ASM Handbook, Volume 15: Casting
ASM Handbook Committee, p 906–917
DOI: 10.1361/asmhba0005227

Solidification During Casting of Metal-Matrix Composites

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METAL-MATRIX COMPOSITES (MMCs) are engineered combinations of two or more materials in which reinforcing phases are dispersed in a metal or an alloy. Structurally, cast MMCs 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 irons, 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 MMCs 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 the size, shape, surface properties, volume fraction, and distribution of the reinforcement and by controlling the solidification conditions, MMCs 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 MMCs 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 MMCs 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	Approximate density, g/cm³	Tensile strength, ksi	Specific strength, in.	Tensile modulus, msi	Specific modulus, in.
Aluminum alloys					
2024	2.77	70	2.53×10^6	10.6	3.83×10^7
7075	2.80	83	2.96×10^6	10.4	3.71×10^7
Ti-6Al-4V (bar)					
25°C	4.51	165	3.66×10^6	16.5	3.66×10^7
650°C	4.51	50	1.11×10^6	12.5	2.77×10^7
Magnesium (Dowmetal)	1.81	36	1.99×10^6	6.5	3.59×10^7
Aluminum	2.70	13	4.81×10^6	10	3.70×10^7
6061-Al		17	6.30×10^6	10	3.70×10^7
2124-Al		17	6.30×10^6	10.5	3.89×10^7
SiC_w	3.00	75	2.50×10^6	30	1.00×10^8
$SiC_{w(+)}$	3.00	100	3.33×10^6	50	1.67×10^8
Al_2O_{3w}	3.00	80	2.67×10^6	40	1.33×10^8
B_{4C_p}	3.00	1.55	5.17×10^5	45	1.50×10^7
$C_{(p)}$	3.00	1.45	4.83×10^5	50	1.67×10^7
$Be_{(p)}$	3.00	90	3.00×10^6	45	1.50×10^7
$W_{(p)}$	3.00	140	4.67×10^6	75	2.50×10^7
Al/Boron					
0°	2.65	90	3.40×10^6	30	1.13×10^8
90°	2.65	15	5.66×10^5	30	1.13×10^8
Al/SiC					
0°	2.70	90	3.33×10^6	14	5.19×10^7
90°	2.70	15	5.56×10^5	14	5.19×10^7

Table 2 Selected potential applications of cast metal-matrix composites

Composite	Application	Special features
Aluminum/graphite	Bearings	Cheaper, lighter, self-lubricating, corrosion Cu, Pb, Sn, Zn, etc.
Aluminum/graphite, aluminum/α-Al_2O_3, aluminum/SiC-Al_2O_3	Automobile pistons, cylinder liners, piston rings, connecting rods	Reduced wear, self-seizing, cold start, lighter, consumer fuel, improved efficiency
Copper/graphite	Sliding electrical contacts	Excellent conductivity and self-lubricating properties
Aluminum/SiC	Turbine-bucket impellers	High compressive load
Aluminum/zinc or carbon microballoons		Ultralight materials
Magnesium/carbon fiber	Tubular components for space structures	Zero thermal expansion, high compressive strength, good specific strength and specific stiffness
Aluminum/cermet, aluminum/SiC, aluminum/silica	Cutting tools, machine shields, impellers	Hard, abrasion-resistant materials
Aluminum/lead, aluminum/clay	Low-cost, low-energy materials	

Solidification Of Metal Matrix Composites

Lei Shi

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 soldification 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 Processing of Reinforced Metals* R. Asthana,1998 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 Solidification of Metal Matrix Composites P. K. Rohatgi,1990 *Heat and Mass Transport in the Solidification of Metal Matrix Composites* Bechir Moussa,2000

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 of Particulate Reinforced Metal Matrix Composites, 2007 Ed** Technology Research Editors,2007-01-01 Numerical Modeling of Solidification of Metal Matrix Composites with Natural Convection E. K. Lee,2002 **Solidification Rate Effects in Metal-matrix Composites** Andreas Michael Borchert,1991 **Interface Propagation in the Solidification of Metal Matrix Composites** James Edward Simpson,1999 **Numerical Simulation of Solidification of Reinforced Metal Matrix Composites** Eng Kwong Lee,2003 *Nucleation Phenomenon During Solidification of Metal Matrix Composites* ,1994 A detailed analysis of possible interfaces in cast aluminum silicon base reinforced particle composites containing SiC Al2O3 and C indicates that several different kinds of interfaces can form The reinforcements may be totally surrounded by primary phase or primary silicon or by the eutectic between Al and Si In addition in some cases some of the original coatings or their reaction products in the case of coated particles like nickel or

