Aluminum Alloy for High Temperature Applications

A novel low cost cast aluminum alloy offers dramatic strength at high temperatures

NASA’s Marshall Space Flight Center originally developed a high-performance piston alloy to meet U.S. legislative restrictions on vehicular exhaust hydrocarbon emissions. NASA 398 aluminum alloy exhibits excellent tensile and fatigue strength at elevated temperatures. NASA 398 alloy also offers superior wear resistance, surface hardness, dimensional stability, and lower thermal expansion compared to conventional aluminum alloys. NASA 398 has been used in mass production and has enabled award-winning and innovative commercial products, and the NASA Marshall Technology Transfer Office is seeking new licensees that may also benefit from its adoption.

**BENEFITS**

- Provides significant improvement in tensile strength at elevated temperatures (500°F - 700°F)
- Enables optimized designs that require less material, thus reducing part weight and cost
- Is suitable for mass production using conventional casting techniques
- Enables improved engine performance and reduced emissions in automotive piston applications
NASA's Technology Transfer Program
pursues the widest possible applications
of agency technology to benefit US
citizens. Through partnerships and
licensing agreements with industry,
the program ensures that NASA's
investments in pioneering research find
secondary uses that benefit the economy,
create jobs, and improve quality of life.

More Information
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THE TECHNOLOGY

NASA 398 is an aluminum-silicon hypereutectic alloy (16% w. Si) with a microstructure
that consists of small polygonal primary silicon particles evenly distributed in an
aluminum matrix. The alloy can be utilized in automotive applications with high
mechanical loading at elevated temperatures from 500 °F (260°C) to 700 °F (370°C), and
can offer significant improvements in strength relative to most conventional aluminum
alloys.

Material physical and mechanical properties for NASA 398-T-5 (permanent mold) are
provided in Table 1 below. Additional information is available on request and at the
following website:


Table 1 NASA 398-T5 (Permanent Mold): Typical Tensile Properties

| Temperature | 75 °F 400 °F 500 °F 600 °F 700 °F |
|-------------|------------------|------------------|------------------|------------------|
| °F °C       | Time at test     | Tensile strength | Yield strength   | Elongation       | Hardness at 25°C | Modulus of elasticity |
|             | temperature      | ksi Mpa          | ksi Mpa          | in 4D, %         | HRB Msi          | Msi GPA              |
|             | (hour)           |                  |                  |                  |                 |                     |
| 75          | 25               | 40 277           | 34 235           | 0.4              | 71 12.8          | 88.6                 |
| 400         | 205              | 32 221           | 28 194           | 0.8              | 64 11.0          | 76.1                 |
| 500         | 260              | 27 187           | 23 159           | 1.5              | 55 10.5          | 72.7                 |
| 600         | 315              | 22 152           | 18 124           | 2.5              | 48 9.0           | 62.3                 |
| 700         | 370              | 16 111           | 13 90            | 4.5              | 33 8.0           | 55.4                 |

Comparison testing of tensile strength between a conventional aluminum alloy and
NASA 398.

APPLICATIONS

The technology has several potential applications:

- Internal combustion engines and high
temperature components such as
  pistons, manifolds, brake calipers,
cylinder heads, and heat exchangers.
- Applications requiring light-weight,
  high-strength, and wear-resistant
  alloys at elevated temperatures.
- Potential replacement for cast
titanium and iron-based alloys to
  reduce part weight and cost

PUBLICATIONS

Marshall has received several patents for
protection of NASA 398, including:

U.S. Patent No. 6,918,970
U.S. Patent No. 6,669,792
U.S. Patent No. 6,592,687
U.S. Patent No. 6,419,769
U.S. Patent No. 6,399,020

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MFS-31828-1, MFS-31294-7-CIP, MFS-31294-2-CIP2,
MFS-31294-6-CIP, MFS-31294-5-CIP