DEVELOPMENT OF FRACTURE FIXATION PLATES PROTOTYPE THROUGH METAL INJECTION MOULDING (MIM) PROCESS

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1. Introduction

Although the conventional processes for producing implant have been long accepted and to produce good implants in terms of their properties, there are several drawbacks associated with these processes. For example, the chances of corrosion of the implants arising from inhomogeneties induced by casting or mechanical working process. Moreover, this process also exhibit the defects and tolerance limitations of the implants and not suitable for the high melting point materials. Many implant, are produced from difficult-to-machine materials such as stainless steel, cobalt-chromium alloys and titanium alloys. The process is quite complicated and involves an extensive machining operation and time. The drawback of conventional manufacturing processes have led to the objective of this study i.e. to provide for a method for producing metallic implant which are cost-effective as well as having excellent mechanical strength and an affinity to living bodies. The approach to solving this problem is the adaptation of the injection moulding process for manufacturing of said metallic implant. The MIM process has been discussed elsewhere [1,2,3,4]

2. Experimental

The 316L stainless steel powder medical grade ISO 5832 used in this experiment was a gas-atomised powder having a median particle size of 15 um. The powder was mixed with a proprietary organic binder that consists of polyethylene , paraffin wax and stearic acid in certain ratio with the powder loading of 65 vol. %. The mixing was carried out using a Z-blade mixer at 160^{o}C in duration of 2 hours. The tensile specimen and and product was prepared using Arbugh Metal injection moulding machine. The green densities of the moulded parts were measured using the water immersion method. Debinding was performed in two steps; solvent extraction to remove the paraffin wax and thermal pyrolysis to remove poly ethylene. The green specimen were immersed in heptane and held at a temperature of 60^{o}C for 5 hours. For thermal pyrolysis, the leached specimens were put in furnace under vacuum atmosphere. The cycle consisted of heating rate of 3^{o}C/min to 450^{o}C and soaking for 1 hour. The sintering process was performed in the furnace with the heating rate of 10^{o}C/min to the sintering temperature of 1390^{o}Cfor 60 minutes Then, the tensile of sintered specimen were determined using UTM machine. The density and physical properties of the product also been determine according to the MPIF standard.

3. Results and Discussion

3.1 Injection moulding of the products

The detail of the processing parameters during injection is in Table 1. All the injection parts were good and free from normal defects such as short moulding, obvious flashes at the parting surfaces and obvious separation between the powder and binder. The die cavity could be filled completely without any porosity or inadequate bonding of flow lines and yet allowing the moulded component to be sufficiently rigid for removal. The moulded parts hardened sufficiently in the mould, which was at room temperatures, to be removed within 10-15 seconds. The moulded parts had sufficient strengths to be handled. The green density is about 5.2 g/cm^3 or 65 % of theoretical density.

Table 1: Moulding parameters (optimum) for producing fracture fixation plates component

Moulding parameters	value
Injection temp	200°C
Injection pressure	1200-1300 bar
Cycle time	10-15 sec
Mould temperature	Room temperature
Clamping force	600 KN

3.2 Sintering Process of Fracture Plates

A complete sintering process in vacuum at 1390^{o}C for 1 hours resulted in fairly distributed pores around the sample, indicating that the feedstock was well mixed. The sintered density was measured to be 7.8 g/cm^3, which is about 99% of theoretical density. Figure 1 showed the microstructure of 316 L stainless steel after etching Furthermore, the pores appear to occupy sites located at grain boundaries and in the grain interiors. It clearly shows a single phase austenitic microstructure, which comply with the ISO 5832-1 for implant quality stainless steel.

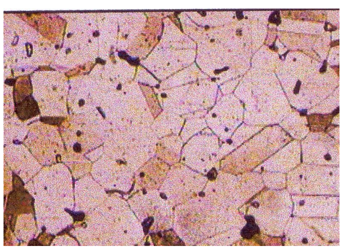

Figure 1: The microstructure of etched fracture plates sintered at 1390°C

Table 2 shows the physical and mechanical properties of the product using MIM technique. The properties comply with the international standard MPIF 35 metal injection moulding parts and ASTM 5832-1.

Table 2: The properties of fracture fixation plates

properties	units
density	7.88 g/cm3
shrinkage	15-20%
hardness	300 Hv
UTS	> 510 MPa
Yield strength	> 300 MPa
elongation	> 40%

CONCLUSIONS

It was shown in this study that the fracture fixation plates are suitable for production by the injection moulding process. All the injection moulded fracture fixation plates were successfully moulded using a temperature of 200°C with maximum injection pressure of 1200 to 1300 bar. The moulded samples were good and free from normal defects such as short moulding, flashing and parting surfaces. The highest final sintered densities were about 99% of theoretical maximum value with good mechanical properties which comply to the international standard.

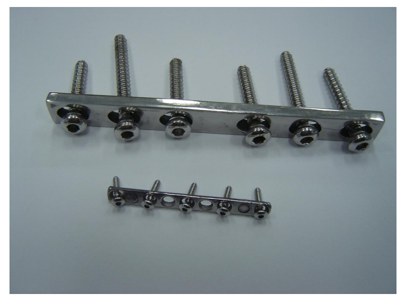

Figure 2: The final product of fracture fixation plates using MIM process

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