RECENT DEVELOPMENTS IN FERROUS POWDER METALLURGY ALLOYS

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A systems approach to engineered ferrous powder metallurgy (P/M) materials is described. The approach encompasses the use of high compressible, high performance powders in premixes produced using proprietary mixing technology that employs patented binders. To ensure that an appropriate microstructure is achieved to suit the functional requirements of a particular application, alloys are formulated based on knowledge of the compaction and sintering cycle that will be used to make the P/M parts. These premixes have improved flow and die filling characteristics that result in greater consistency throughout the entire P/M part manufacturing process. In addition, the use of binder treated premixes leads to reduced dusting and segregation of alloy additions. Binder treated premixes produced using high compressible, prealloyed molybdenum steel powders are shown to be particularly well suited for quench-hardening, sinter-hardening, and high temperature sintering. They also form the basis for a series of chromium, manganese, and chrome-manganese P/M 'Steels. The systems approach will be augmented during 1994 by the introduction of new material and process technology that enables part densities of 7.3 to 7.5 g/cm^3 to be achieved through single compaction processing.

INTRODUCTION

In order to meet the requirements of more demanding applications there is a trend towards higher P/M part densities. This has led to the development of powders with improved compressibility and processes · designed to take full advantage of these new materials.

Two recent developments in ferrous powder metallurgy have been of particular significance from both a technical and commercial perspective. Binder treated premixes have been found to reduce dusting and segregation, improve flow and die filling characteristics, and lead to greater consistency in parts making The introduction of water atomized prealloyed powders with compressibility's comparable to those of iron powders has added considerable flexibility to the manner in which ferrous alloys are constituted? These new prealloyed powders, which use molybdenum as their principal alloy addition, may be combined with other alloy additions in a binder treated premix and used to develop an appropriate microstructure for applications which demand good static and dynamic mechanical properties.' This is the cornerstone of a systems approach to engineered P/M materials.

SYSTEMS APPROACH TO ENGINEERED P/M MATERIALS

Binder Treated Premixes

While admixed powders are the most susceptible to dusting and segregation, prealloyed and partially alloyed (Distaloy) powders are also prone to dusting and segregation of lubricant and admixed graphite. This may is marketed as Ancorsteel 85 HP and the powder with l.5%w/o molybdenum is designated Ancorsteel 150 HP. When compared with nickel-molybdenum prealloys, the molybdenum prealloys result in significantly higher densities when subjected to optimized double pressing/double sintering processing (2P2S). This, in turn leads to enhance mechanical properties.

The new powders have compressibility's comparable to those of atomized iron powders (6.7 to 6.8 g/cm^3) as shown in figure 3. This means that the new powders provide great flexibility. They may be used to provide homogeneous quench-hardened and tempered microstructures, or may be used to replace iron powder as the basis for admixed materials.[4] In conjunction with binder treatment technology this provides significant opportunities for material development, P/M parts may be heat treated by quenching and tempering or carburizing. However, these are secondary operations, which entail additional processing such as reheating the parts in a controlled atmosphere followed by quench-hardening and tempering. The quench-hardened and tempered tensile strength of a single pressed and sintered (1PIS) (1102'C) ANCORBOND premix of Ancorsteel 85 HP with 2w/o nickel and 0~Sw/o graphite exceeds that of a 2P2S, 4w/o nickel steel, FN-O405HT as illustrated in Figure 4.

Under certain circumstances the need for secondary hardening processes may be eliminated if the P/M parts are cooled rapidly enough directly after sintering. The rate of cooling experienced by parts following sintering influences the microstructural constituents, which are formed. The microstructural constituents present depend on:

- Effective cooling rate
- Mass and shape of the part (ruling section)
- Material composition (hardenability)

Conventionally sintered copper and nickel steels such as FC-0208 and FN-0205 usually yield microstructures consisting of ferrite and pearlite. More highly alloyed · materials such as partially alloyed low-alloy steels (Distaloys) may form some bainite in addition to ferrite and fine unresolved' pearlite. However, if the sintering furnace is modified to permit the cooling rate to be increased, it is possible to produce martensitic areas in the microstructure and this result in increased strength and hardness.

Sinter hardening refers to a process where the cooling rate experienced in the cooling zone of the sintering furnace is fast enough that a significant portion of the steel matrix is transformed into martensite. The concept is illustrated in the simplified continuous cooling transformation diagram shown in Figure 5. Depending on the composition and the mass of the part, cooling rates of 1 to 8'C/s, in the temperature range from 850 to 200'C, formance powders in premixes produced-using proprietary mixing technology that employs patented binders **(ANCORBOND). To** ensure that an appropriate m/ere-structure is achieved to suit the functional requirements **of** a particular application, alloys arc formulated based on a knowledge of the compaction and sintering cycle that will be used to make the P/M parts. Considerable flexibility is provided to the P/M part fabricators. New material and process technology, due to be introduced during 1994, further enhances the systems approach and permits part densities of from 7.3 to 7.5 g/em' to be achieved by single compaction processing.

