Pacific Northwest National Laboratory

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Low Cost Cast Aluminum Metal Matrix Composites

Importance of Our Work

Our scientists are working on a rapid melting-mixing process to produce aluminum metal matrix composite materials, at a lower cost than current production methods. Innovative and cost-effective casting and finishing processes for MMC components are under development.

Benefits

- Provide lightweight, castable, aluminum metal matrix composite options for $1 per pound
- Reduction in primary and secondary foundry and finishing costs, through a reduction in labor time and scrap waste
- Over-all manufacturing cost reduction for MMC based automotive components

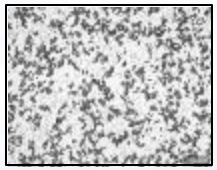
Project Participants

Industry – MC-21, Aluminum Consultants Group, Eck Industries, MMCC, Inc., BFD, Inc.

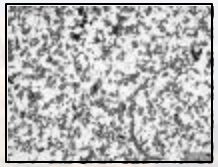
National Labs – Pacific Northwest National Laboratory, Oak Ridge National Laboratory

Low-Cost Al-MMC Evaluation

- Mechanical and physical property testing
- Tribology evaluation
- Microstructural evaluation
- Foundry trials and evaluation
- Innovative brake system designs to utilize aluminum metal matrix composite materials



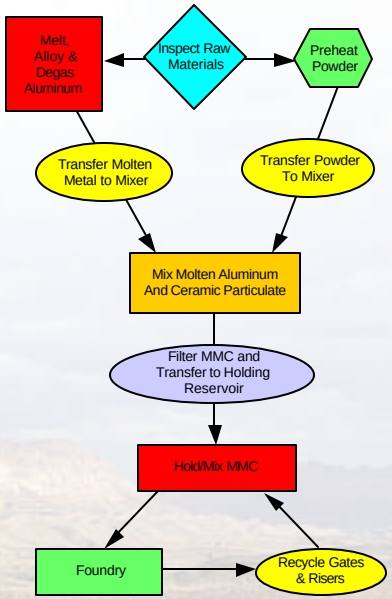
Duralcan F3S.20S



MC-21 Low-Cost 359/SiC/20p

Shown is the microstructure comparison between the industry standard Duralcan Al-MMC casting material and the MC-21 low-cost Al-MMC castable alloy. The low-cost material has good reinforcement distribution and structural integrity.

Diagram of Low-Cost MMC Mixing Process



Modular Mixing Concept

Modular in-plant or foundry design consists of three units,

- melter – high-rate electric furnace
- mixer – high speed mixing and stirring
- holder – low speed agitation for long time periods.

The system is designed for rapid mixing to reduce over-all compositing time and therefore labor cost. Melting and mixing times are reduced from hours to minutes.

An alternate grade of silicone carbide, with a larger size distribution of particles, further reduces raw materials costs. The system is designed at 600kg capacity, but can be easily scaled according to customer demand.

Innovative Casting Concepts

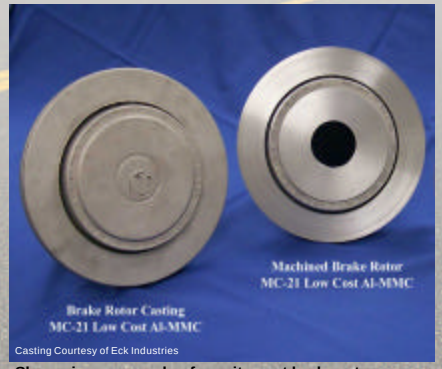
The innovative casting processes focus on the production of an automotive brake rotor and other brake system components. The concepts, such as Centrifugal Casting, the BFD Inc. ONNEX process, and the MMCC Inc. APIC ä process, are based on selective reinforcement of brake component. These casting processes are used to selectively place the second-phase matrix-reinforcing particles, where they have the most benefit for improving the component physical properties. This also assists in reducing finishing time and expenses, by reducing unnecessary machining of hard MMC surfaces.

Property Comparision of Duralcan and MC-21 Material

Composite Material	Modulus [1] (GPa)	Elongation [2] (%)	Yield Strength T6 (MPa)	Yield Strength T7 (MPa)	UTS T6 (MPa)	UTS T7 (MPa)	Hardness Cast (HRB)	Hardness T4 (HRB)	Hardness T6 (HRB)	Average CTE (10^{-6}/K)	Thermal Conductivity [4] (W/m-K)
Duralcan w/ F500 SiC	100.4	--	*	NA	290 **	NA	26	60	77	20.5	135
MC-21 w/ F500 SiC	100.5	0.38	290	NA	310	NA	29	60	77	20.5	125
MC-21 w/ Low Cost SiC	102.3	0.43	278 [3]	221 [3]	299 [3]	244 [3]	29	62	78	19.0	132
Duralcan F3S.20S (Reported)	98.6	0.40	338 [3]	214 [3]	359 [3]	262 [3]	NA	NA	77	20.7	144

* 0.2% offset not achievable ** Fracture strength
(1) Results obtained by ultrasonic testing (2) T6 condition values (3) Cast-to-size tensile bars (4) At temperature of 25C

The mechanical and physical properties of the low-cost Al-MMC material is comparable with currently available Al-MMC materials.



Casting Courtesy of Eck Industries

Shown is an example of gravity cast brake rotors from the MC-21 low cost 359/SiC/20p material.

Prototype 60kg MMC mixer.

Prototype MMC holding furnace.