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Pre-mixed Partially Alloyed Iron Powder for Warm Compaction: KIP Clean Mix HW Series*

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powder metallurgy. Material C containing no graphite was prepared to investigate the powder behavior during warm compaction. Material D was solely composed of base iron powder and was prepared for comparison with material C.

2.1.2

Compacting and sintering conditions for materials A and B are as shown is **2**. (For convenience sake, warm compaction and cold compaction are hereafter abbreviated as WC and CC respectively in the tables and figures.)

2.1.3 -

Sintered materials obtained under the conditions listed in Table 2 were subjected to carburization for 9 ks at 1 193 K and carbon potential of 0.9 mass%, and then for 2.64 ks at 1 123 K and carbon potential of of particle rearrangement and those of plastic deformation, respectively. The value on the left-hand side of Eq. (3), $C_\varepsilon(p)$, was called the porosity reduction ratio. The constants in Eq. (2), a, b, A, and B were abtained from measured values by means of the non-linear least-squares method. The contributions of particle rearrangement and plastic deformation in the compacting process were estimated by comparing the magnitudes of the constants, a and A.

2.2.3

Green compacts compacted into blocks of 10 mm in width × 35 mm in length × 3 mm in thickness were subjected to 3-point bending tests to evaluate their transvers rupture strength.

2.2.4 f - ,

Tensile strength, elongation, impact value, and Rockwell hardness were measured for each test specimen. In addition, contact fatigue strength was measured for warm-compacted, sintered and heat-treated compacts and DPDS-treated compacts. The contact fatigue apparent density exhibit only small changes with temperature from ambient temperature to 423 K. This behavior apparently results from the fact that KW-wax has a high melting point and is less-sensitive to temperature changes, which provides the advantage that precise temperature control is not required during warm compaction of this material.

The green density of material A was higher than that of cold-compacted material B. The temperature dependence tended to decrease in a range beyond 373 K. Its high density at ambient temperature results from particle rearrangement promoted by KW-wax as will be described later. The decrease in the temperature dependence of the density in the high temperature range is considered as the result that KW-wax does not melt in this temperature region due to its high melting point and partially remains within the green compact.

3.2

4 shows the compaction pressure dependence of the reduction rate of porosities of materials C and D at 433 K. The values observed in the experiment and those calculated by the regression equation are in a good agreement. Figure 4 also includes the values obtained for the first term, $C_{\varepsilon,1}(p)$, and the second term, $C_{\varepsilon,2}(p)$, in the regression equation. At a constant compaction pressure, material C exhibited a higher porosity reduction ratio than material D which was solely composed of iron powder, demonstrating the advantage provided by the lubricant KW-wax in obtaining a higher-density compact. Comparing $C_{\varepsilon,1}(p)$ and $C_{\varepsilon,2}(p)$ of each material, it is apparent that $C_{\varepsilon,1}(p)$ of material C increases steeply at a relatively low compaction pressure and then approaches a constant value. This behavior occurs because the lubricant KW-wax added to material C promotes the particle rearrangement even at a low compaction pressure and contributes to the densification of the powder. It was previously reported that the densification of material by warm compaction is attributable to an increase of plastic deformation capability of iron powder by heating.9) Thus, HW Series iron powder pre-mix with KW-wax

49.95ses 3Tc

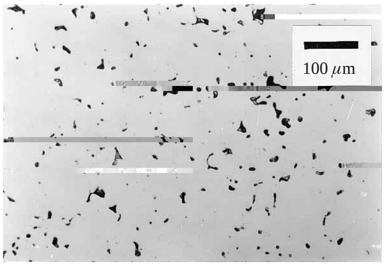

Photo 2 Microstructure of the center part of as-sintered material A

3.4

3 and 4 show sintered density, dimensional change, Charpy impact value, hardness, tensile strength, elongation, and contact fatigue strength of sintered material and heat-treated material respectively.

The tensile strength, impact value and hardness increase in proportion to the increase in density, thus confirming the effect of densification by warm compaction. 1 and 2, respectively, show the microstructures near the surface and in the center part of warm-compacted and sintered compact, having a density of 7.38 Mg/m^3

results of analyzing the compacting behavior. The mechanical properties of warm-compacted and sintered material are thus improved not only by the increase in density but also by promotion of particle rearrangement, which leads to the uniform distribution of nearly circular pores of size with narrow distribution throughout the sintered compact.

by a process of warm-compacting, sintering and carburizing heat-treatment, tends to decrease with increasing density. This behavior is interpreted that the decrease in ratio of open pores in the surface area with increase in density, suppresses carburization inside materials. In the gas-carburizing treatment of warm-compacted and sintered material, a future issue is to optimize the carburizing conditions.

1) S. H. Luk, H. G. Rutz, and M. Lutz: A New Method for Manufacturing High Performance Powder Metallurgy Compof29.8(en2F Man-) TJ-15.2741 -1.1765 TD0.4553 Tw (uf)-9.5(acturing High P)39