

Solidification During Casting of Metal-Matrix Composites

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METAL-MATRIX COMPOSITES (MMC's) are engineered combinations of two or more materials in which reinforcing phases are dispersed in a metal or an alloy. Structurally, cast MMC's consist of continuous or discontinuous fibers (designated by the subscript f), whiskers (w), or particles (p) in a metal or an alloy that solidifies in the restricted spaces between the reinforcing phase (or phases) to form the bulk of the matrix. There are several cast materials, such as aluminum-silicon alloys and cast iron, that exhibit two-phase microstructure in which the volume and shape of the phases are governed by phase equilibria and that have a long history of foundry production. Modern cast MMC's differ from these traditional materials in that any selected volume, shape, and size of reinforcement can be introduced into the matrix, even beyond the permissible limits presented by the phase diagrams.

By carefully controlling fiber size, shape, surface properties, volume fraction, and distribution of the reinforcement and by controlling the solidification conditions, MMC's can be synthesized having a tailored set of useful engineering properties. For example, as shown in Table 1, combinations of very high specific strength and specific modulus, beyond those of conventional monolithic alloys, are achievable. Table 2 summarizes the applications of several commonly used MMC's and the properties that make them suitable for

their applications. Microstructural design and synthesis procedures have been developed to achieve unique combinations of properties, including improved elevated-temperature and fatigue strengths, increased damping ability, tailored electrical and thermal conductivities,

reduced wear rates, and targeted coefficients of thermal expansion. These tailored properties provide opportunities for a variety of new applications for MMC's that were not possible using conventional materials. For more information about MMC types and their applications, see the

Table 1 Specific strength and specific modulus of some metal matrices, reinforcements, and metal-matrix composites

Material	Amount of fiber reinforcement, vol %	Specific strength, N m/kg	Specific modulus, N m/kg
Al-10Al ₂ O ₃	40	30,000	7.59×10^7
Al	40	4,950-6,200	4.498×10^7
Ti-20Al ₂ O ₃ (p)	—	—	—
Ti	20	47,337	3.77×10^7
Al	20	50,652	—
Injection (Thermix)	18	26,339	—
Aluminum	30	26,340	6.53×10^7
AlSi10Mg	—	11,440	2.53×10^7
Ti6Al4V	—	17,349	3.59×10^7
Al ₂ O ₃	100	76,431	3.507×10^8
SiC _f	100	6.67×10^7	$2.19 \times 3.29 \times 10^8$
Al ₂ O ₃ /SiC _f	100	80,000	3.175×10^8
SiC _f	100	1.554×10^7	1.62×10^7
C _f	100	1.493×10^7	1.25×10^7
SiC _f	100	86,459	8.88×10^7
W _f	100	149,754	1.79×10^7
Aluminum	—	—	—
Al	50	8,900	7.03×10^7
AlSi10Mg	50	5,263	5.44×10^7
Al	—	—	—
Al	50	6,363	1.092×10^7
Al	50	3,467	—

Table 2 Selected potential applications of cast metal-matrix composites

Composites	Applications	Special features
Aluminum/graphite	Bearings	Chemical, light, self-lubricating, corrosion Cu, Pb, Sn, Zn, etc.
Aluminum/graphite, aluminum/SiC-Al ₂ O ₃	Automobile pistons, cylinder bores, piston rings, connecting rods	Reduced wear, increasing cold start, lightness, corrosion (Sn, Zn)
Aluminum/SiC-Al ₂ O ₃	—	Improved efficiency
Copper/graphite	—	—
Aluminum/SiC	Sliding elements of contacts	Excellent conductivity and lubricating properties
Aluminum/iron or carbon reinforcements	Thrust-bearing impellers	High compressive strength
Magnesium/graphite fibers	—	Lightweight materials
Aluminum/graphite	Turbine compressors for space vehicles	Low thermal expansion, high-temperature strength, good specific strength and specific stiffness
Aluminum/graphite, aluminum/SiC, aluminum/SiC	Cutting tools, machine elements, impellers	Hard, abrasion-resistant materials
Aluminum/SiC, aluminum/SiC	—	—
Aluminum/SiC, aluminum/SiC	Low-cost, low-energy materials	—

Solidification Of Metal Matrix Composites

James Edward Simpson



Solidification Of Metal Matrix Composites:

Microstructure Formation During Solidification of Metal Matrix Composites P. K. Rohatgi,1993 This collection of papers from Materials Week 92 held in Chicago USA November 1992 identifies and defines the fundamental principles of solidification of metal matrix composites Areas of discussion include nucleation growth heat flow particle pushing interface stability and segregation during solidification of metal matrix composites

Solidification Processing of Metal Matrix Composites Nikhil Gupta,Warren H. Hunt,2006-11-10 Solidification Processing of Metal Matrix Composites MMCs focuses primarily on microcomposites but also covers macrocomposites nanocomposites and foams There are four main areas detailed fundamentals of solidification synthesis which examines issues related to stir mixing pressure infiltration transfer of particles or fibers through gas liquid and liquid solid interfaces and particle fiber interactions with fluids processing and microstructures which focuses on microstructure formation during solidification of MMC under different conditions such as nucleation growth heat transfer microsegregation macrosegregation and interactions between solidifying interfaces particles and fibers and properties of solidification processing covering the relationship between the microstructures and properties Comparisons are made between properties of solidification processed composites and monolithic and composites made by solid and vapor phase processes It also details the application of solidification processed MMCs revealing current and future applications especially in automotive aerospace railroad thermal management electromechanical machinery and recreational equipment sectors

Solidification of Metal Matrix Composites P. K. Rohatgi,1990 *Solidification of Particulate Reinforced Metal Matrix Composites* CSA Journal Division,Materials Information (Information service),Cambridge Scientific Abstracts, Inc,British Library. Document Supply Centre,Linda Hall Library. Document Services,2002*

Solidification Processing of Reinforced Metals R. Asthana,1998-04-06 Much of the success of composites can be attributed to the development of innovative processes Many useful composites are envisaged by materials scientists but the problem of how to make them is often the greater hurdle This process oriented book focuses on the basic principles of composite fabrication Upon studying these processes one is immediately struck by the diversity of ideas and techniques In some cases these have been borrowed from other technologies and were designed for use with quite different materials In other cases some very clever new means have been developed which take account of the characteristics of metals and ceramics and the higher temperatures which are typically involved in their processing

Heat and Mass Transport in the Solidification of Metal Matrix Composites Bechir Moussa,2000 *Solidification Rate Effects in Metal-matrix Composites* Andreas Michael Borchert,1991 *Interface Propagation in the Solidification of Metal Matrix Composites* James Edward Simpson,1999 Solidification of Particulate Reinforced Metal Matrix Composites, 2007 Ed Technology Research Editors,2007-01-01 Metal Matrix Composites Anne Isabelle Mertens,Stanislav Kolisnychenko,2023-11-16 Aggregated Book

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