ABSTRACT

The present study aimed to investigate the microstructure and mechanical properties of Al-Cu-Zn-Fe-Ti-Mg alloy (≈2219 aluminum alloy) microalloyed with silver (Ag in the range 0–0.1 wt.%) under different thermo-mechanical process conditions for obtaining high specific strength, reasonable ductility, high fracture toughness and good corrosion resistance properties. Five different alloys were prepared with varying silver content. Chemical analysis was done to determine the percentage composition by weight of each element of the alloy. Microstructural characterization and mechanical properties were determined at different heat treatment conditions in cast as well as cast-rolled conditions. Age hardening behavior of alloys was performed by means of transmission electron microscope (TEM). Hot deformation behavior and processing maps were also generated by relevant microstructural study. Artificial neural network (ANN) modeling was also carried out to predict the flow stress.

Microstructural investigation revealed the presence of intermetallic $CuAl_2$ and metastable Al-Cu-Fe-Zn-Si-Mn phases at the grain boundary regions. The metastable phase reduced with further solutionized heat treatment and subsequent rolling process. Also the dendritic structure was eliminated resulting in improved mechanical properties. During precipitation strengthening process hardness was at its peak in between 40–45 hour for all alloys at 150 °C temperature. The maximum hardness was observed in the alloy containing 0.07 wt.% silver after 45 hours of ageing at 150 °C.

The strength and hardness increased with the increase in silver content up to 0.07 wt.% along with reasonable ductility. The highest strength of the alloy was obtained in the rolled-solutionized-age hardened condition. Tensile fracture surface observation by scanning electron microscope revealed brittle failure mode in as-cast alloys whereas the heat treated alloys exhibited features typical of ductile failure.

The hot compression tests were carried out at constant true strain rates in the range of 0.001–10 s^{-1} and temperatures in the range of 300–500 °C. The flow stress of alloys decreased with increasing silver content. Constitutive models correlating the peak flow stress with deformation temperature and strain rates for the two alloys were developed using hyperbolic-sine relationship. The activation energy for deformation of the 2219 aluminum alloy decreased with the addition of silver. Comparison of the predicted and experimental values of peak flow stress revealed that 88% of the data could be predicted within an error of ± 12.5% indicating good predictive capability for the developed constitutive relationships.

Flow stress as a function of strain, strain rate and temperature during hot deformation was predicted for all alloys by artificial neural network (ANN) modeling in "MATLABR201a". A large number of simulations were carried out to generate a weight function as well as to reduce the error. The coefficient of determination (R^2) during the prediction of more than 0.97 indicates very good prediction capability by artificial neural network technique.