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Editorial

Insight into the Properties of Novel Materials—Superalloys, Ferrous and Lightweight Alloys and Metal Matrix Composites

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1. Introduction and Scope

Modern industries heavily rely on the advancement of novel materials to meet the demanding requirements of a wide range of applications. These applications span from marine propulsion systems and automobile internal combustion engines to jet turbine engines. The operational conditions these systems endure often involve a combination of high temperatures, pressures, and cyclic tension/compression loads. Creating these systems involves substantial research and development efforts, sometimes necessitating the creation of entirely new manufacturing processes. This can result in high production costs, particularly when pioneering process technologies are involved. Moreover, the lifecycle of these systems necessitates considerations regarding the reusability and recyclability of the employed materials.

The unceasing pursuit of enhanced operational efficiency drives the ongoing exploration of novel materials with superior properties. A diverse array of materials, including superalloys, ferrous metals, lightweight alloys, and metal matrix composites, have recently been introduced to the market, showcasing significantly improved characteristics. The challenges linked to production costs and the recyclability of these innovative materials have prompted the emergence of various new solutions.

This Special Issue presents a curated collection of five research papers [1–5] focusing on diverse aspects of new material development. These aspects encompass the characterization of material properties, fitness-for-service assessments for various applications, implementation, and production processes.

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2. Contributions

The first paper by Muslić et al. [1] investigated the impact of Equal Channel Angular Pressing (ECAP) on the hardness of a metal matrix-based composite (MMC) reinforced with Fly Ash particles. Using an A356 aluminum alloy base, the composite underwent multiple ECAP passes, resulting in progressively higher hardness values. The results demonstrated hardness enhancement after each pass, with varying indentation load sizes, following patterns that were effectively described by Meyer's law and revealing distinct indentation size effects in both cast and pressed samples.

In the second paper [2], Elsayed et al. employed in situ neutron diffraction to investigate the impact of grain refinement on grain growth during the solidification of Al-5 wt.% Cu and Mg-5 wt.% Zn alloys. Grain refinement was achieved through the addition of Al-5Ti-1B and Zr, respectively. Neutron diffraction experiments involved heating the alloys above the liquidus and then cooling in controlled temperature steps while monitoring solidification. The addition of grain refiners led to substantial reductions in grain size (92%) in both alloy types, with distinct microstructural differences observed. Neutron diffraction facilitated the analysis of individual plane solid fraction growth for various phases in the alloys, revealing unique solidification behavior in relation to grain refinement and alloy composition.

Kumar et al. [3] utilized an artificial neural network (ANN) to predict erosion wear in stainless steel 420, a material used for slurry transportation components. Erosion wear was evaluated using a slurry pot tester under varying conditions of rotational speed, time duration, and solid concentration with fly ash as the erodent. The ANN model designed in MATLAB accurately aligned with experimental results, offering an efficient method for forecasting erosion wear rates across different conditions, thereby saving time and resources compared to extensive experimental trials.

Stroh et al. [4] evaluated the effects that modification of iron-bearing intermetallics in a rare earth modified aluminum alloy (A356 + 3.5% RE) has on the elevated temperature (250–300 °C) tensile and creep performance. The minor chemistry alteration of the alloy transformed the brittle Al_5FeSi and $Al_9FeMg_3Si_5$ phases into $Al_{15}(Fe,Mn)_3Si_2$, reduced the size, and modified the morphology of the AlSiRE intermetallic. These alterations led to a 9–14% increase in properties.

The development of the new alloy, Mercalloy A362™, aimed to enhance marine transportation performance and efficiency by lightening Mercury Marine's lower transmission gearcase while improving recyclability. Although the prototype initially failed under standard service conditions due to accumulated residual stress, a T5 heat treatment mitigated this issue by reducing stress by approximately 50%. This research [5] investigated the effects of the T5 heat treatment on the alloy's intermetallic volume fraction, morphology, and tensile performance, revealing minor changes in intermetallics, but similar tensile properties in both the as-cast and T5 conditions. The combination of stress analysis and this study's findings optimized the manufacturing process, successfully introducing the gearcase into the competitive marine industry.

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