

Short Communication

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Novel Combined Feeding Approach to Produce Quality Al6061 Composites for Heat Sinks

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Abstract: This elementary work aims to address agglomeration and non-uniform dispersion of reinforcement particles in stir casting using Al6061 alloy (AA 6061) as a matrix and Aluminium oxide (Al_2O_3) as reinforcement particles. A novel combined feeding method of Encapsulate feeding technique & Two Step Stir Casting was developed & attempted to produce good quality composites by varying weight fractions of Aluminium Oxide (0 to 5 wt.%). The wetting agent Mg (2 wt.%) added in all castings to ensure better binding between ceramics and matrix. The SEM photomicrograph ensures homogenous dispersion of reinforcement particles by combined feeding method. The thermal properties of produced good quality composites are enhanced with increase in Aluminium Oxide (Al_2O_3) from 0 to 5 wt.%.

Keywords: Al6061; Al_2O_3 ; Encapsulate feeding; Two Step Stir Casting; Thermal Properties

1 Introduction

Aluminium matrix composite materials (AMCs) embarks high attention among research community as its replacing conventional engineering materials over decades due to its superior customized properties like high strength

to light weight, stiffness, corrosion resistance etc. majorly as structural components in automotive and aerospace industry [1]. Research community also did too many structural examinations than thermal behavior observation of produced composites [2, 3]. Al6061 alloys composites are vastly concentrated on structural applications only [4, 5]. The objective of the present work predominantly to control contemporary challenges like agglomeration and non-uniform dispersion of reinforcement particles in stir casting. Some researchers attempted with the above perspective and ended up in vain, although some may claim uniform dispersion but enough clarity in results is not discussed [6]. In the present work, combined feeding method of novel encapsulate feeding and two step stir casting was developed to produce good quality aluminium composites with uniform particle distribution. Apart from structural applications, Al6061 T-6 grade (AA 6061) is used as Material of construction in Heat Sink fins due to its cast ability and good workability nature as well as its alloy composition supports thermal & corrosion balance in a greater extent. Amidst numerous ceramic particles, Aluminium Oxide (Al_2O_3) is chemically suitable with aluminium due to its excellent bonding nature between base metal and ceramics without any inter-metallic phases [6].

2 Materials & methods

To overcome agglomeration and uneven dispersion of particles combined feeding method of novel innovative Encapsulate feeding technique and two step mixing is used to produce good quality AMC's. Sequential process is as follows. In this feeding method, To suit with the crucible the preliminarily purchased Al6061 solid shaft with 85mm Outer diameter (OD) machined as a hollow cylindrical cup shape with the dimensions of 85mm Outer diameter, 65mm internal diameter, 150mm length and 30mm of bottom thickness. Next, the reinforcement particles (5% of Aluminium Oxide) kept inside aluminum foil sheet (as shown in Figure 1). 2% of Mg is used as wetting and binding agent

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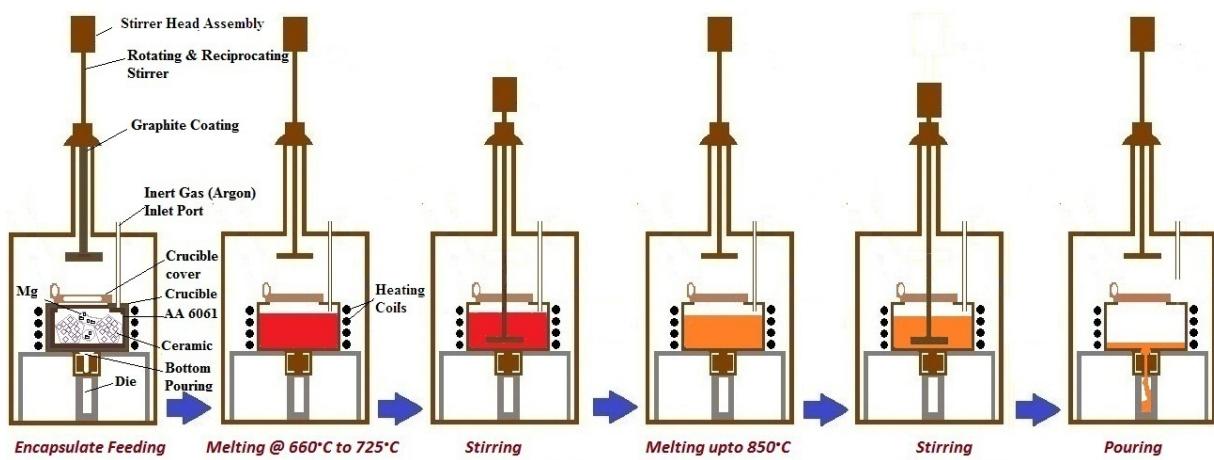


Figure 1: Schematic Representation of Sequential process in combined Feeding

to enhance bonding between reinforcement particles and base metal [4].

