HIGH-PERFORMANCE ALUMINUM TECHNOLOGY

Lightweight Aluminum in Powder Metallurgy
**THE MARKET’S DRIVE TOWARD LIGHTWEIGHT TECHNOLOGY**

**Market Drivers**

- CO₂ emissions and fuel economy standards are mandating vehicle mass reduction
- Internal combustion engines and hybrid electric vehicle efficiency hinges on smaller engine size, increased transmission speed
- Reduction in mass reduces energy use for all forms of energy: ICE, Hybrid, and Electric

**GKN Solutions**

- GKN’s lightweight technology minimizes component mass without compromising performance
- GKN’s advanced Powder Metallurgy (PM) technology produces high-strength, net-shape parts geared toward ICE, hybrid and vehicle electrification
- **GKN is the leader in PM technology and develops lightweight, high-performance Aluminum materials and products**

**Graph/The International Council in Clean Transportation**
COMBINING EFFICIENT PROCESSING WITH ADVANCED LIGHTWEIGHT MATERIALS

Why Powder Metallurgy?

- Unrivaled Design Freedom
- Unique part geometries
- Simplified product design without compromised functionality
- High material utilization greater than 90 percent
- Rapid prototype development, scalable to high-volume production

Why GKN?

- Aluminum Metal Matrix Composite (Al MMC) Technology
  - Hard ceramic, uniformly distributed within tough Al-alloy matrix
  - Improved static and dynamic performance over conventional Al-alloys
  - Readily forgeable, significantly increasing mechanical performance
- Novel Al-Alloy with High Thermal Conductivity (TC2000 series)
  - Versatile material for thermal management applications

PRODUCT

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>Net shape</th>
<th>Efficiency</th>
<th>Inertia</th>
<th>Thermal</th>
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GKN’s Aluminum MMC

**Specific Strength**

- Higher strength-to-weight ratio, allowing for mass reduction and improved vehicle efficiency
- Forging specific strength exceeds steel PM alloys and forgings

**Wear Resistance**

- Superior resistance to sliding wear for use in hydraulic applications
- Minimized oil contamination (no abrasive Si particles), improved pump efficiency
- CTE match with aluminum housing improves overall pump efficiency

### Specific Strength Tensile $[\text{MPa}/(\text{g/cm}^3)]$

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<th>Materials</th>
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### ASTM G77 – Block-on-Ring Wear Test

- Increasing Wear Resistance
- Wear Scar Width (mm)
- Mass Change of Ring (g)

- Al 6061-T6511: 6.587, 0.0214
- Cast Al A380: 3.387, 0.0023
- Cast Al B390: 1.954, 0.0126
- Al PM MMC: 1.467, 0.0015
- Cast Iron: 0.701, 0.0001
GKN’s TC2000 is the PM counterpart to commercially pure, wrought aluminum. TC2000 outperforms conventional extrusions and castings by limiting solute impurities within the aluminum matrix.
GKN Powder Metallurgy produces over 30 million engine camshaft caps per year, designed to exceed unique customer requirements. Several material options allow for design flexibility to optimize geometric precision, strength, toughness, wear resistance and/or cost.

- GKN's PM netshape design only requires customer line bore
- High wear and fatigue resistance (with optional MMC material)
- Unique Z-loc, for dowel elimination
This MPIF award-winning Planetary Reaction Carrier is the first commercial use of powder metal Aluminum MMC material for a carrier application. The technology won the 2018 Grand Prize in the MPIF Design Excellence Awards.

- Introduction of aluminum reduced the mass of the carrier application by 1 kg
- High wear resistance and lower inertial mass
- Maintains strength and fatigue at operating temperature of 150 degrees Celsius
- Industry-winning dimensional precision
Forged Products

Tailored preform design allows for highly controllable plastic flow

Near-net shape, and economical process eliminates subsequent working operations

Fatigue properties exceed wrought forged Aluminum

GKN is in production development of Aluminum forged products:

- Tailored preform design allows for highly controllable plastic flow
- Near-net shape, and economical process eliminates subsequent working operations
- Fatigue properties exceed wrought forged Aluminum

Bending Fatigue Strength

GKN’s 2618 MMC

Wrought 2618

Conventional Forged Material

GKN’s Forged MMC Material
GKN’s heat sink was developed to replace die cast components for a car radio cooling application.

- Unique tower and three section sizes, not practical for casting or extrusion
- Higher thermal conductivity, requiring less thermal mass
- No machining required, providing cost savings
- High ductility, reducing risk of cracking during mechanical attachment
ALUMINUM TECHNOLOGY

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