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RESEARCH ARTICLE

Effect of sintering parameters on physical and mechanical properties of powder injection moulded stainless steel-hydroxyapatite composite

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Abstract

The combination of metallic bio-inert material, stainless-steel 316L (SS316L) and a bio-active material, hydroxyapatite (HA) can produce a composite which has superior properties for orthopaedic applications. The main objective of this study is to investigate the effects of sintering temperature and holding time on the physical and mechanical properties of the sintered part. 50wt.% SS316L and 50wt.% HA were mixed with a binder system of palm stearin (PS) and polyethylene (PE) at 61 vol.% powder loading. Rheological properties show a pseudo-plastic behaviour of the feedstock, where viscosity decreases with increasing shear rate. The feedstock was injection moulded into a tensile bar shape while thermal debinding was carried out at 320˚C and 500˚C. The brown parts were sintered at 1000, 1100, 1200 and 1300˚C, with three different sintering times of 1, 3 and 5 hours in the furnace. It was found that the highest sintered density measured was 95.61% of the theoretical density. In addition, the highest hardness and Young's modulus measured were 150.45 HV and 52.61 GPa respectively, which are higher than those of human bone. The lowest percentage of carbon content was 0.022wt.% given by the sample sintered at 1300˚C for 1 hour. Therefore, SS316L/HA composite with good mechanical and physical properties was successfully produced through the PIM process.

Introduction

Powder injection moulding (PIM) is an efficient process to produce small components made from ceramic or metal powders having complex geometry, high precision, excellent final properties and net-shaped products at low cost [1–3]. Such process is a combination of plastic

sintered part to become denser as the holding time increased from 1 hour to 5 hours. The HA phase began to change to β-TCP phase when sintered at 1000˚C while changed to TTCP phase at 1100˚C through the decomposition process. Meanwhile, no changes were observed in the intensity when the holding time increased. The density increased with the increasing sintering temperature where the highest density value was 4.33g/cm^3 after 1 hour of sintering at 1300˚C. In addition, HA decomposed into TCP and TTCP phases, the density was found to be decreased. It was found that the Young's modulus of the sintered parts was higher than that of human bones. As the sintering temperature increases, hardness and Young's modulus will also increase due to the densification process. However, the Young's modulus was found to be decreased as the sintering time increases. Finally, sintering at 1300˚C gave the lowest weight percentage of carbon content of 0.022wt.%.

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Writing – review & editing: Farhana Mohd Foudzi.

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