nickel aluminum intermetallics in nickel coated reinforcements Cu or Cu aluminum intermetallics in Cu coated reinforcements may also form the interface The reaction between dispersoids and the alloy itself can form a complex interface These different interfaces have also been experimentally observed in the microstructures of cast particulate composites with the exception of primary a aluminum surrounding the reinforcement The absence of alpha aluminum on the reinforcements is attributed to possible lack of nucleation persistent lateral growth and a thermal lag between the reinforcement and the matrix Estimates of works of adhesion for the different interfaces observed in cast composites have been made using the London Van der Waal equation correlated to the properties of the composites and used to identify the possibilities of further improving these properties *Solidification of Particulate Reinforced Metal Matrix Composites* Technology Research Editors,2006-01-01 **Solidification of Particulate Reinforced Metal Matrix Composites** Craig Emerson,2009-01-01 **Particle-dendrite Interactions During the Solidification of Undercooled Metal-matrix Composites** Jason Sebright,2004 **Solidification Analysis of Metal Matrix Composites Aluminium 11.8% Silicon Alloy Reinforced with Titanium Carbide Particulates** Nanang Fatchurrohman,2009 Composite is a material system composed of a mixture or combination of two or more constituents that differ in form and chemical composition and which are essentially insoluble in each other Metal matrix composites MMC are engineered materials composed of an elemental or alloy as a matrix in which an insoluble second phase reinforcer is embedded and distributed to achieve property improvement Application of MMC comprises a broad range in aircraft automotive defence technology and astronautics components The performance during its work life of MMC is determined by the mechanical properties The mechanical properties of MMC are linked to microconstituents formed and its characteristics For MMC processed by casting method the solidification behaviour will determine the type of microconstituents formed and its properties In this study casting via vortex mixing method is employed to produce MMC aluminium 11 8% silicon alloy LM6 reinforced with different volume percentages 0 5 10 15 20 25% of titanium particulates TiCp cast using sand and copper moulds Temperature measurements during cooling and solidification are used as the main source to analyse solidification properties fraction solid and latent heat generation using Fourier thermal analysis method A metallographic study is performed to observe the particulates distribution and microconstituents present A hardness test is carried out the results show that 25% volume addition of TiCp cast using copper mould has the best result This result correspond to the improved microstructure as particulates are well distributed in the matrix which can be seen on the photomicrographs From the visual observation of photomicrographs the increment addition of particulates will promote more nucleation sites and grain size is reduced due to faster solidification of casting using copper mould high heat extraction capacity For production using sand mould the maximum mean value of hardness 54 38 Rockwell number is reached by addition of 25% volume content TiCp solidification time fraction solid equals to 1 at 195 seconds and volumetric latent heat generated 245 63 103kJ m3 The best result is obtained by fabrication of LM6

TiCp MMC using copper mould permanent die the maximum mean value of hardness 76 82 Rockwell number is reached by addition of 25% TiCp volume content solidification time fraction equals to 1 at 5 seconds fastest and volumetric latent heat generated 100 77 kJ m3 From the results it is concluded that casting of LM6 TiCp MMC is successfully achieved using vortex mixing technique and that addition of particulates influence solidification characteristics which in turn affect the properties of the MMC The Role of Rapid Solidification Processing in the Fabrication of Fiber Reinforced Metal Matrix Composites ,1989 *Solidification, Porosity and Optimization of Metal-matrix Composite Processing* Jijin Yang,2000 **Solidification and Gravity III** A. Roósz,Markus Rettenmayr,D. Watring,2000-01-05 Proceedings of the Third International Conference on Solidification and Gravity held in Miskolc Hungary April 25 28 1999 **Studies in the Solidification Behaviour of Aluminium Alloy/alumina Metal Matrix Composites (MMC's).** Q. F. Li,1991

This book delves into Solidification Of Metal Matrix Composites. Solidification Of Metal Matrix Composites is a crucial topic that must be grasped by everyone, ranging from students and scholars to the general public. This book will furnish comprehensive and in-depth insights into Solidification Of Metal Matrix Composites, encompassing both the fundamentals and more intricate discussions.

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This book is crafted in an easy-to-understand language and is complemented by engaging illustrations. It is highly recommended for anyone seeking to gain a comprehensive understanding of Solidification Of Metal Matrix Composites.

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