High-Performance Die Casting Alloys: Castings for Improved Readiness

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Objective

The objective of this work, which is supported by the Defense Supply Center and overseen by the North American Die Casting Association (NADCA) is to develop premium grade aluminum-based die casting alloys that have mechanical properties that meet the increasing demands of advanced applications. Specifically, we aim to develop alloys that have either 8-10% higher yield strength or 20-30% higher elongation than A380 alloy so as to produce a10-12% improvement in the alloy's quality index.

Introduction

The quality Index (QI) is a parameter that allows comparison of important tensile properties (strength and ductility) of alloys using a single numerical value. The index is generally calculated from measured tensile or yield strength (TS or YS) and elongation (e%) by giving each of these properties a different weight. Since each of the properties may have a different relative importance depending on the intended application, the weight of a property may be different for different applications. Currently there is no universal equation for calculating the Quality Index that is accepted for all alloys and all casting processes. In the early 1970's, Jacob developed the QI for 356 and 357 alloys [1] and later Caceres provided a physical meaning for the concept of Quality Index [2]. Caceres, in collaboration with us expanded the use of QI to die casting alloys [3]. The equation for calculating Quality Index of die casting alloys is given by

$$QI = YS + 210 \times \log(e) + 13$$

Where YS is yield strength in MPa and e is elongation in percent.

Methodology

The alloy development work focused on two fronts:

(1) Developing an optimized alloy with chemical composition that lies within (or very close to) the chemical composition of A380 alloy, but with relatively tighter limits placed on the optimized amounts of the constituent elements.

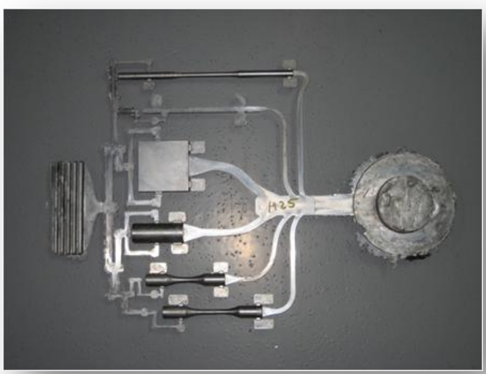
(2) Developing a new die-casting alloy with a chemical composition that is different from that of A380 alloy.

Die casting was performed at Contech and Premier

The as-cast tensile, fatigue, and impact test specimens were produced in a single die designed by NADCA

100 - 130 shots were made with each alloy

Specimens were also removed from production castings



Salient Results

Tensile Properties Compared to A380 Alloy
Die cast specimens

NEW ALLOY: **A380*** exhibits:

21% increase in RT ductility (4.63% vs 3.83%)

4.4% increase in RT yield strength (23.7 ksi vs 22.7 ksi)

→ **8.3% increase in *QI* (316 vs 291)**

NEW ALLOY: **AMC380** exhibits:

2.7% decrease in RT ductility (3.72% vs 3.83%)

23% increase in RT yield strength (27.9 ksi vs 22.7 ksi)

→ **11.5% increase in *QI* (325 vs 291)**

New Alloy **(AMC1045Sr)** exhibits:

39% decrease in RT ductility (1.83% vs 3.83%)

55% increase in RT yield strength (35.2 ksi vs 22.7 ksi)

→ **14.0% increase in *QI* (332 vs 291)**

Tensile Properties Compared to A380 Alloy
Specimens extracted from die castings

NEW ALLOY: **AMC380** exhibits:

2.7% increase in RT ductility (2.38% vs 2.32%)

45% increase in RT yield strength (31.0 ksi vs 21.4 ksi)

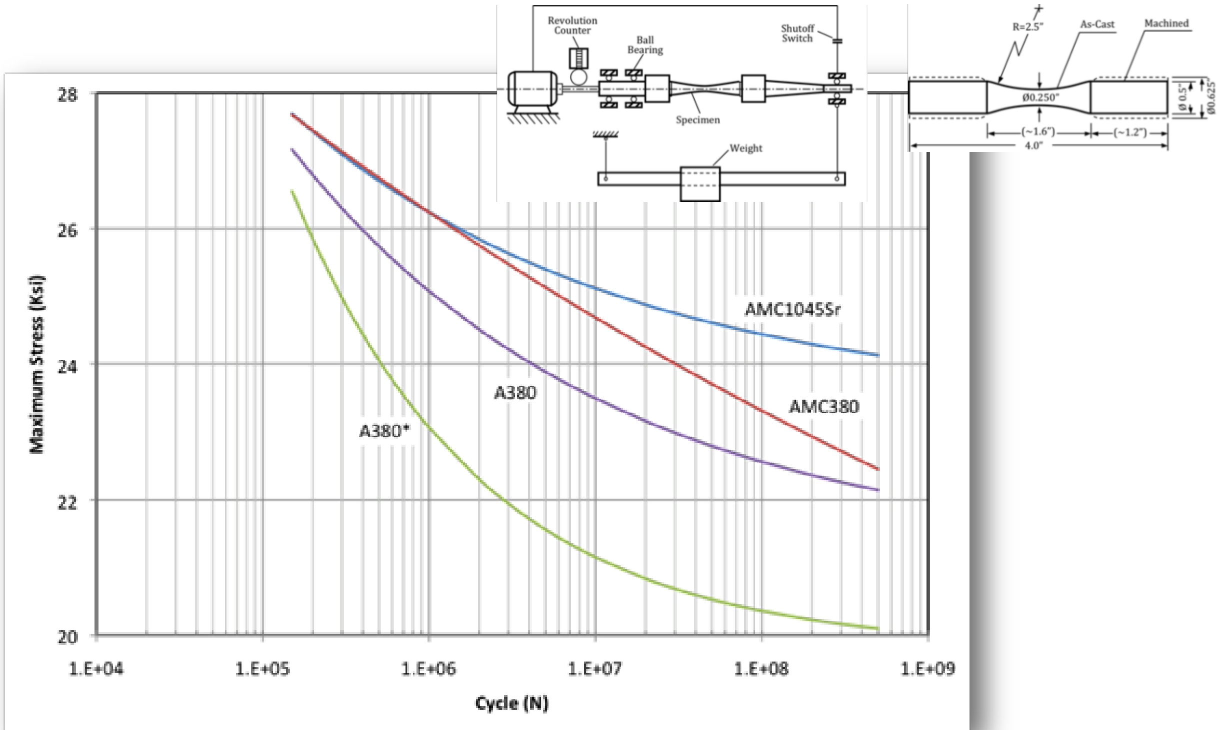
→ **28.6% increase in *QI* (302 vs 235)**

NEW ALLOY: **AMC1045Sr** exhibits:

24% decrease in RT ductility (1.76% vs 2.32%)

97% increase in RT yield strength (42.2 ksi vs 21.4 ksi)

→ **49.0% increase in *QI* (350 vs 235)**



Fatigue characteristics of the new alloys.