CHARACTERISATION OF STAINLESS STEEL 316L AND PALM STEARIN BASED BINDER BY USING METAL INJECTION MOLDING (MIM) PROCESS

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ABSTRAK

Polisterin telah menjadi isu degradasi sekian lama kerana ia tidak boleh terurai secara semulajadi. Dalam projek ini. Polisterin (PS) yang telah dikitar semula telah dijadikan sebagai pengikat utama dalam pengacuan suntikan logam (MIM). Objektif projek ini ialah untuk menyiasat parameter suntikan optimum untuk keluli tahan karat 316L dengan pengikat polimer (PS, PE, stearin sawit dan gliserol) dan kajian ciri kekerasan dan keliangan juga mikrostruktur selepas acuan suntikan. Bahan suapan 63wt%, 64wt% dan 65wt% dihasilkan daripada proses pencampuran. Kesemua sebuk mentah disuntik dengan parameter suntikan yang telah dimanipulasi bagi suhu acuan dan tekanan untuk mencari parameter yang optimum yang boleh menghasilkan bentuk ‘dumb bell’ yang sempurna. Parameter suntikan (suhu acuan: 110 hingga 115 ^{o}C dan tekanan : 7 hingga 8kPa) boleh menghasilkan bentuk ‘dumb bell’ yang sempurna diteruskan dengan proses penyahikatan, proses pensinteran, ujian mekanikal dan analisa. Daripada kajian, bahan suapan 63wt% menunjukkan pengaliran dan pembentukan yang bagus serta tahap ketahanan tinggi (388Hv) selain tahap keliangan yang rendah (89%) apabila menggunakan 110°C sebagai suhu acuan dan tekanan sebanyak 7kPa.

ABSTRACT

Polystyrene (PS) has been a nature's degradable issue as it cannot biodegradable. In this project, recycle polystyrene (PS) is used as main binder in Metal Injection Molding (MIM). The research aims are to investigate the optimum injection parameter for stainless steel 316L with polymeric binder (PS,PE, palm stearin and glycerol) and study its hardness and porosity also microstructure after injection molding. 63wt%, 64wt% and 65wt% of powder loading of feedstock were prepared in mixing process. All prepared feedstock were injected under manipulated injection parameter for mold temperature and pressure to find the optimum parameter which can inject full dumb bell shape. The injection parameter (mold temperature: 110 to 115°C and pressure: 7 to 8kPa) which able to produce full dumb bell shape is continued for debinding process, thermal pyrolisis process, sintering process, mechanical testing and analysis. From the studies, 63wt% of powder loading shows good flowability and moldability with high hardness (388Hv) and low porosity (89%) when using 110°C as mold temperature and 7kPa of pressure.

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1.0 Introduction

Metalworking industries has been growing up since then and metalworkers started to learn and implemented better quality product from metal alloys such as wrought iron, cast iron and steels. From this implementation, people started to develop more products form iron and metal alloys and trigger Industry Revolution where boilers, steam engines and railways can be made from mass production.

As for today, many products are being made in metal from advance metal alloy. The techniques of fabricating the metals are also facing a revolution. The revolution in technique of fabricating metal has introduced Metal Injection Molding (MIM). By using this technique precise and intricate product from big to nano-scale size product can be made. This technique often used in electronic industry. This process is similarly like baking a cake.

MIM is a process of manufacturing where combination of metal powder and binder can produce a very precise, optimum mechanical properties and intricate shape product. Binders used in this process can be organic and inorganic product. For an instance, recycle polymer product can be implemented and use as binder since it is hard to degrade naturally in earth besides it creates hazardous gas when polymer degrades naturally with other items. The resource of recycle polymer can be found in mineral water bottle, beads of pillow, shampoo bottle and even toys (Rashid,2011).