The wrapped ceramic powder (Aluminium Oxide) & wetting agent (Magnesium) are placed inside hollow cylindrical cup and closed using cup cap. The furnace heats up to 725°C (even though melting point of base metal around 660°C to 680°C) and the molten slurry base metal arresting reinforcement particles in all the directions due to gaseous layer formed by the base metal. Next, the single blade graphite coated mechanical stirrer agitates to break gaseous region and reinforcement particles mix up with base metal. The speed of the stirrer gradually increases up to 500 rpm for 4 minutes with argon gas environment to avoid oxidation. Then stirrer speed gradually reduced to null (zero) value and the composite slurry again heated upto 850°C then the stirrer is further rotated with gradual increase in rpm upto 500 rpm for the same 4 mins and then slurry transferred into preheated mould (500°C) through an arrangement namely bottom tapping with the help of funnel. Then it is quickly air quenched to reduce the time for settling of fragments/molecules (particles) in the fluid/liquefied matrix material [6]. The above cycle is repeated with varied fractions as 1, 2, 3, and 4 Vol.% of Al₂O₃ molecules (particles) reinforcement to fabricate different composition of Al/ Al₂O₃ composites [6]. Casted ingots were machined to suit SEM, EDS & Pin-fin Apparatus as per their own standards and norms.

3 Results & discussion

In regular feeding the composites produced are of least quality with blow holes and breaks many a times due to reinforcement clusters during secondary operations such

as drilling, machining while sample preparation whereas the innovative combined feeding method of Encapsulate feeding technique & Two Step Stir Casting casted composites supports as user friendly during secondary operations. In below SEM images (Figure 2) indicates clusters, blow holes, defect zone, uniformly distributed region. In this combined feeding novel approach, the base metal, reinforcement & wetting agent undergo thermal decomposition so that it forms gaseous layer in-between the top & bottom of the wrapped ceramic particles. Hence the reinforcement particles are arrested within the molten metal. This mechanism put forth an essential part in uniform dispersion pattern of reinforcement particles rather than regular feeding technique. After the mechanical stirring process with the argon gas environment, stirring breaks their gaseous layer around and the arrested reinforcement particle splitted into the liquefied/fluidized matrix material. Then it is further heated upto 850°C and again stirred to accomplish uniform dispersion evenly. Thus, reinforcement particles dispersion is uniformly achieved as shown in Figure 2.c. & 2.d in AA 6061+5% Al₂O₃ through this combined feeding novel approach.

This EDS (elemental distribution analysis) result corresponds to the prepared Al/Al₂O₃ composite of 5% composition. The below Figure 3 proves the traces of Carbon, Oxygen, Magnesium, Aluminium presence in the composite specimen.

The below graph plot Figure 4 shows the enhancement of thermal conductivity in Al6061 by adding various percentages of ceramic fillers. This interface filler reduces the contact resistance offered by thermal ambience in the molten matrix. The thermal conductivity property purely depends on heat conduction propagated by diffusion which solely the material behaviour where as the co-

