Design of titanium alloys processed using additive manufacturing for structural applications

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Additive manufacturing of components made of metallic alloys are produced using a feedstock (usually powders or wire) of conventional alloys. In the case of titanium alloy components, the application of essentially all industrially competitive techniques for additive manufacturing result in characteristic defects, being coarse columnar grains (in the direction of deposition), porosity, and residual stresses. This paper addresses the first of these, where the solution sought involves the development of modified/new alloys specifically for the given manufacturing process. The proposed solution involved the application of computational thermodynamics to identify which alloying additions to titanium alloys result in an increase in the freezing range of the given alloy base, such that a columnar to equiaxed transition (CET) may be effected. These alloying additions, mainly eutectoid formers, have been found, at critical concentrations, to cause a CET to occur, resulting in a relatively fine equiaxed microstructure. Of course, the amount of solute addition for these elements usually exceeds their solubility limit in the various titanium alloys, and, therefore, a further effort involving alloy development is required. Two types of alloys are being developed, the first with essentially identical properties as the (given) base alloy, and the second, alloys with enhanced properties. These various efforts will be described during this presentation.