

CHARACTERISTICS OF INJECTION MOLDING OF 17-4PH STAINLESS STEEL POWDER

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Introduction

Metal Injection Molding (MIM) is increasingly being accepted as a suitable and cost effective method for the high volume production of small, complex-shaped and high performance parts. The technique involves mixing of metal powder with a binder, injection of the resulting mixture into the mold, removal of the binder and then sintering to consolidate the part to its final density [1]. The binder provides the powder with the fluidity necessary for molding. It also strongly influences the maximum solid fraction of the mixture that can be molded, the green strength of the molded part and the properties of the final products after debinding [1-5].

Successful production of parts by the MIM process is closely related to the formulation of the binder for use with the powder. The role of the binder is to serve as a temporary or transient phase to impart flowability and moldability. This will enable the shaping of the feedstock to the required shape during injection molding [2]. The dimension precision of molding stage has an important effect on the dimension precision of the final parts. Sintering temperature is the most important processing parameters for dimension precision and properties of the final materials [4]. This study investigates the physical and mechanical properties of 17-4PH stainless steel at every step involved.

Experimental

The gas atomized 17-4PH stainless steel powder used in the present study was obtained from Sandvik, United States of America. The

chemical composition of the powder given by the manufacturer is tabulated in Table 1.

Table 1. Chemical Composition of 17-4PH powder

Fe	Ni	Cr	C	Cu	Nb+Ta	Others
78.35	5.0	17.5	0.07	5.0	0.45	2.0

The mixing was carried out using a Z-blade mixer at 160°C in duration of 2 hours. The feedstock is then granulated in the pellet form so that it can be easily fed in an injection molding machine. The tensile specimen was prepared using vertical injection molding MCP HEK-GmbH. The green density of the molded part were measure using water immersion method. Debinding was performed in two steps; solvent extraction to remove the palm stearin (PS) and stearic acid (SA) and thermal pyrolysis to remove polyethylene(PE), thermoplastic natural rubber (TPNR) and paraffin wax (PW). The green specimen were immersed in heptanes and held at temperature of 60°C for time ranging 10 to 300 minutes. For thermal pyrolysis, the leached specimens were put in furnace under vacuum atmosphere. The cycle consisted of heating rate of 1°C/min to 450°C and soaking for 1 hour. The sintering process was performed in the furnace with the heating rate of 10°C/min to the sintering temperature of 1380°C. The specimen were soaked for 1 hour and then cooled at the natural rate of the furnace with no power supplied. Tensile test was carried out using an UTS machine, while the density of sintered parts was carried out using Archimedes method.

RESULTS AND DISCUSSION

In this work, the binder system consists of polyethylene (PE), paraffin wax (PW), palm stearin (PS), thermoplastic natural rubber (TPNR) and stearic acid (SA) was modified to investigate the moldability, dimensional stability of the molded component during debinding and dimensional precision after sintering. The preliminary selection of the binder formulation was based on the rheological test. After several attempt, the binder system consist of 55wt% PS, 45wt% TPNR (PS/TPNR), 55wt% PW, 45wt% TPNR (PW/TPNR), 70wt% PS, 30wt% PE (PS/PE) and 55wt% PW, 35wt% PE, 10wt% SA (PW/PE/SA) was chosen to prepare the feedstock with the powder loading of 65 vol%.

After several trials, the feedstock was fully molded and defect free at 220°C with the injection pressure around 1200 bar. Debinding was performed in two steps. In the first stage, solvent extraction process was carried out in a water bath held at 60°C for 5 hours. The specimens were immersed in heptane solution in a bed of glass beads in order to reduce the possibility of sagging. The leached specimens were dried overnight in the oven at 45°C to remove the remaining heptane. The remain binders like PE, TPNR and SA removed by thermal pyrolysis in the furnace at 450°C with heating rate rate of 1°C/min and soaking for 1 hour.

Sintering was conducted at elevated temperature to just below the melting point of the metal powder. Figure 1 shows the density of specimens at different sintering temperatures.

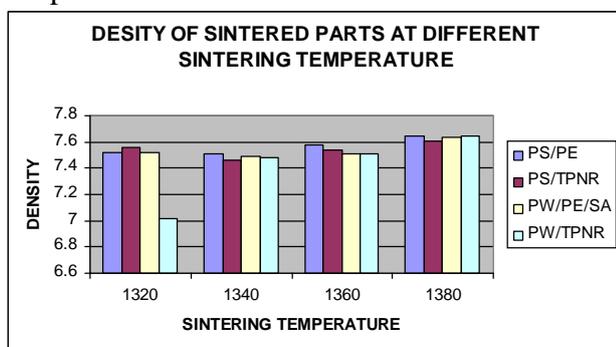


Figure 1 Density measurement of 17-4PH sintered parts at different sintering temperature

The lower density of the parts indicates that the air entrapped from shrinkage process. However it must be stressed that higher sintering temperature will increase manufacturing cost due to higher thermal energy needed. According to MPIF Standard 35 for metal injection molded of 17-4 PH stainless steel, the acceptable percentage level of the theoretical density is 96-98%. Therefore sufficient temperature is preferable in MIM industry.

CONCLUSIONS

It was found that the metal injection molding process using the binder system consist of PS/TPNR, PW/TPNR, PS/PE and PW/PE/SA has been successfully developed for 17-4PH stainless steel powder. Sintering temperature of 1380°C give more dense to the sintered parts and comply the MPIF Standard 35 for Metal Injection Molding.

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