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Direct Laser Fabrication and Characterization of Cu-Al-Ni Shape Memory Alloy for Seismic Damping Applications

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Abstract : Metal additive manufacture technologies have gained strong support and acceptance as a promising and alternative method to manufacture high performance complex geometry products. The main purpose of the present work is to study the microstructure and phase transformation temperatures of Cu-Al-Ni shape memory alloys fabricated from a direct laser additive process using metallic powders as precursors. The potential application is to manufacture self-centering seismic dampers for earthquake protection of buildings out of a copper based alloy by an additive process. In this process, the Cu-Al-Ni alloy is melted, inside of a high temperature and vacuum chamber with the aid of a high power fiber laser under inert atmosphere. The laser provides the energy to melt the alloy powder layer. The process allows fabricating fully dense, oxygen-free Cu-Al-Ni specimens using different laser power levels, laser powder interaction times, furnace ambient temperatures, and cooling rates as well as modifying concentration of the alloying elements. Two sets of specimens were fabricated with a nominal composition of Cu-13Al-3Ni and Cu-13Al-4Ni in wt.%, however, semi-quantitative chemical analysis using EDX examination showed that the specimens' resulting composition was closer to Cu-12Al-5Ni and Cu-11Al-8Ni, respectively. In spite of that fact, it is expected that the specimens should still possess shape memory behavior. To confirm this hypothesis, phase transformation temperatures will be measured using DSC technique, to look for martensitic and austenitic phase transformations at 150°C. So far, metallographic analysis of the specimens showed defined martensitic microstructures. Moreover, XRD technique revealed diffraction peaks corresponding to (0 0 18) and (1 2 8) planes, which are too associated with the presence of martensitic phase. We conclude that it would be possible to obtain fully dense Cu-Al-Ni alloys having shape memory effect behavior by direct laser fabrication process, and to advance into fabrication of self centering seismic dampers by a controllable metal additive manufacturing process.

Keywords : Cu-Al-Ni alloys, direct laser fabrication, shape memory alloy, self-centering seismic dampers
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