Paragraph Ran in the Queries

Paper Title: Dual precipitate simultaneous enhancement of tensile and fatigue strength in (FeCoNi)86Al7Ti7 high-entropy alloy fabricated using selective laser melting

Content :

Mechanical properties

3.3.1. Monotonic tensile properties

As shown in Fig. 6(a), the room-temperature stress-strain curves of the as-built and as-annealed HEAs showed that the as-built HEA had a yield strength (σ_{YS}) of 693 ± 9 MPa, ultimate tensile strength (σ_{UTS}) of 990 ± 14 MPa, and total elongation (ε_{TE}) value of ~30% ± 1%. After annealing, the present alloy achieved increases in σ_{YS} (~1169 ± 18 MPa), σ_{UTS} (~1471 ± 35 MPa), and ε_{TE} ~10% ± 1%, where the yield strength and ultimate tensile strength of the heat-treated samples were higher than the as-built samples. By contrast, heat treatment reduced plastic elongation by half, reaching ~10% in the sample. This phenomenon was attributed to the coherent nano-sized $L1_2$ and incoherent $L2_1$ precipitates within the FCC matrix.

During the rapid solidification process of SLM, the precipitation of the $L1_2$ precipitates was hindered, and Ti-rich and Al-rich phases formed in the interdendritic and MPB regions, resulting in lower tensile strength and higher plastic performance of the as-built samples. The ultrafast cooling rate and ultrahigh temperature gradient in the melting pool during the SLM process inhibited the formation of the strengthening phase. Thus, the tensile strength was enhanced due to fine-grain strengthening and dislocation strengthening. The as-built sample was more plastic, and when heat treatment was carried out, as demonstrated in Fig. 4(a), the $L1_2$ and $L2_1$ precipitates in the matrix of the heat-treated samples, and interactions between the strengthening phases and dislocations were observed. The $L1_2$ and $L2_1$ precipitates prevented dislocations from moving freely in the matrix and the pinning effect resulted in an increase in tensile strength.

However, the material's ability to store dislocations and decrease average dislocation travel distance was reduced due to the nano-sized sharable $L1_2$ precipitates. Hence a drop in ductility was observed in the as-annealed specimen compared to the original conditions. Fig. 6(b) shows the strain-hardening behaviors of the present alloys, which were plotted with true strain. The three-stage strain-hardening curves, similarly observed in the other HEAs, decreased sharply in the elastic deformation region (stage I) and then steadily decreased (stage II) in the ~23% range for the as-built alloy and the ~7% true strain range for the as-annealed alloy. Finally, a dramatic decline in stage III continued until a fracture occurred. Interestingly, strain-hardening of the as-annealed alloy throughout deformation was much higher than the as-built alloy, which was attributed to the unique structure that was produced during the heat treatment process.

3.3.2. Fatigue property

The stress range (σ_r) vs. fatigue life (N_f), generally known as the S-N curve, was plotted for both specimens, as shown in Fig. 7(a). At a higher tested stress level of 700–800 MPa (0.71%–0.81% of UTS) for the as-built specimens and 800–1100 MPa (0.54%–0.75% of UTS) for the as-annealed specimens, the material could remain in the high cycle fatigue (HCF) regime, usually referred to as fatigue life between 10^4 and 10^5 cycles. As the stress level decreased, the fatigue life of the as-built samples gradually increased continuously. Nevertheless, the fatigue data points for the as-annealed specimens were highly dispersed, especially when σ_r was below 700 MPa, and the distribution of data points was highly dispersed. The dispersion could reach two orders of magnitude, and considering that the crack initiation process consumed most of the fatigue life, the sensitivity of the stress level life could be attributed to changes in the fatigue crack initiation process. In addition, estimations for the endurance limit based on the stress range to which the material was subjected for 10^7 cycles without failure were ~500 MPa and ~650 MPa for the as-built and as-annealed alloys, respectively.