UNIVERSITI TEKNOLOGI MARA

INJECTION MOLDING PROCESS OPTIMIZATION TO PRODUCE POROUS COPPER USING PALM STEARIN BINDER

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ABSTRACT

Metal injection molding (MIM) is a promising technique for fabricating porous metal parts as it can produce complex parts with a controlled porous structure. This research is focused on producing porous copper parts using MIM process where sodium chloride (NaCl) is used as the space holder material. The volume fraction of NaCl was set to 20 vol% to replace the copper volume fraction, while the binder volume fraction was kept constant. Three powder loadings were used which are 59, 61 and 63 vol% based on critical powder loading volume percentage (CPVP). The feedstock is prepared by using sigma blade mixer and the feedstock shows constant torque values which indicate homogeneous mixing during torque analysis. The rheological behavior of the feedstock was investigated by using capillary rheometer machine where all feedstock exhibit pseudo plastic behavior. The feedstocks were analyzed further in terms of flow behavior index (n), activation energy (E) and mold ability index (α). All feedstock produced acceptable value and suitable for injection molding process. Taguchi method of L_9orthogonal array was used as a tool in optimization of MIM parameters for the highest green strength. Parameters that were optimized were powder loading, mixing temperature, mixing speed and injection temperature. Results from analysis of variance (ANOVA) shows that powder loading has the highest contribution for green strength with 61.81% followed by injection temperature (30.01%), mixing speed (7.48%) and mixing temperatures (0.69%). Optimum parameters from Taguchi method were used and injection molding process was carried out to produce tensile bar shape samples. The effect of different sintering heating rate towards properties of sintered parts was studied. As a result, sintering heating rate of 0.5°C/min shows positive results in terms of shrinkage, density and thermal conductivity compared to others (1.0 and 0.75°C/min). Sintered parts at heating rate of 0.5°C/min produced uniform shrinkage (1.42%), high density (6.51g/cm^3), high thermal conductivity (429.09 W/mk) with low porosity (25.59%). The optimized sintered part can improve heat exchanger application as the production of porous copper part using MIM technique can form small complex shape with high thermal conductivity in less weight ratio.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

Metal injection molding (MIM) is a powder metallurgy forming process using metallic powders. This process existed more than centuries ago and became widely recognized as an alternative way of producing high quality parts for many important applications [1]. This process gives advantages in terms of material usage, shape complexity, dimensional control, high density output, good surface finish, low cost and many more as compared to other metal forming methods such as forging, casting, extrusion, drawing and others.

The use of MIM in producing copper is still in its early stages as only a few researches have reported. One of the pioneers in the research of producing copper using MIM states that injection molding of feedstock that contains 66 Vol% of copper was possible under argon atmosphere [2]. Besides that, a local researcher have reported that feedstock preparation and characterization of copper feedstock can be successfully injected by using 59 Vol% copper powder [3]. Based on these findings, the binder used is the same which are Polyethylene (PE), Paraffin Wax (PW) and Stearic Acid (SA). Local binder such as Palm Stearin (PS) have not yet experimented and tested. PS is a local binder and proven to work as a binder in MIM [4],[5].

The fabrication of porous copper for heat sink is not a new area. Research done by Y.Liu et al. [6] reported that heat sinks made of porous copper lotus-type with coolant have outstanding performance on heat dissipation. Moreover, investigation on heat transfer performance of lotus-type porous copper heat sink with a porosity of 29% can achieve heat transfer coefficient up to 9 W/ (cm^2K) [7]. Based from these researchers, heat sinks by using porous copper can be said as promising outcomes and fabrication of heat sink of porous copper by using MIM have not yet been reported. Therefore, this study will focus on producing porous copper parts by using MIM process.

Furthermore, implementation of design of experiment (DOE) by using Taguchi method will be studied. Taguchi method is used as a tool in optimization of MIM