# Optimizing Iron Removal in Secondary Aluminum Alloys Melts: Role of Manganese, Chromium, and Silicon

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**Abstract**

Aluminum alloys are renowned for their exceptional strength-to-weight ratio, superior castability, excellent thermal and electrical conductivities, and remarkable corrosion resistance. This distinctive combination of properties makes aluminum alloys highly versatile, finding applications across various industries, including automotive, aerospace, packaging, electrical wiring and cables, construction, and consumer electronics. Additionally, aluminum's high recyclability positions it as a key material supporting a circular economy. Secondary aluminum has garnered significant attention for its low energy consumption, reduced emissions, and excellent recyclability. The energy required for secondary aluminum production is just 5% of the energy needed for primary aluminum production. However, as aluminum alloy products end their service life, substantial quantities of scrap aluminum alloys enter the recycling stream. This process inevitably introduces impurity elements, such as Si, Fe, Mg, and Mn, which can adversely affect the mechanical properties of the resulting alloys. Impurity contamination can significantly reduce the economic value of aluminum scrap, often leading to its downcycling into lower-value products. Controlling the impurity content in aluminum scrap melts is very crucial. This study explores the use of alloying elements like Mn and Cr to enhance the efficient separation of Fe in Al-Si alloys through a gravity sedimentation technique. The efficiency of Fe-containing intermetallic particle phase separation is influenced by the concentrations of Mn, Cr, and Si and critical factors such as holding temperature and settling time. The CALPHAD method was employed using ThermoCalc to determine the appropriate temperature for the formation of impurity-rich intermetallic phases in the experimental alloys. The presence of Mn and Cr facilitates the formation of impurity-rich intermetallic phases, while high Si content not only lowers the solidification temperature of the α-Al phase but also broadens the temperature range for the formation of impurity-rich intermetallic phases and expedites their sedimentation. A significant decrease (>70%) in the concentration of both Fe and Mn was observed within one hour in the presence of chromium in the high Fe-containing aluminum alloy. Building on the results of lab-scale experiments, a series of large-scale trials were conducted, successfully replicating the findings observed at the laboratory level during production trials.

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