Abstract

The effect of Nb or Ta addition and cooling rate of 10-10^3 K/s on the evolution of homogeneity and mechanical properties in the arc melted ingots (AMIs) and suction cast rods (SCRs) of $CoCrFeNiNb_x$ ($0.45 \leq x \leq 0.65$) and $CoCrFeNiTa_y$ ($0.45 \leq y \leq 0.65$) eutectic high entropy alloys (EHEAs) have been investigated. The microstructure of the EHEAs comprised of FCC and Fe_2Nb/Co_2Ta type Laves phase, which remained same under different processing conditions. The AMIs exhibited high yield strength (σ_y) of 1.6-2.1 GPa with high compressive fracture strain (ε_f) up to 17.4% at room temperature. Whereas, the SCRs exhibited high σ_y of 1.7-2.3 GPa, due to the higher cooling rate and evolution of nano-/ultrafine lamellar spacing. The λ_w varies in the range of 130- 220 nm with hardness variation of 581-620 HV only in x = 0.5 AMI pointing to the evolution of a homogeneous microstructure. Further, the evolution of EHEAs have been assessed considering the mixing enthalpy (ΔH_{mix}), valence electron concentration (VEC) and atomic size difference (δ_r), which showed that phase stability occurred when $-18 \leq \Delta H_{mix} \leq -6$, $6 \leq VEC \leq 8.5$ and $\delta_r > 3\%$. An artificial neural network (ANN) base tool has been developed using single channel and four channel binary output approaches, which showed matching accuracy of 85.95% and 92.97% for the main dataset, where the same is 70.83% and 91.67% for the deployment dataset, respectively, for phase predication. The hot deformation induced microstructure evolution and spheroidization in ultrafine lamellar x = 0.5 SCR retained high σ_y of 1.3-1.9 GPa exhibiting ε_f of 5.7-12.5% at room temperature (RT)-723 K and strain hardening up to 1.9-2.2 GPa. Whereas, y = 0.4 SCR EHEA exhibited strain hardening with σ_y = 1.4-1.9 GPa and ε_f =11.1- 15.6% for the same temperature range. A gradual decrease of σ_y occurred at above 973 K exhibiting strain softening without any failure even at ε_f>50%. The microstructural coarsening and lamellar instabilities involve termination migration, cylinderization, edge spheroidization and boundary splitting. The strain rate sensitivity (m) and the activation volume (V^*) of AMIs and SCRs have been studied at strain rate in between 8×10^{-5}- 8×10^{-3}/s. The m value of the EHEAs with λ_w of 70-202 nm lies in between 0.0070-0.0082 and the V^* has been estimated to lie in between 27.4-43.7b^3. Further, the effect of prior deformation on the hardness, m and V^* have been investigated using strain rate jump test and nanoindentation to explore the deformation mechanism.

Keywords: Eutectic; High entropy alloys; Cooling rate; Lamellar microstructure; Hot deformation; Phase stability; Phase prediction; Mechanical properties; Dislocations; Strength.