Ph.D.Details

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Abstract

Metal matrix nanocomposites (MMNCs) are superior to conventional alloys in terms of mechanical and thermal properties and are adaptable for current industrial requirements. The low density with adequate strength, ductility, and the flexible processing capability makes Aluminium (Al) and its alloys the most investigated matrices for nanocomposites and solidification processing methods such as casting are cost-effective for large-scale fabrication of MMNCs. However, particle agglomeration, severe interfacial reaction of *ex-situ* added nanoparticles and fluidity reduction individually or collectively can deteriorate the mechanical properties of solidification processed MMNCs and these issues are not yet unravelled completely. Hence, in the present work, an attempt has been made to address the above stated challenges in MMNC fabrication by in-situ synthesis of nanocomposites and their semisolid processing. Ultrasonic treatment (UT) is employed to synthesize thermally stable *in-situ* nanoparticles and semisolid processing of nanocomposite is primarily aimed to alleviate the fluidity related issues. To comprehend the scope of work, pure Al was selected for optimization of UT processing parameters to synthesise *in-situ* nanocomposites. A356 and Al 2014 alloys were selected as the matrix materials and reinforced with *in-situ* TiB_2 particles. A comprehensive study on the effect of reinforcement particles on age hardening behaviour of A356 and Al 2014 matrices was conducted. An attempt to understand the effect of UT on strontium based eutectic modification of A356 alloy was also made. The structure-property correlation is investigated and discussed in detail. Pilot studies for optimisation of UT process parameters shown that the post *in-situ* reaction ultrasonic treatment of salt-melt route Al/TiB_2 composite was effective to fabricate and disperse nanoparticles effectively in the matrix of the composites. Post reaction UT of A356/TiB_2 and Al 2014/2TiB_2 composites producedparticles of 34 ± 16 and 24 ± 13nm respectively. As the combined effect of ultrasonic assisted *in-situ* synthesis of TiB_2 nanoparticles, eutectic modification and thixoforming, the yield strength of A356 alloy improved by 64 MPa with concomitant ductility enhancement from 4.5 to 7.4 %. Similarly, the yield strength of as-thixoformed Al 2014 alloy is increased by 102 MPa with ductility enhancement from 17.1 to 18.7 %. Structure-property correlation studies show that particle-dislocation interactions in as-cast condition and combination of particle-dislocation interactions and shearing of precipitates by dislocations in precipitation hardened condition enhance the strength. These results have a significant impact in the field of Aluminium MMNCs.