The role of modern physical metallurgy in alloy development and materials processing

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Physical metallurgy is one of the foundational components of materials science and engineering, having been brought out of the blacksmiths' trade by highly gifted scientists, such as Sir Alan Cottrell (e.g., Theoretical Structural Metallurgy, published by Edward Arnold in *1948*). The term “modern physical metallurgy“ was first coined by Ray Smallman (Modern Physical Metallurgy, published by Butterworths in *1962*). Since these early days, physical metallurgy has been impacted in a very significant way by (at least) two developments, being firstly advanced techniques for materials characterization and secondly computational materials science. In this talk, examples of the use of (very) modern physical metallurgy in alloy development and metallic materials processing will be given. In the first of these, the application of development of refractory high entropy alloys (RHEA) is considered. In this work, computational materials sciences, primarily involving computational thermodynamics and phase field modeling, has been applied to provide a methodology for the selection of potentially useful RHEAs. Regarding the application of materials characterization, the deformation mechanisms of these alloys has been investigated using a combination of high resolution (scanning) transmission electron microscopy and diffraction contrast techniques. Advances made in the understanding of the behavior of these alloys will be described. Regarding materials processing, two aspects will be discussed. Firstly, the advantages of the application of powder metallurgy, primarily involving the hot isostatic pressing (HIP) of powders, to the processing of RHEAs will be described. This approach involves the use of blends of elemental powders and an example of this technique will be described. Secondly, the application of the principles of modern physical metallurgy to provide a solution to the application-limiting phenomenon of prior particle boundaries in Ni-based alloys processed using HIP will be described.