A Comparison of Techniques for Processing Powder Metal Injection Molded 17-4 PH Materials

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Abstract

While 17-4 PH stainless steel is a well established alloy in the powder metal injection molding industry, various techniques are used by different companies to produce the parts from this alloy. 17-4 PH is produced by sintering under partial pressures of nitrogen, sintering under hydrogen and sintering under vacuum. In this work parts made from the two different BASF feedstocks, made from a master alloy and gas atomized powder, were sintered for the same time and temperature under nitrogen, vacuum and hydrogen. The physical properties, microstructures and chemical compositions have been compared for the different sintering atmospheres and the causes for the differences discussed.

Introduction

17-4 PH is the most widely used MIM stainless steel material. There are two basic ways the powders are formulated; either as a pre-alloyed atomized powder (the principal means of atomizing being gas or water) or by mixing carbonyl iron powder to a master alloy. Both these techniques result in acceptable products, depending on the sintering process employed.

There are many different ways by which the 17-4 PH materials are sintered. The technology used by the founding fathers of MIM, Ray Wiech, Peter Roth, Karl Zueger and Ray Millett in the early 1980s, of pre-sintering in hydrogen to 1150^{o}C, followed by removal to a vacuum furnace and sintering under vacuum at above 1300^{o}C, is still being practiced. Some manufacturers use a partial pressure of nitrogen, or argon or vacuum while others use hydrogen under atmospheric pressures but at a lower temperature and longer time or hydrogen partial pressures at a high temperature in a refractory metal furnace. Zhang and German [1] had sintered 17-4 in vacuum, hydrogen-nitrogen mixtures and pure hydrogen and suggested 1300^{o}C was the optimum sintering temperature. They found that vacuum and hydrogen-nitrogen atmospheres resulted in poor densities and lower corrosion resistance and the best corrosion resistance was obtained by sintering in hydrogen.

This large variation in the sintering practice does cause a variation in the physical properties obtained which hopefully fall within the MIMA/EPMA specification limits. Neither of these specifications spells out how the alloy should be processed. It is the intent of this work to show the effects of different processing atmospheres on the end properties of MIM 17-4 PH materials.