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The Study of Sintering Process in Metal Forming

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Abstract

Powder metallurgy is a technique used to produce metal components through the process of compacting and sintering metal powders. The sintering process involves heating the powder below its melting point, which allows the metal particles to bond together through a diffusion mechanism. This study examines the sintering mechanism, the factors that influence it, and the mechanical properties of the resulting materials. The research methods include a literature review and a literature study to collect information related to the sintering process of powder metal such as Al, Mg, Ti, Cu, Ni and Fe. The results show that sintering temperature and holding time of MMCs,AMCs have a significant effect on particle size that increase mechanical properties such as compressive strength, tensile strength, elastic modulus and density. Thus, a deeper understanding of the sintering process can improve the quality of metal products produced from powder metallurgy.

Keywords: Powder Metallurgy; Sintering; Temperature; Particle Size; Mechanical Properties.

Introduction

Sintering is an important process in powder metallurgy used to solidify metal powders into a solid form. This process involves heating the powder below melting temperature, so that the metal particles can bond with each other through physical and chemical mechanisms. PM also has applied in composite material, such as Metal matrix composites (MMCs) (Kok, 2005). MMCs with matrix materials such as Al, Mg, Ti, Cu, Ni and Fe. (Saxena et al, 2022). Aluminum matrix composites (AMCs) use aluminum as the matrix material (Ramachandra et al, 2015).

AMCs applications in electronic has additionally properties such high thermal conductivity and low weight properties (Namdev et al, 2024 & Parikh et al, 2023). Even the Al alloys have poor wear resistance and limited tolerance to high temperatures (Pramanik et al,2008 & Bauria et al, 2007). In sintered Fe-Co-Si alloy has results a sophisticated structure that realizes both good magnetic and mechanical properties (Suetsuna, 2023) and also sintering of zirconia affects its mechanical and optical properties (Lawson et al, 2020. Jansen, 2019. Liu et al. 2022). The powder metallurgy (PM) is heavily influenced by compaction pressure, holding temperature, and holding

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time, which are basic parameters determining the properties of PM products (Li et al, 2016).

PM is a solid-state composite manufacturing technique used in the production of both particle-reinforced and fiber reinforced metal matrix composites (Kumar et al, 2020). There are other types of soft magnetic materials, such as compressed powder material and sintered material (Shokrollah, 2007. Bas et al, 2003. Perigo et al, 2018). Mechanical performance can influences by various shape of particle such as spherical, platelets, or irregular and regular geometric forms (Dey, 2016) and integration of solid reinforcement elements (Bharat et al, 2021). Optional secondary processing can be conducted to enhance the performance and characteristics of the structure (Tripathy et al, 2017).

Research Methods

Methods that used to improve the properties of MMCs, such as mechanical properties, wear resistance, corrosion resistance and elastic modulus, reinforcement materials that have the ability to combine with the matrix material are used (Bodunrin et al, 2015). PM production method that shown in Figure 1.

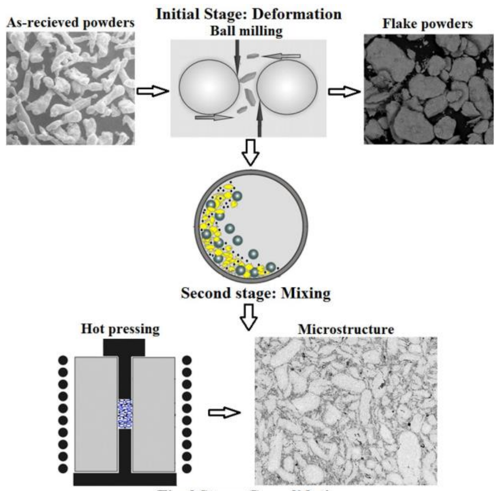

Figure 1. The stage of flake powder metallurgy process (Varol et al, 2018)

MgO, as a hard ceramic material, is added to the matrix material, increasing the strength and hardness of the AMCs. The AMCs Al alloy as matrix samples were prepared by cold isostatic pressing method under 200 MPa pressurewith sintering temperatures (575 ˚C, 600 ˚C, and 625 ˚C). The density of the composite decreased. Maximum density values were achieved at 625 ˚C. The maximum hardness of 44 BHN was measured in the 625˚C-sintered 5% MgO reinforced sample. Compressive strength increased and then followed a reverse trend at all. The maximum compressive strength is 288 MPa in specimens with 2.5% volume percent MgO sintered at 625 ˚C (Baghchesara et al, 2012).

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Results and Discussion

The effect of Al_2O_3, SiC, MgO had significantly increase mechanical performance of MMCs such hardness properties, compressive strength. It can be effected from particle size factor and alumina (Dils et al, 2024).

In addition, as the alumina particle size decreased, hardness, yield strength, compressive strength and elongation increased, while factors such as wear resistance, micro structure grain size and distribution homogeneity in the matrix decreased. Silica content in AMCs has effect in yield strength, ultimate tensile strength and hardness was decrease (Michael et al, 2015). Mechanical properties that PSR increased linear with ultimate tensile strength increase is affected by particle size , same as with Slipenyuk et. al. that e importance of particle size on the structural and surface properties of composites and the control of powder parameters in PM processes, as shown in Figure 2.

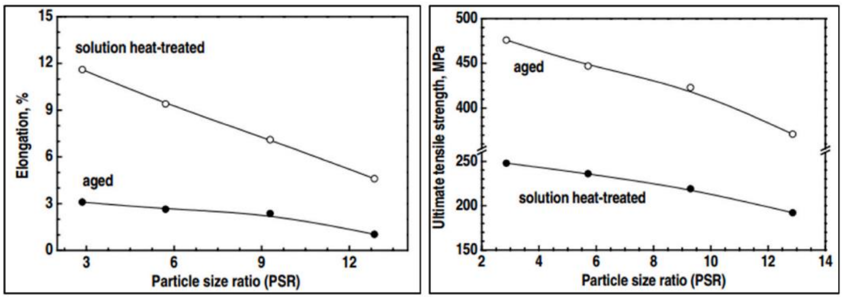

Figure 2 Effect of PSR on elongation and UTS of the composites in solution heat treated and aged condition (Slipenyuk et al, 2004)

Conclusion

Comprehensive study of development powder metallurgy in MMCs, AMCs has detail results mechanical properties such as tensile strength, hardness, etc is effect from Alumina, silica carbide addition. Increasing sintering temperatures and pressures can help reduce porosity and make the material compacted, this study will guide future research aimed at the develop lightweight, durable and economical

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