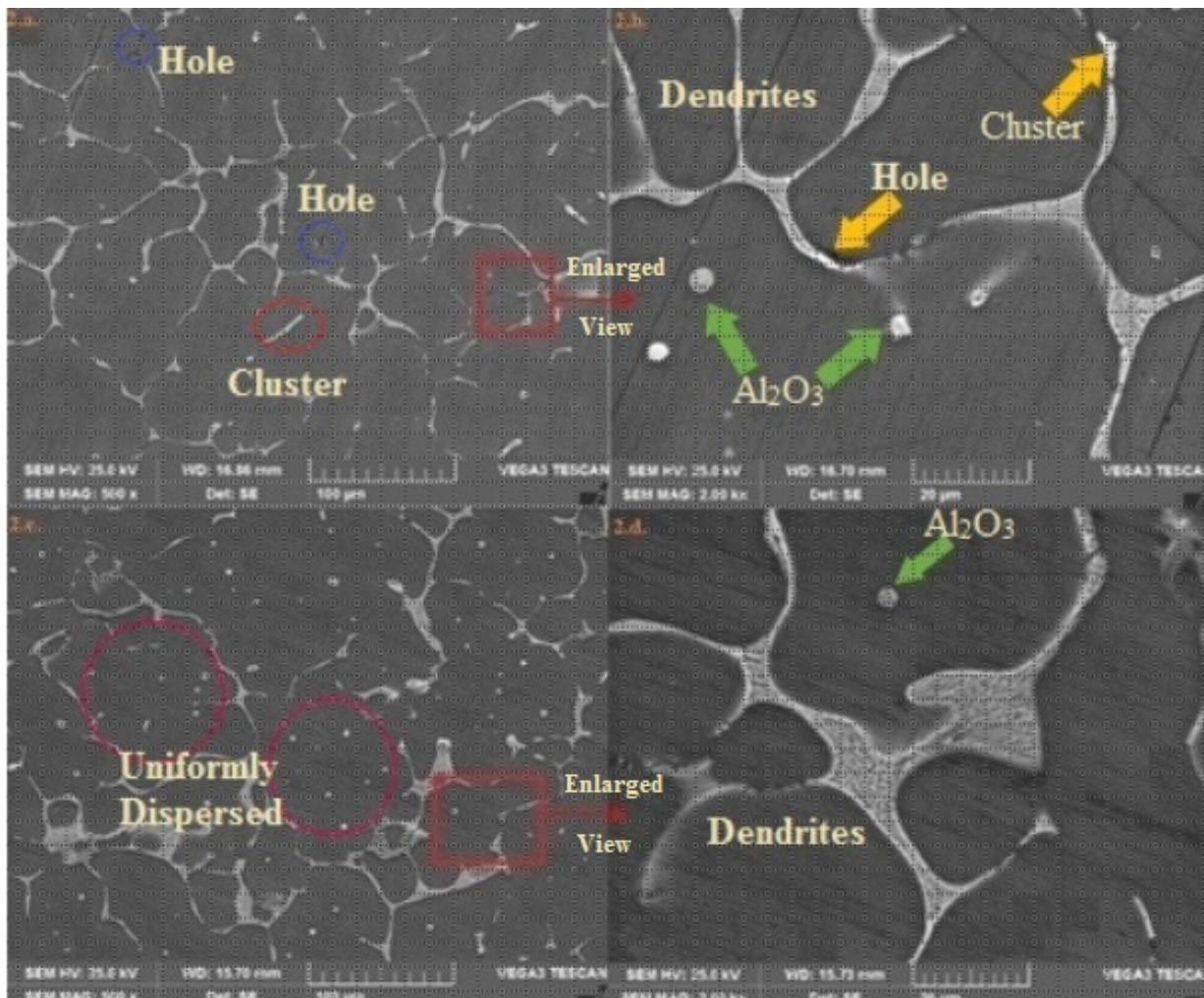


Figure 2: SEM comparison of AMCs

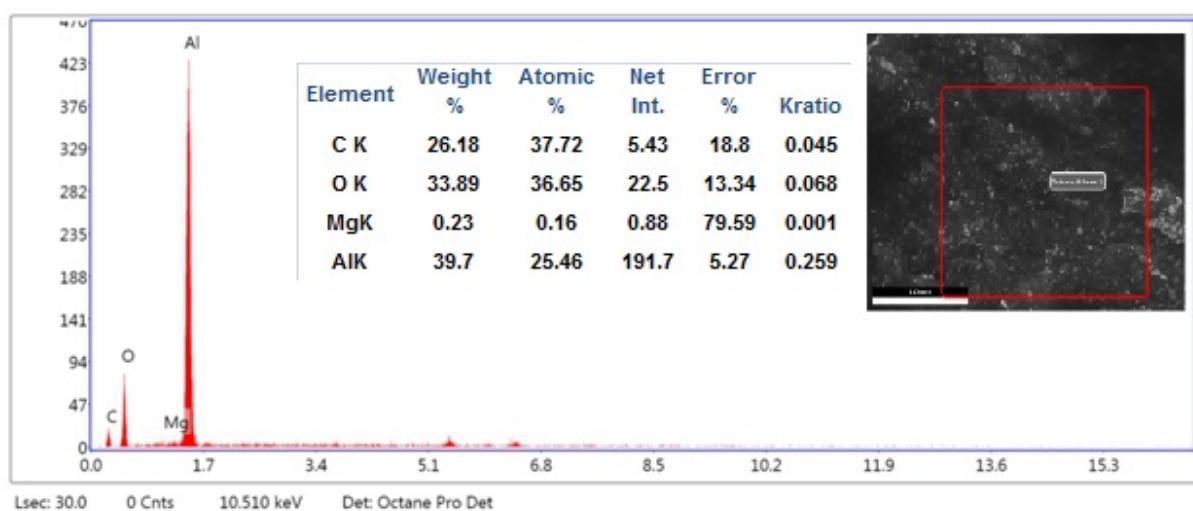


Figure 3: EDS image of 5% Al/Al₂O₃ composite

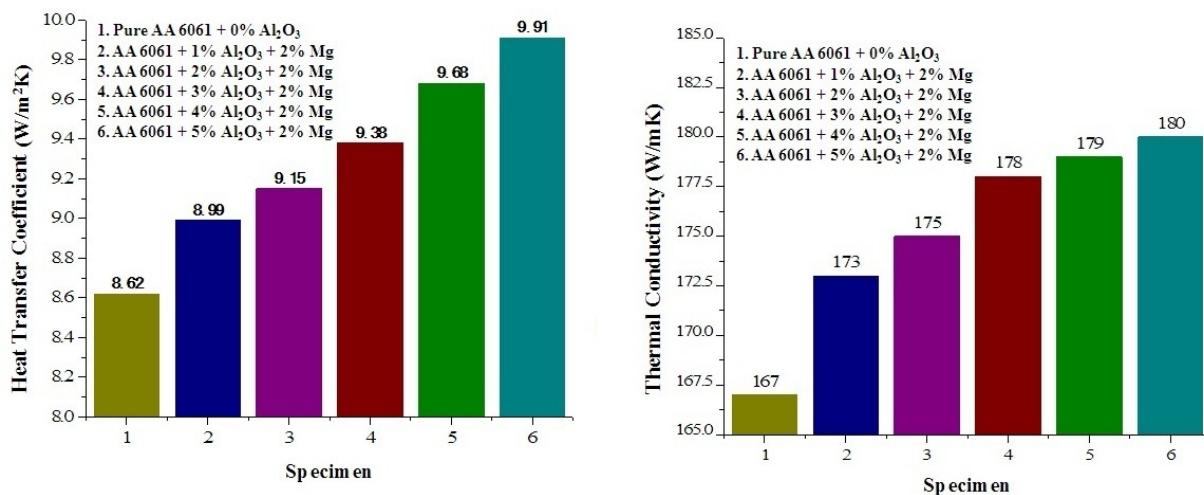


Figure 4: Thermal Properties of Al/Al₂O₃ composites with pure AL6061 through Pin-Fin

efficient of heat transfer is a convection property due to the macroscopic movement of the air above the solid surface. from the graph, it evidently shows that by increasing the Al₂O₃ contents in Al matrix, there is a decrement in thermal contact resistance *i.e.* it reduces coefficient of thermal expansion. So that thermal conductivity increases gradually by percentage whereas in 3% drastic raise denotes peak point even though enhancement continues further.

4 Conclusion

The combined feeding approach is the best & efficient way to produce good quality Al/Al₂O₃ homogeneously dispersed composites in stir casting method. The fabricated Al/Al₂O₃ composites of varied composition exhibits high thermal conductivity (180 W/mK at 5% composition) properties compared with same sort of presently used heat transfer aluminum alloys especially in electronics, heat sinks and also for various applications. This constitutes the exceptional expectation for enhancement of heat transfer. The probable advantages of the Al/Al₂O₃ composites such as further characterization and analyzing of mechanical properties will be estimated in future as extension work of this research.

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References

- [1] D.K. Das, P.C. Mishra, S. Singh and S.Pattanaik, Int. J of Mech. & Mater. Engg., 9 (2014) 6.
- [2] M.Sambathkumar, P. Navaneethakrishnan, K. Ponappa and K.S.K. Sasikumar, Latin American J of Solids & Structures, 14 (2017) 243-255.
- [3] A.Gnanavelbabu, K. Rajkumar, and P. Saravanan, Mater. & Manuf. Processes, 33 (2018) 1313-1323.
- [4] S. Gopalakrishnan and N. Murugan, Composites Part B: Engineering, 43 (2012) 302-308.
- [5] Y. Pazhouhanfar and B. Eghbali, Materials Science and Engineering: A, 710 (2018) 172-180.
- [6] S. M. Quader, B. S. Murthy, P. R. Reddy. J of Minerals & Mater. Characterization & Engg. 4 (2016) 135-142.