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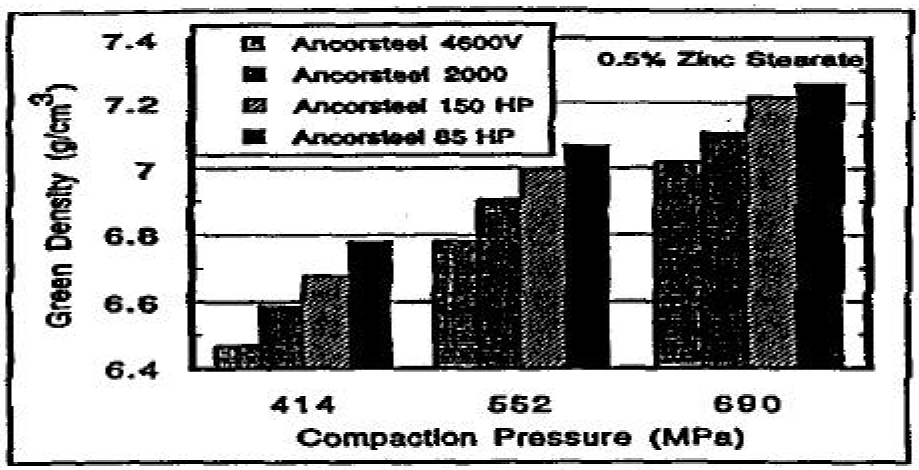

FIGURE 3. Compressibility of various prealloyed low-alloy powders.

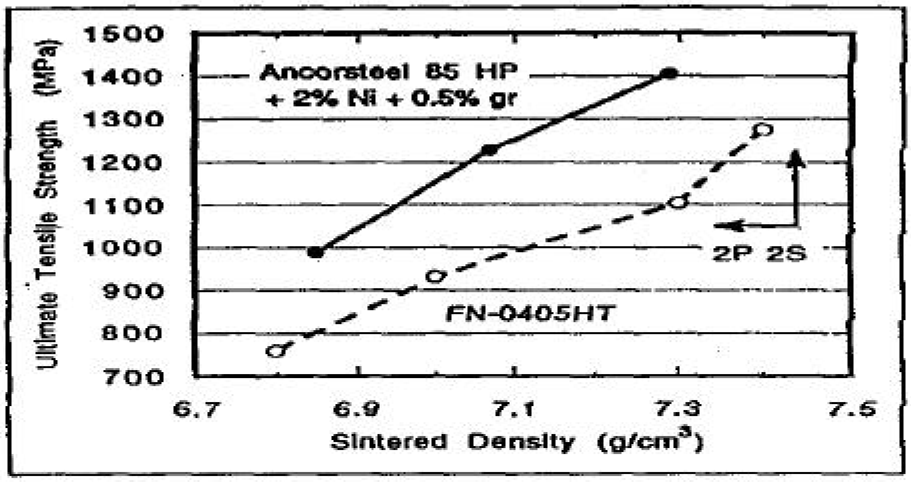

FIGURE 4. Quench-Hardened and tempered tensile strength of Ancorsteel 85 HP + 2% Ni + 0.5% gr. compared with that of FN-0405HT from MPIF Std. 35.

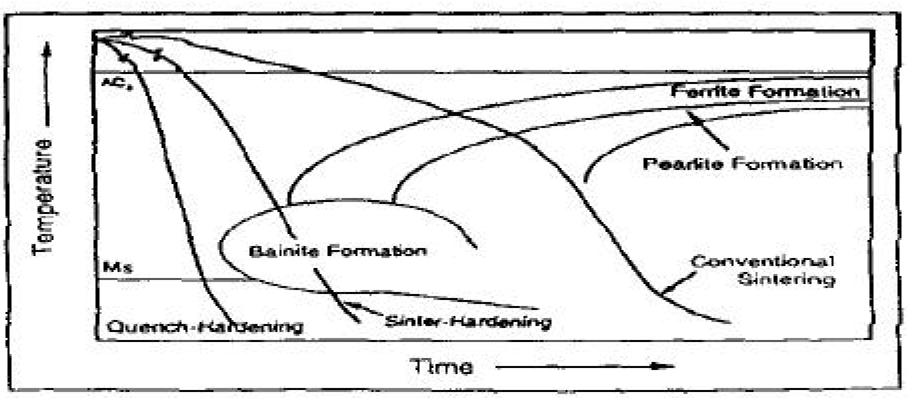

FIGURE 5. Continuous cooling transformation diagram - schematic.