TIP Project Brief – 090033/10H003

Manufacturing
Transformational Casting Technology for Fabrication of Ultra-High Performance Lightweight Aluminum and Magnesium Nanocomposites

Develop a novel casting technology, based on ultrasonic cavitation dispersion of nanoparticles in metal melts, for large-scale production of aluminum and magnesium matrix nanocomposites.

Sponsor: The Board of Regents of the University of Wisconsin System
Madison, WI

- Project Performance Period: 2/1/2010 - 1/31/2015
- Total project (est.): $10,092 K
- Requested TIP funds: $4,863 K

This multidisciplinary joint venture team led by the University of Wisconsin-Madison is attempting to develop a commercial-scale method for thoroughly mixing and dispersing nanoparticles in molten metals to enable the manufacture of large and complex metal castings with greatly enhanced performance characteristics. The joint-venture team includes Eck Industries, Inc., Nanostructured & Amorphous Materials, Inc., the Oshkosh Corporation, and Wisconsin Alumni Research Foundation. To improve performance and energy efficiency, engineers increasingly are turning from iron and steel to lightweight alloys of aluminum and magnesium. The properties of these alloys can be enhanced considerably if nanoparticles, usually ceramics, are used as a reinforcement to form so-called metal matrix nanocomposites (MMNCs). To date, the use of these nanocomposites has been limited to relatively small and uncomplicated shapes because of the difficulty of evenly dispersing the nanoparticles. With relatively high surface-to-volume ratios and poor wettability, conventional mechanical stirring tends to leave the nanoparticles clumped together like a poorly mixed cake batter. Powder metallurgy techniques—the metals and nanoparticles are premixed as powders before sintering—works better, but it's costly, time-consuming and doesn't scale well to large, complex parts like engine blocks. To meet the need for a large-scale mixing and dispersing technology, the joint venture plans to scale up an experimental technique developed at the University of Wisconsin-Madison that uses high intensity ultrasonic waves to disperse the nanoparticles through molten metal. The high intensity ultrasonic waves induce acoustic cavitation in the liquid metal, causing the transient formation, growth and collapse of microbubbles. The collapse of the bubbles produces microscopic hot spots that can reach temperatures above 5000 degrees Celsius and create severe microscale shock waves at a very short time. The sum result is a violent stirring and dispersing that in laboratory tests leads to effective dispersion of the nanoparticles. The University of Wisconsin-Madison based this proposal on a laboratory-scale, trial-and-error process on small samples. While the laboratory tests at Wisconsin are very promising, there are significant and fundamental challenges and risks in scaling up the system to mass produce premium-quality aluminum and magnesium MMNC components for practical applications. If successful, however, commercial scale production of these metal nanocomposites will enable transformative changes in multiple industries, directly addressing the critical national needs of reducing oil dependency, lowering greenhouse gas emission, and maintaining U.S. leadership in manufacturing. Along the way the project will build an unprecedented knowledge base for design, processing, and properties of MMNCs. The project plan calls for an industrial consortium to be established at the end of the project to disseminate and implement the research results.

For project information:
Brian Mattmiller, (608) 890-3004
bsmattmi@engr.wisc.edu

Active Project Members

- Eck Industries, Inc. (Manitowoc, WI)
  [Original, Active JV Member]
- Oshkosh Corporation (Oshkosh, WI)
  [Original, Active JV Member]
- The Board of Regents of the University of Wisconsin System (Madison, WI)
  [Original, Active JV Member]
- Wisconsin Alumni Research Foundation (WARF) (Madison, WI)
  [Original, Active JV Member]