A Methodology for Evaluating Sinter-Hardening Capability

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Abstract:

The cost advantages of eliminating secondary heat treat operations by using sinter-hardening powders have become evident. The growth of high hardenability powders for ferrous powder metal components necessitates some methodology for determining the appropriate furnace cooling rate and powder alloy that will accommodate sufficient hardening of different sized parts. Fundamental data that characterizes the cooling rates in a specific furnace and fundamental data that describes the hardenability of the powder at air hardening cooling rates is required. Once available, finite element or finite difference methods can be used to model hardness profiles on a specific part. In this way, crucial parameters such as maximum allowable section size for sinter hardening on a given furnace can be determined.

Introduction:

Cost advantages of using ferrous metal powders that transform to martensite during the cooling stage of sintering are driving increased production of these powder grades. The cost advantage stems from the elimination of secondary heat treat operations. With the growth in use of these powders, it is imperative that powder metal component producers be able to understand how highly alloyed their powder needs to be and how much cooling power their sintering furnace must have to produce different section sized parts. Given the current state of available information, this is difficult at best.

It is accepted knowledge in the industry that some form of forced convective cooling in the sintering furnace is required to obtain a high degree of martensitic transformation. Conventional radiator fan cooling will not effectively harden the most common sinter-harden grades. Most industry work describes cooling rates in these furnaces on company specific fixtures or on thermocouples that are not imbedded in powder metal components. Furthermore, the cooling rates given do not always cover the relevant temperature ranges for all transformation products. For the bainite prone sinter-hardening grades, good cooling rates must be maintained in the 350-550° C (660-1020° F) range. One method for describing the cooling rate in this range for a given furnace is given by Duchesne, et al.[1] This is an excellent method to save on thermocoupling real parts and still describe the cooling rate. It does not, however, fundamentally describe the cooling provided by the furnace and therefore can not provide hardness and microstructure