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Ultrasonic Vibration Method for Nano Metal Matrix Composites (NMMCS) of Aluminium Alloys: An Unconventional Approach

Dhirendra Kumar Verma | Assistant Professor (ME) IIMT College of Engineering Greater Noida, U.P.

ABSTRACT

Now a days the Nano Metal Matrix Composites (NMMCs) are highly effective and playing a vital role in production area as compared to the unreinforced Metal Matrix Composites (MMCs). The reason of this effectiveness is their improved properties like mechanical, wear strength, stiffness, higher thermal properties, reduced weight, higher surface to volume ratio and good damping behaviour etc. These Composites are costly at initial phase of production but if the whole mass production system is considered then the machine components of nano composites are more cost effective due to their long life of operation and improved properties. Also they improve the efficiency of a mechanical system because conversion of energy from one form to another is always there and reduced weight of (NMMCs) are helpful to achieve this objective.

KEYWORDS NMMC, MMC, AMMC, UVS, MSC, EMS.

INTRODUCTION

It is a universal fact that the growth of the technology depends upon the advances in the attributes of any single material or a family of materials. Composite materials are the examples of such growth since last two decades and it has been proved by various researchers by their conclusions throughout the world. The commonly used matrix materials are Titanium, Magnesium and Aluminium. In this method the nano particles of different sizes are reinforced into the base molten alloy by various techniques and it comes under liquid state processing of composites. Usually 1 to 100nm sized nano particles of Al_2O_3, SiC and B_4C are used to process with the various series of base alloys. As per the literature survey, the composites fabricated by liquid state stirring produces excellent bonding between ceramic reinforcement and base alloy when few reactive elements are added Mg, Ti, Ca, and Zr etc.

CONVENTIONAL METHODS FOR NMMC PROCESSING

The processing of Nano Metal Matrix Composites (NMMC) is mainly of two types i.e. Solid state processing which includes diffusion bonding, powder metallurgy, vapour deposition etc. and Liquid state processing like mechanical stir casting (MSC) and Electro mechanical Stirring (EMS). The latest approach under this category is Ultrasonic vibration Stirring (UVS). The several other conventional methods are also available for composite fabrication like high energy ball milling, mechanical alloying nano sintering sputtering, and spray deposition. Experimental experience says that the above said methods are having their limitations as they are not perfect to retain the nano scale grain size due to rapid and excessive growth of grains during processing. The issue is the settlement of reinforced particulates in a uniform order into the base alloy. The conventional method for composites is shown in the following figure I. i.e. Mechanical stir casting method.

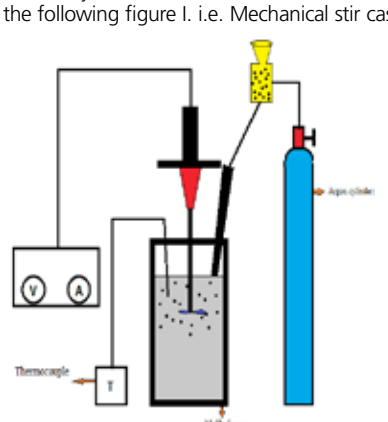

Figure I: Mechanical Stirring Setup

Another modified method is Electromagnetic Stir Casting in which the stirrer has been removed from the melt and in-spite of that an electric motor is used. This motor is of 3 phase induction type having 1440 rpm which results a suitable combination for stirring the melt. A 3 phase autotransformer is also used to regulate the current and voltage of the motor by which the rpm of the rotating melt can be controlled. Experimentally it has been observed that (20-22) Amp current and (70-73) V voltage is more than sufficient for stirring. Here the important parameter is the volume and weight of the base alloy which has to be used for the composite fabrication. Usually 900 gm. to 1000 gm. base alloy is used in which the nanoparticles are reinforced in the proportion of 0.5%, 1%, 1.5% and 2% by the weight of the alloy separately. These combinations will produce the four different ingots after solidification of the melt and further it will be machined for the analysis of the mechanical properties and improved surface properties. As shown in figure II the EMS process defines the composite casting under the influence of vacuum. One very important part of this process is the preheating of the reinforced particles and addition of micro sized Mg powder in case of nano alumina and Al alloy. Preheating of nano particles breaks the oxide layer from the particle surface and it reduces the probability of cluster formation during mixing of these ceramic particles. Mg powder is helpful to improve the wettability of the melt by which the reinforcement become easier and uniform mixing takes place. This mixing is done at the temperature when the melt is in the mushy zone and by regulating current from autotransformer during process the solidification is done and particles became settled as the uniform structure.

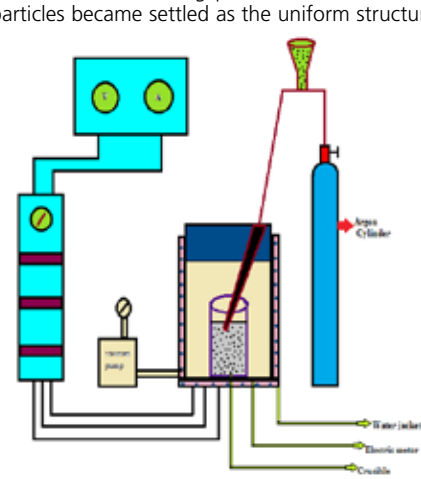

Figure II: EMS Setup

Again there are some limitations in this process like furnace and motor cannot be arranged together because the melting of alloy takes place at higher temperature around (700-800) ^{0}C. Also the furnace temperature is very high around 1400^{0}C and it may damage the copper coils of the motor. So during EMS process the furnace and motor is required to arrange separately.

