UNIVERSITI TEKNOLOGI MARA

INJECTION MOULDING OF POROUS 316L STAINLESS STEEL USING SACCHAROSE AS A SPACE HOLDER MATERIAL

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ABSTRACT

Metal injection molding (MIM) is a manufacturing process which has promising technique as it offers several advantages in producing part. MIM route with a space holder replication was employed in this study. Saccharose as a space holder material was introduced at the stage of powder-binder mixing followed by injection moulding. 316L stainless steel (316L SS) powder, binder components (low density polyethylene, palm stearin) and two different sizes of saccharose in the range of 163 microns to 250 microns and 44 microns to 63 microns were used for this study. The mixing process involving the incorporation of the space holder was conducted and assessed at various parameters prior to solvent debinding and sintering. Flow behavior index (n), flow activation energy, E (kJ/mol) and moldability index of all feedstock with different composition had acceptable value to be implemented for injection molding process. Optimum debinding temperature chosen based on the screening test was 60°C as palm stearin was completely removed from the green part at 60°C for 5 hours with no visual defect observed on the surface of the brown part. Thermal debinding was performed at temperature of 450°C, heating rate of 1°C/min and 1 hour holding time. Sintering process was carried out in Argon environment using a high temperature furnace with sintering temperature of 1250 and 1270°C, heating rate of 3°C/min and 1 hour holding time. Physical and mechanical properties of sintered and porous 316L SS sintered part were studied. The average density in the range of 6.18 to 7.26 g/cm^3 and porosity in the range of 8.91 to 22.46% with isolated and interconnected pores. Tensile strength and Young's Modulus possessed by sintered part with 0%, 20% coarse and fine saccharose content in the range of 163.41 to 424.93 MPa and 4.99 to 10.78 GPa, respectively. Porous 316L SS was successfully fabricated by employing saccharose as space holder material through MIM process. Porous sintered part produced had potential in medical applications because Young's Modulus obtained more comparable to cortical bone (5 to 27GPa).

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CHAPTER 1

INTRODUCTION

1.1 Overview of Chapter One

The first chapter of this thesis opens with the background of the study and further describes the metal injection molding (MIM) process in producing porous 316L stainless steel (316L SS). This is followed by problem statement, research objectives, scope of study and significance in research.

1.2 Research Background

Development of porous metallic implants for biomedical applications has been actively researched in recent years due to some concerns related to 'stress shielding' effect which eventually leads to bone resorption. In order to alleviate stress shielding problem, pores were introduced in metals as it capable to reduce Young's modulus of metallic implant [1]. Porous materials for implants has gaining interest of researchers as a method in achieving stable long-term fixation for full bone ingrowth [2]. Porous structure exhibits good energy absorption and reduce mismatch of materials stiffness between bone and metallic implant [3]. Stainless steel is one of the most commonly used materials in biomedical applications due to its corrosion resistance, excellent mechanical strength and good biocompatibility properties [4].

Abdullah (2015) fabricated 316L SS foam by using powder compaction method. Porous stainless steel was fabricated by using carbamide as space holder via powder metallurgy route [5]. Rafter et al. (2014) have conducted research on development of 316L SS foam with different composition of 316L SS using compaction method by utilizing crystalline sugar as space holder. Two compositions of 316L SS powder selected were 50 and 55 weight in percentage. Research concluded that stainless steel foam has been successfully fabricated through process of conventional powder metallurgy [6]. Joshi et al. (2015) used powder metallurgy route to produce stainless steel foams with urea which act as space holder. In this research, powder metallurgy was combined with space holder and compaction technique was employed to produce the parts. The pores obtained were acicular in shape and there were some circular shape