ABSTRACT

A novel dual-phase high entropy alloy comprising of FCC and BCC phases is processed at a large scale under industrial environment to understand the castability and scalability of high entropy alloys with a special attention towards strength-ductility balance and its potential use in high strain rate applications. Subsequently, appropriate experiments using split Hopkinson pressure bar were conducted and deformation behaviour from microstructural aspects were analysed. To understand the effect of cooling rate of solidification on the mechanical properties, the alloy was remelted and rapidly solidified at small-scale suction-cast laboratory environment. Furthermore, friction stir processing was also employed as a viable and effective rapid mass-production based thermo-mechanical process and the processed samples were compressed under a range of strain rates. For comparative analysis of the large-scale as-cast alloy, the suction-cast alloy and the friction stir processed alloy, the hardness, compressive strength, strain rate sensitivity, strain hardening behaviour and deformation mechanisms of all the alloy samples under both quasi-static and dynamic loading were examined. The friction stir processed samples exhibited the highest strength and the lowest strain rate sensitivity among all the conditions of the alloy. The as-cast alloy samples exhibited the highest strain rate sensitivity among all the alloy samples and excellent strain hardening at high strain rate of loading. The rapidly cooled suction-cast alloy displayed higher strength than the as-cast condition but lower strength than the friction stir processed samples. Similarly, the strain rate sensitivity of the suction-cast alloy was higher than the friction stir processed alloy and lower than the as-cast alloy. All the alloy samples were characterised by distinct deformation mechanisms under different strain rate regimes. The as-cast alloy resulted in wavy deformation bands under quasi-static loading conditions and deformation twins near interphase boundary under dynamic loading conditions. The suction-cast alloy under quasi-static compression displayed clear strain partitioning between FCC and BCC phases at moderate strains and the deformation became homogeneous without any strain partitioning at higher strains. The dynamic deformation in the suction-cast alloy resulted in the formation of deformation twins and bands. The friction stir processing of the as-cast alloy led to very high FCC to BCC phase transformation and grain refinement, and the deformation of the processed alloy further exhibited moderate stress induced phase transformation effect under both quasi-static and dynamic conditions. However, distinct twins were formed in friction stir processed alloy under dynamic loading which were almost absent under quasi-static compression.

Keywords: *High Entropy Alloys, Strengthening Mechanisms, High Strain Rate, Strain Rate Sensitivity, Deformation Mechanisms, Friction stir Processing*