

Sintering Techniques for High-Performance Engineering Materials: A Comparative Study

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Abstract: *Sintering is a critical production process in powder metallurgy and engineering, improving the structural and functional characteristics of materials through densification and atomic diffusion. This research presents a comparative review of different sintering processes, such as conventional sintering, hot pressing, microwave sintering, and spark plasma sintering (SPS). Although conventional sintering is common due to its cost and simplicity, it has limitations in terms of long processing times and grain coarsening. Hot pressing enhances densification but is restricted in scalability and geometry. SPS can achieve fast densification with very little grain growth and is thus appropriate for high-performance nanomaterials, while microwave sintering is an energy-saving route with increased processing speeds. The research compares these methods in terms of important performance parameters including densification effectiveness, mechanical strength, processing velocity, and industrial suitability. The results indicate that sophisticated sintering techniques such as SPS and microwave sintering provide better microstructural control and efficiency, thus being suitable for high-performance aerospace, biomedical, and electronics applications. The work contributes to the choice of best sintering methods for engineering applications with focus on sustainability and enhanced material performance.*

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