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AN EVALUATION 0F METAL POWDER AND POLYMER MIXTURE USED FOR LOW PRESSURE INJECTION MOULDING

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Introduction

In the present study, the wetting of the metallic powder by organic medium was evaluated and correlated against the powder characteristics. The metal powder injection process backs 1920 and consists in a mixture of metal powders with organic binders, debinding and sintering. The process follows the same principles of the plastic injection moulding. The powder injection process has many technological advantages as a high number production of small and intricate parts. The market for this type of parts has been dominated up to now by casting techniques. The wettability is an important indicator of the metal injected parts success. Therefore, the powder particles characteristics highly influence the debinding stage, which is the most critical and slowest step of the process.

Experimental

The material used consisted of a mixture that can be considered as a modified polymeric system. This mixture consists of 60 % volume of a very fine stainless steel AISI 316 L powder (below 25 μm) and 40 % volume of binders, whose 15 % of polyethylene gives to the part, green strength. The remaining binders, 15 % of carnauba wax is responsible for the lubrication and the 10 % of paraffin aims the viscosity reducing, in order to facilitate the injection of the metallic mass. The metallic powder had its morphology characterised by scanning electron microscopy, specific surface area analysis, mean particle evaluation by a Fisher sub-sieve sizer and particle size distribution done by laser diffraction. The wetting characteristics were evaluated by direct observation of the mass in the scanning electron microscope. A low-pressure powder injector (0.7 MPa) was used and small bars were obtained using a pressure of 0.5 MPa. Thermal debinding was used to remove the binders from the compact with the assistance of fine alumina powders. The debinding was performed in a furnace up to 600 °C for 4 h. After binder removal the bars were brought up to temperatures close to sintering, 900, 1000, 1100 e 1200 °C. The mechanical properties variation against sintering temperature was evaluated by means of density measurements and micro hardness indentations.

Results and discussion

The powder morphology showed to be predominantly spherical, see Figure 1. The spherical morphology is preferred for a high packing density. The particle size distribution is bimodal, see Table 1. According to literature[1] the bimodal distribution facilitate packing and densification. The Fisher sub-sieve sizer it was used to measure the mean particle size and by using the formula $S = 6/\rho d$, where S = specific surface area, ρ = theoretical density and d = mean particle size, the specific surface area was calculated. The specific surface area reflects the powders' reactivity and hence particle wetting by the organic binders. The densification at temperatures close to sintering give rise to a density increase, which benefit the mechanical properties as showed by the microhardness measurements, see Table 2. The organic binders used resulted in a good wettability characteristics by not allowing the formation of holes, as can be observed in Figure 2. The holes formation may give rise to a poor thermal distribution during debinding, originating cracks and distortions.

Conclusions

It may be concluded that the organic binders used allow a good metal powder wettability characteristics by producing free holes bars. The powders characteristics were favourable to the low-pressure injection due to the bimodal distribution, small particle size and low specific surface area. At temperature close to the sintering, there is a hardness rise meaning good mechanical properties. The debindig assisted with alumina showed efficient in terms of the bars shape retention and defects reduction.

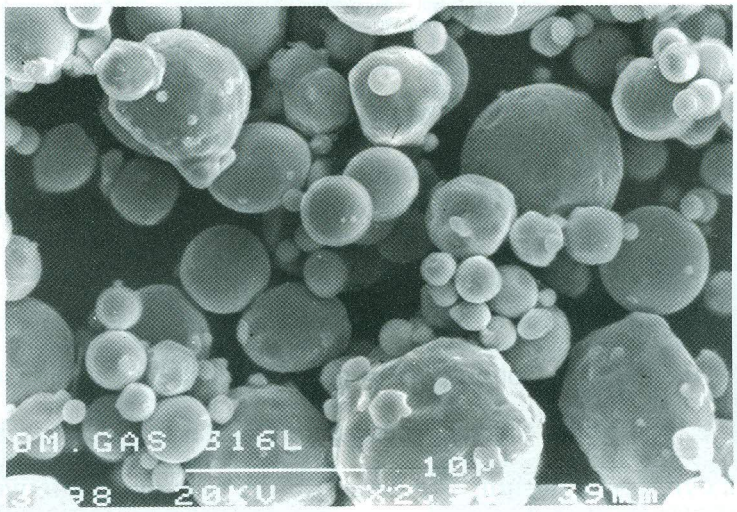

Figure 1. Secondary electron scanning micrograph showing the stainless steel powder morphology.

Table 1. Particles size distribution, specific surface area and mean particle size of the powder used.

Laser diffraction (µm)	d10 = 1.85 d50 = 8.25 d90 = 20.24
Fisher sub-sieve sizer	mean size = 8.285 µm specific surface area = 0.0905 m^2/g

Table 2. Density and microhardness evolution versus sintering temperature.

Temperature (°C)	900	1000	1100	1200
Density (g/cm^3)	4.704	5.420	5.616	5.912
Microhardness (HB)	53	77	116	151

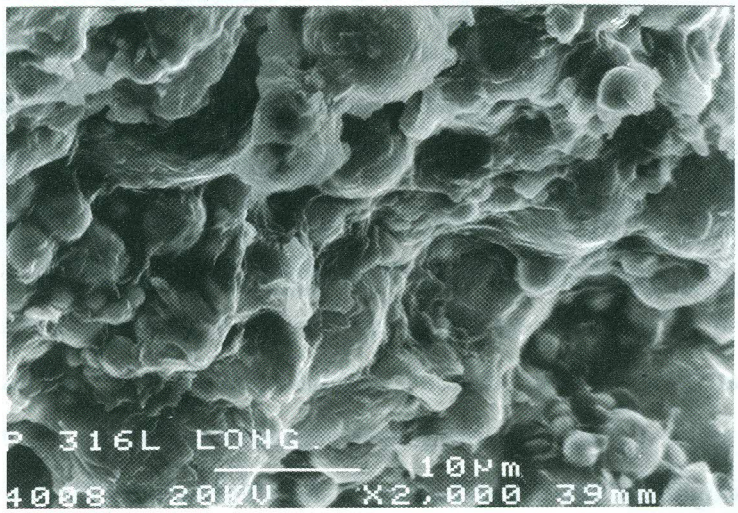

Figure 2. Secondary electron scanning micrograph shows the metal – binder wettability.

References

[1] THÜMMLER, F.; OBERACKER, R. *An Introduction to Powder Metallurgy*. The Institute of Materials, London, 1993. p. 144.

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