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INJECTION MOULDING OF 316L STAINLESS STEEL POWDER USING PALM STEARIN BASED BINDER SYSTEM

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Thesis submitted in fulfillment of the requirements
For the degree of
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Candidate's Declaration

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any other degree or qualification.

In the event that my thesis be found to violate the conditions mentioned above, I voluntarily waive the right of conferment of my degree and agree to be subjected to the disciplinary rules and regulations of Universiti Teknologi MARA.

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ABSTRACT

Metal Injection Moulding (MIM) process is an economically attractive method of producing large amounts of small and complex metallic parts. This is achieved by combining the productivity of injection moulding with the versatility of sintering metal particulates. In MIM, the powdered metal is blended with a binder to obtain a feedstock. The binder imparts flowability to the blend at injection moulding conditions and strength at ambient conditions. After moulding, the binder is removed in a sequence of steps that usually involves solvent extraction and thermal pyrolysis. Once the binder is removed, the metal particles are sintered. Accordingly, though the binder should not dictate the final composition, it has an influence on the process. Today, new local binder composition and its effectiveness as a binder system to all type of metal powder are the focus of many investigations. In this research work, a gas atomised 316L stainless steel (SS) powder with different particle size (16 µm and 45 µm) were evaluated using a locally binder system comprising a major fraction of palm stearin (PS) and polyethylene (PE). All the feedstock prepared shows homogeneity with pseudoplastic behaviour which is suitable for MIM process. Feedstock was prepared in a Z-blade mixer for batch mixing and subsequent injection moulding was carried out to form a tensile specimen. Prior to sintering, the moulded specimen were leached in heptane to remove the PS and then heated in furnace to remove the remaining PE binder. Some defect was detected for the specimen made with courser powder after being thermal pyrolysis. However, for fine powder (16 µm), all specimens were in good condition. After being sintered, the specimen gives 91% of the theoretical density. In order to achieve high density of sintered specimen, the powder loading was increase to the optimum powder loading of 65 vol.% and these results in specimens with 97.6% theoretical density. The influence of PS content was optimised in order to make full use of this in MIM work. Experimental evidence showed that the maximum content of PS in binder system allowable is up to 70 wt.%. The result also showed that increasing the PS content may shorten the overall debinding process and higher sintered density of 99.1% of theoretical maximum value can be achieved. Besides PS/PE system, another backbone binder; polypropylene (PP) with different composition was evaluated to show the interaction with PS. Although the rheological properties show dilatant behaviour, the feedstock was successfully injection moulded and achieved high density of green specimen. Moreover, the specimen was easy to handle during solvent extraction and thermal pyrolysis. Higher sintered density of 99.25% was achieved as compared to PS/PE binder formulation. Introduction of stearic acid (SA) in the binder that act as a lubricant helped in the mixing process to produce a homogeneous blend and the torque reached a steady state value in a short time. Increasing the stearic acid in the binder system resulted in lowered viscosity, thus improving the injection mouldability of the feedstock. This new developed binder, PS can also be injection moulded with water atomised 316L stainless steel powder, and the density achieved is 96% that of theoretical density. High physical and mechanical properties of the sintered specimen can be achieved as sintered at the temperature of 1360 ^{o}C with the heating rate of 10 ^{o}C/min under vacuum atmosphere followed by 95% N_2/5% H_2 and argon condition.

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