly. Thompson and Zinkham [6] also examined that addition of alloying elements like Zr, Cr and Fe in a 7075 Aluminium alloy results in different kinds of inter-metallic phases of various size ranges which results in microstructural refinement and influences in age hardening characteristics as well as recrystallisation and grain growth. The inter-metallic precipitates also causes for higher strength and fatigue crack growth resistance. Heusler and Schneider [7] examined that addition of Mg, Na and Sr in small quantities influenced the eutectic transformation of Al–Si cast alloys and modified silicon morphologies to a great extent and thus improve its strength and toughness. It is further reported by Dash and Makhlouf [8] that the castability of Al–Si alloys improved, hydrogen absorption decreased and microstructure got refined and modified due to addition of Mg, Mn, Cu, Sr and Ti. All these factors lead to higher strength and ductility. The 7178 series alloys based on Al–Zn–Mg system have unique combination of desirable characteristics including low density, high strength and fracture toughness [9]. Increased strength of these alloys was achieved through the formation of finer inter-metallic precipitates with increasing Zn, Mg and Cu concentration [10]. However, improved mechanical properties require a strict control on alloy preparation and processing aiming to achieve refined and modified microstructure along with generation of fine coherent precipitates. Elements like Ti [8], Cr [6], Zr [6] and Sc [5], and component like TiB_2 [11] are used for obtaining refined microstructure.

Calcium has been used by Mihriban and Pekguleryuz as an important alloying element in magnesium alloys to improve their high temperature strength vis-a-vis creep resistance [12]. It was examined by these investigators that Ca offers a thermally stable second phase Mg_2Ca and thus significantly improved the elevated temperature strength and creep property. Ca added Mg–Al alloy becomes a promising low cost magnesium alloy for improved heat resistant and elevated temperature creep resistant automobile engine component applications [13]. It was reported that the addition of small amount of Ca into Mg–Al alloys can result in refinement of grain-structure and thus increasing their mechanical properties [14,15]. It was also examined by Drits et al. [16] that addition of Ca in Mg-alloys not only refined the microstructure and improved its creep resistance but also improved its high temperature oxidation resistance. In this context, it is suspicious that calcium can also be used as grain refiner for Al–Zn–Mg alloy. But this aspect, to the best of our knowledge had been overlooked so far.

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