When metal powder and binders are mixed in mixing machine, it creates a mixture of feedstock (Rashid and Amalina,2011) . Feedstock has to be transformed into granulate shape in order to melt it in injection molding for shaping into desired

shape product. At this stage, feedstock is heated and melted at polymer melting point then injected in the mould. After injection process, the desired part is allowed to cool to a solid form. In order to obtain the metal part, part which also known as green part has to undergo debinding process. In this process, low melting point binder is removed and the remaining part is sintered to ensure binder is completely removed from metal part in sintering process. Low melting point binder in this binder system is palm stearin. Palm stearin will be removed from the specimen through debinding process. Other binders are removed via sintering process which requires more heat.

1.1 Significant and Benefits of Research

MIM process is a new approach in Malaysia. By applying MIM in Malaysia, many profits can be gained and new gadgets can be produced without dependency on import product. Malaysia has high potential in MIM industry as the material for binder and powder metal can be obtained in Malaysia. Binder for MIM can adapt a wide range of materials because MIM can be used for high temperature in melting temperature. Local binder of MIM is beneficial to industry and has become a great concern in research. Binder system of MIM has been varied and attempted in research in order to find the most cost reduction and can shorten production process.

Polystyrene has been used for food container in 1990s. Polystyrene has become a favorable food container among the businessman especially in food industry because of hygiene factor where the food is resisted from bacteria growth and water from entering the food. Polystyrene has been made for other various products such as solid spoons and folks, polystyrene cups and plates and disposable polystyrene razor. Polystyrene has attracted many industries as its light weight, economical and sturdy which against moisture but at the same time maintain its original shape.

Polystyrene has become a critical issue in Malaysia where it can be biodegradable. Polystyrene can only degrade after 500 years in earth and resistance

to photolysis as reported by Amruta (2013). Polystyrene has been introduced as potential main binder in MIM. The character of can be burnt and vanished in air has captured researchers to try polystyrene as binder in MIM.

Palm oil has become one of the largest exports in Malaysia. In 2007, palm oil industry has obtained RM 31.8 billion. Fractions of palm oil are majority of palm stearin and palm olein as reported by Siew Lin (2007). As in palm stearin, there are many fatty acids which can be used as lubricant and surfactant in MIM's binder system. One of fatty acids in palm stearin is stearic acid which is commonly used in MIM binder system as lubricant. Besides its high melting point which is in range of 44 to 56 ºC higher than room temperature, palm stearin is categorized as potential lubricant and surfactant for MIM's binder system. Palm stearin is also economical in price and easy to obtain in Malaysia rather than other foreign country. The most unique characteristic of palm stearin is that chemistry composition of palm stearin can be modified to meet the requirement of MIM.

1.2 Objective of Research

The main objective in this research is to investigate the optimum metal injection parameter for the prepared feedstock which are 63wt%, 64wt% and 65wt% of powder loading. Another objective is to study the sintered specimen in hardness and porosity in order to find the best injection parameter.

1.3 Problem Statement

Polystyrene (PS) and polyethylene (PE) have environmental problem in biodegradable. PS and PE are introduced as binder in MIM in order to overcome this problem as these polymers are classified as thermoplastic. PS and PE can be burnt and vanished in the air.

1. No study in optimum metal injection molding parameter (mold temperature, injection holding time, melting temperature and injection pressure) has been done for stainless steel 316L for particle size of 7.157µm.
2. Optimum powder loading composition of 63wt%, 64wt% and 65wt%. is not found yet for stainless steel 316L with powder particle of 7.157µm and powder loading of 63% and 64%.

1.4 Scope of Work

The scope of this research is to investigate the optimum powder loading and binder composition for stainless steel 316L by using MIM process.

1. Preparation of feedstock with different solid loading (63wt%, 64wt% and 65wt%) mixed with polymeric binder by using Metal Injection Molding (MIM).

2. The green part was injected with different injection molding parameter to find optimum MIM parameter for each powder loading. The manipulated injection parameters were mold temperature (110 to 115ºC) and injection pressure (7 to 8 bar). Optimum parameter value of mold temperature and injection pressure will inject full dumb bell part with good mechanical properties.

3. The sintered part was injected with manipulated injection molding parameter was related with its hardness property.

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