ABSTRACT

The present work is focused on the development of in-situ aluminium metal matrix composites (AMMC) with generation and variation of the reinforcement phase. Aluminium is commonly available metal with extraordinary physical, mechanical and chemical properties. Light weight property of the aluminium makes it a suitable candidate in aerospace, aircraft and automotive industries. Only one drawback of the aluminium is its soft nature. Using composite approach and by adding hard ceramic particles as the reinforcement in this soft aluminium metal can improve its strength and overcome its weaknesses. While making AMMC, uniform distributions of these ceramic reinforcing particles are very important. Apart from the strength, AMMCs also offer improvements in various properties such as stiffness, high temperature properties, wear and abrasion resistance, damping capacity, reduction in density, etc. These properties not only increase the performance of the AMMCs but also make it economic and environment friendly materials as compared to the existing monolithic materials such as different metallic alloy systems in various applications. In present experimental work to synthesise the AMMC, commercially pure aluminium (LM 0) grade was used as matrix material and MnO_2 powder was used as reinforcement. Magnesium metal was used as wetting agent in this $Al - MnO_2$ system. Study was conducted in three different phases to analyse various properties using both qualitative as well as quantitative approach.

In phase 1 study, synthesis of Al-Mg systems. The magnesium metal was optimized in present commercially pure aluminium (CPA). Different amounts of the magnesium were added such as 0.05 wt %, 0.15 wt %, 0.5 wt %, 1 wt %, 1.5 wt %, 2 wt %, 3 wt %, 4 wt %, 5 wt %, 6 wt % and 7 wt %. Out of all these additions, 3 wt % Mg was optimized.

In phase 2 study, preparation of $Al - MnO_2$ systems. Optimisation of MnO_2 in aluminium (LM 0) matrix was carried out without addition of magnesium. Different amount of the MnO_2 were added in CPA such as 0.5 wt %, 1 wt %, 1.5 wt %, 2 wt %, 2.5 wt %, 3 wt %, 3.5 wt % and 4 wt %. Sequences of addition of the MnO_2 also changed such as MnO_2 added, (1) *AFTER* the melting of CPA (Sequence A) and (2) *BEFORE* the melting of CPA (Sequence B).

In phase 3 study, optimized amount of magnesium i.e. 3 wt % Mg was kept fixed in all cases whereas different amount of MnO_2 reinforcement were added such as 1 wt %, 2.5 wt % and 4 wt %. Also the sequences of reinforcement addition were changed like in phase 2 study. The sequence of reinforcement addition offers direct changes into the mechanical and metallurgical properties of final in-situ composite.

Formation of different in-situ phases were studied for all above samples. When MnO_2 powder

was added after the melting of the CPA (Sequence A), the generation of $MgFeSiO_3$, Al_3Mg_2, Mn_3AlC and Al_2O_3 in-situ phases were observed. In case of MnO_2 powder addition before the melting of the CPA (Sequence B), the formation of $MgFeSiO_3$, Al_2Mg_3, Mn_3AlC, $MnAl_6$ and Al_2O_3 as in-situ phases were observed.

Samples were prepared for various characterizations such as hardness test, tensile test, density test, optical microscopy, scanning electron microscopy with energy dispersive spectroscopy (SEM-EDS) and X-Ray diffraction (XRD) to evaluate different micro-mechanical properties of the composite.

Finally, it was found that the best route for addition of the MnO_2 reinforcement in the $Al - 3wt\%Mg$ system (present system) is when MnO_2 reinforcement was added before the melting of the aluminium matrix (Sequence B) with 2.5 wt % MnO_2 amount. This optimized route is quite new and gives reliable results which can serve the purpose for different industrial needs.

Keywords:
Commercially pure aluminium, in-situ composite, XRD, Mn_3AlC, $MnAl_6$ and Al_2O_3