ABSTRACT

The development of Metal Matrix Composites (MMCs) with metal/metal alloy as matrix and ceramic as reinforcement is an innovative approach for developing materials with better strength, good wear & corrosion resistance and high-temperature stability. Ceramic particles reinforced MMCs are potential candidates for structural, automobile, aviation and transportation applications. The presence of hard ceramic particles prevents the dislocation motion and grain boundary migration. Iron-based alloys are widely used in manufacturing equipment, mining industries and other heavy duty applications due to their high strength and high wear resistance. There is a lack of systematic studies on mechanical and corrosion behavior of ZrO_2 reinforced Fe-Ni alloy based metal matrix composites to the best of our knowledge. Therefore, the present thesis work is focused towards developing $Fe_{(100-x)}Ni_{(x)}$ alloys and (Fe-Ni)-ZrO_2 composites with different ratios of Fe/Ni and (Fe-Ni)/ZrO_2, respectively.

First $Fe_{(100-x)}Ni_{(x)}$ alloys (x= 10, 20, 30, 40 and 50 wt.%) specimens have been prepared via conventional powder metallurgy route using commercially available metal powders. Sintering was done at 1000°C/1h, 1200°C/1h, and 1250°C/1h in an inert atmosphere. Different physical (phase, microstructure and density), mechanical (hardness and wear properties) and electrochemical properties (corrosion behavior in 3.5 wt.% NaCl solution) of synthesized alloy specimens were measured. During sintering, varying proportion of γ and α-(Fe,Ni) phases form with changing composition and sintering temperatures. Phase formation has an impact on the mechanical and corrosion properties of prepared alloy specimens. $Fe_{70}Ni_{30}$ specimen was found to contain better wear properties

than other alloy compositions due to the presence of an optimum amount of both γ and α phases, which support each other when an external force is applied. It has also shown a good corrosion resistance in a saline medium.

$Fe_{70}Ni_{30}$ alloy composition is used to prepare (Fe-Ni)-ZrO_2 metal matrix composites with varying ZrO_2 (0, 2.5, 5, 10 and 15 wt.%) concentration. Composite synthesis has been done via powder metallurgy route using commercially available Fe, Ni, and ZrO_2 powders. Sintering was carried out at 1150°C/3h in an inert atmosphere. The presence of ZrO_2 particles in $Fe_{70}Ni_{30}$ metal matrix retard the plastic deformation and thereby increased the hardness of composites. The increase in wear resistance and corrosion resistance up to a certain concentration, i.e., 10 wt.% is observed in ($Fe_{70}Ni_{30}$)-ZrO_2 composites. Above this concentration, the degradation in mechanical and corrosion behavior is observed. The reason for degradation in properties may be stated as: At higher concentration of ZrO_2 particles (15 wt.%), there is increased ceramic-ceramic grain contact leading to weakening of the microstructure at the grain boundaries. The electrolyte gets a path to pass through the metal-ceramic interface and enhances the corrosion.

In the second part, a wet chemical route (sol-gel auto-combustion) followed by hydrogen reduction is used for synthesizing nanocrystalline $Fe_{(100-x)}Ni_{(x)}$ alloy powders, where x = 10, 30 and 50 mole%. Different characterization methods such as XRD, SEM, TEM and magnetic measurement have been used to confirm the nanocrystalline alloy formation. Presence of γ and α phase formation was confirmed with nanosize particles formation. Thereafter, ($Fe_{70}Ni_{30}$)-ZrO_2 MMCs were prepared via powder metallurgy route by adding nano ZrO_2 powder in different concentrations (0, 2.5, 5, 10 and 15 wt.%) and

sintering at 900°C/1h in inert atmosphere. Phase, microstructure, density, hardness and corrosion resistance of the prepared composites have been examined. The increase in all the mechanical and corrosion properties was observed with increasing ZrO_2 reinforcement even up to 15 wt.%. The use of nanopowders in matrix and reinforcement phases has helped in increasing the properties of the composite with high reinforcement content (i.e., 15 wt.%).