ULTRASONIC METHOD OF STIR CASTING

As per the literature survey and experimental analysis it has been observed that the reinforcement of nano sized particles is not up to the mark with MS and EMS processes due to their limitations. So an unconventional approach is introduced here i.e. ultrasonic vibration or frequency method of stirring for metal and ceramics. In this method an ultrasonic probe with transducer is used for the mixing of nano sized ceramic particles and the main objective to introduce this method is only one that the frequency of ultrasonic waves will produce the vibration effect by which the settlement of the nano particles is highly uniform where higher surface to volume ratio is required. Also it may reduce the chances of agglomeration and cluster formation during mixing as these are the remedies inside the melt and produces hard brittle phases after solidification.

ULTRASONIC WAVE PRINCIPLE

With the help of ultrasonic transducer and probe the processing method has been modified. The main features of the ultrasonic waves are, they have high energy and there speed of propagation depends upon their frequencies. These waves can be transmitted over long distance without any loss of energy. The intense ultrasonic radiation has disruptive effect on liquids by causing bubbles and the phenomenon is known as ultrasonic cavitation. Usually (18-20) kHz wave frequency is used to generate the vibration effect inside the melt and at this frequency the bubble formation takes place inside the melt. When these bubbles are not able to retain more energy than explosion takes place and due to this ultrasonic cavitation vibration takes place. At this frequency vibration, reinforcement of nano particles takes place and uniform mixing is possible throughout the melt. This cavitation also retains higher temperature and pressure and helpful to break the clusters inside the melt. Figure III shows the arrangement of subsystems of Ultrasonic assisted stir casting setup.

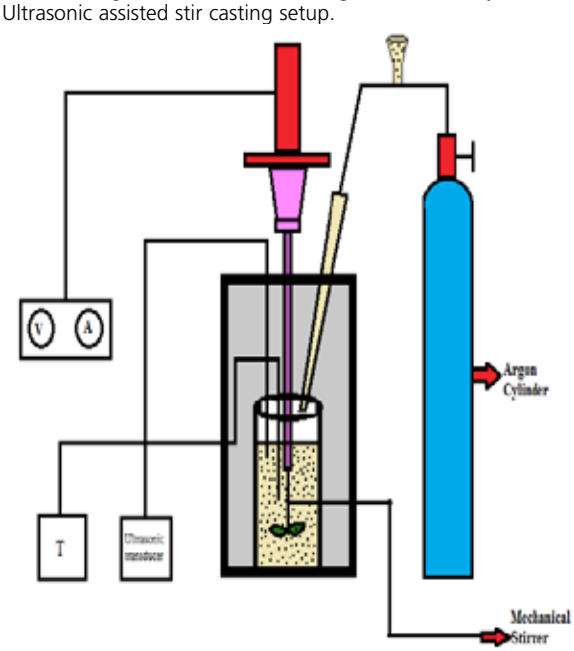

Figure III: UVS Setup

CONCLUSION

After reviewing the above three techniques for composite casting the author concludes that the Ultrasonic vibration stirring method is the best suitable for NMMCs. Finally the properties of such composites will be increased as compared with the samples prepared by MS and EMS processes. Author has submitted the proposal for funding and after successful installation of the whole setup the composites will be characterized in terms of their mechanical properties and surface morphology.

REFERENCES:

1. Ogel,B.andGurbuz,R.(2001),Microstructural characterization and tensile properties of hot pressed Al-SiC composites prepared from pure Al and Cu, Materials Science and Engineering A, Vol. 301, pp.213–220.
2. Chawla K.K., Composite Materials: Science and Engineering, Spinger-Verlag, New York, (1998).
3. Mazumdar S. K., Composites Manufacturing, CRC Press, New York, (2002).
4. Surappa M. K., Aluminium matrix composites: Challenges and opportunities, Sadhana, Vol. 28, Part 1 and 2, (2003), 319-334.
5. Matthews F.L. and Rawlings R.D., Composite Materials: Engineering and science, CRC Press, New York, (1999).
6. Yong Yang, Jie Lan, Xiaochun Li, Study on bulk aluminium matrix nano-composite fabricated by ultrasonic dispersion of nano-sized SiC particles in molten aluminium alloy, Materials Science and Engineering A, 380, (2004) 378–383.
7. Vishwanathan V., Laha T., Balani K., Agarwal A., Seal S., Challenges and advances in nanocomposite processing techniques, Material Science and Engineering, R 54,(2006), 121-285.
8. Hashim J. Looney L. Hashmi M.S.J., Particle distribution in cast metal matrix composites- Part I, Journal of Materials Processing Technology, 123, (2002) 251-257.
9. Hshim J. Looney L. Hashmi M.S.J.,Metal matrix composite production by stir castingmethod, Journal of Materials Processing Technology, 92-93,(1999) 1-7.
10. Sunnel D., Nageshwar Rao D., Satyanarayana Ch., Jain P. K., Estimation of cavitation pressure to disperse carbon nanotube.