A Novel Analytical Technique for Dendritic Microstructures Formed During Directional Solidification of Metallic Alloys and Synthesis of an Alloy Fabrication Protocol for Optimization of Physical Properties

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Exponentially increasing necessity for stronger and long-lasting turbine blades to power our industrial world calls for major development in the solidification protocol of metallic alloys. A mostly theoretical process known as Directional Solidification (DS) utilizes columnar single crystal expansion to achieve structural uniformity, thereby optimizing physical properties. As optimal properties are dependent on homogeneous microstructures of the solidified alloy, the purpose was to establish a relationship between controlled DS protocol factors (solidification speed and thermal gradients) and microstructural homogeneity using a novel, conclusive, reproducible, and industry-applicable method of analysis: an individual cell-to-cell approach rather than a convoluted macro analysis. Within the individual cells,cellular size (CS) and cellular spatial orientation measure (CSO) were the morphological variables created and analyzed. It was hypothesized that increased solidification speeds would result in decreased consistency of CS' and CSO's. A custom constructed DS setup was used to melt and resolidify alloys at various speeds and thermal gradients. Complex image analysis of resulting substructures (in resolidified alloy samples) in which advanced statistical software and computer coding were used found that increased solidification speeds result in increased consistency of CS and CSO values within a given sample.Using the established relationship coupled with higher-level statistical forecasting, a new protocol for alloy fabrication was developed through which manufacturers would save hundreds of millions of dollars and turbine-based engineering would enable fabrication of novel energy solutions, exceedingly efficient transportation, and major advancement of global industry.