KAWASAKI STEEL TECHNICAL REPORT

No.41 (October 1999)

Advances in Iron and Steel Technologies,

Commemorating the 30th Anniversary of

Technical Research Laboratories

Recent Activities in Research of Iron Powder for Powder Metallurgy

Satoshi Uenosono, Shigeaki Takajo, Kuniaki Ogura

Synopsis :

About 78% of iron powder manufactured is used for sintered parts for transportation machines mainly for automobiles in Japan. Research and development have focused on improvement in fundamental properties as well as the productivity of manufacturing sintered parts. Kawasaki Steel, as a major manufacturer of iron powder, has developed new types of powder products for the 10 years to bring to meet the above mentioned demands. This report introduced three typical products: (1) Highly flowable segregation-free iron powder using wax lubricant, (2) Segregation-free iron powder suppressing copper powder segregation and (3) Iron powder for the enhanced machinability of sintered parts containing free graphite.

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Recent Activities in Research of Iron Powder for Powder Metallurgy*



Satoshi Uenosono
Senior Researcher, Iron Powder & Magnetic Material Lab., Technical Res. Labs.

Shigeaki Takajo
Dr. Sci. & Dr. Eng., General Manager, Iron Powder & Magnetic Material Lab., Technical Res. Labs.

Kuniaki Ogura
Staff Assistant General Manager, Iron Powder Sales Dept.

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1 Introduction

Kawasaki Steel produces two kinds of iron powder, i.e., reduced and atomized ones. On the occasion of the 30th anniversary of the foundation of the Technical Research Laboratories, this paper describes the technology trends in powder metallurgy for the past ten years and introduces some new products of the company.

2 Technology Trends in Iron Powder Metallurgy

2.1 Demand for Iron Powder

In Japan, 78% (100 000 t/year) of iron powder is presently used in transportation machines such as automobile parts. The weight of sintered parts per automobile was 6.5 kg in fiscal 1997, an increase of about 80% during last ten years[1]. However, as shown in **Fig. 1**, demand for sintered parts for automobiles has been sluggish since 1991.

In the U.S. and Canada, on the other hand, demand for sintered parts, especially larger parts such as connecting rods and bearing caps has increased rapidly since 1992 and was 310 000 t/year in 1997. Demand for sintered parts for automobiles was 14.1 kg in 1997. In Europe as well, demand for sintered parts for automobiles made an upward turn in 1994 and reached 6.3 kg in 1997.

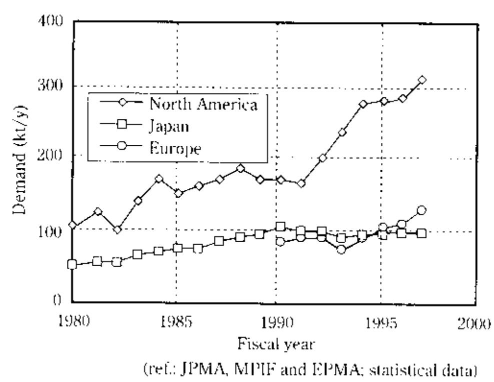

Fig. 1 Trend of iron powder demand for powder metallurgy

In Japan, a sectional committee and a research committee, which were organized under the sponsorship on Japan Powder Metallurgy Association, are investigating applications for new sintered parts.

2.2 Technologies Required to Products of Iron-Based Powder Metallurgy

Products of iron-based powder metallurgy are competing with other products technique in terms of both basic properties and economy. Technological develop-

* Originally published in *Kawasaki Steel Giho*, **31**(1999)1, 64–67

ment is aimed at both improving basic properties and increasing productivity throughout the manufacturing process of parts to reduce their cost.

Recent technologies are described below in terms of basic properties and productivity.

2.3 Improvement in Basic Properties

2.3.1 High strength sintered steel

In the partially alloyed Fe-2Ni-1Mo iron powder (KIP Sigmalloy 2910) developed by Kawasaki Steel, a high tensile strength of 2 000 MPa is obtained by the double press-double sinter process followed by bright quenching and tempering[2]. This increase in strength is due to the strain-induced martensitic transformation of the retained γ-phase distributed in the interior of sintered steel.

2.3.2 High density design

The mechanical properties of sintered materials depend greatly on the sintered density[3]. The double press-double sinter process and sinter forging have been put into practical use in addition to an improvement in compressibility of iron powder. A new process for warm-compaction; iron based powder are pressed at temperatures of about 150°C, has recently been developed[4].

2.4 Technologies for Improving Productivity of Sintered Parts

2.4.1 High dimensional accuracy design of parts

Stability of qualities is important for sintered parts that are mass produced. An improvement in the dimensional accuracy of sintered materials increases the value of parts and can eliminate the need for sizing and machining processes.

In Fe-Cu-C system, which is most popular for iron powder metallurgy, scattered C and Cu content of sintered compacts lowers dimensional accuracy. At Kawasaki Steel, techniques for preventing the segregation of graphite powder and other alloying elements such as copper, have been developed.

Because its much lower specific gravity of graphite than iron powder, graphite powder tends to separate from iron powder, resulting in segregation. Methods by which graphite is adhered to the surface of iron powder with a binder have been developed in order to prevent this phenomenon[5–7]. As shown in **Fig. 2**, dimensional accuracy of sintered parts was improved by reducing carbon segregation with the aid of segregation-free iron powder.

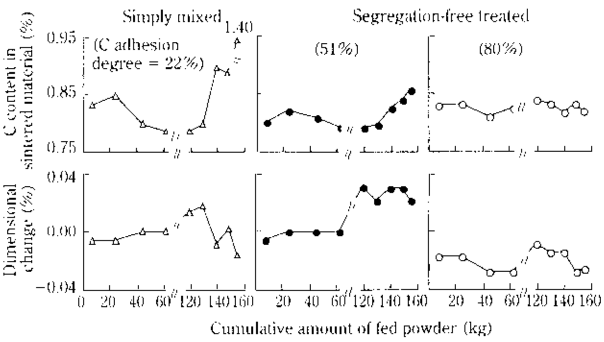

Fig. 2 Stabilization of sintered material properties by segregation-free treatment

2.4.2 High-speed compaction technology

One of manufacturers of sintered parts has developed new technology to enhance productivity through an increase in the compaction speed. For example, iron powder can flow fast and homogeneously by new-type feed shoes into which dry air is introduced[8,9], thereby increasing the compaction speed and improving dimensional accuracy.

2.4.3 Cost reduction by elimination of heat treatment

A technique for improving of as-sintered materials strength by omitting heat treatment is gathering attention as one of techniques to reduce sinter costs. Kawasaki Steel has developed prealloyed iron powder with a Cr-based Fe-1Cr-0.3Mo-0.3V composition (KIP 103V); a tensile strength of 1 000 MPa is obtained after sintering. This high tensile strength derives from a fine pearlite micro structure[10].

2.4.4 Improvement in machinability

To improve the machinability of iron-based sintered materials that are otherwise much less machinable than wrought materials[11], high-purity MnS is generally added[12]. Kawasaki Steel has developed a technique for improving machinability by utilizing the free graphite in sintered compacts.[13]

3 Principal New Technologies Developed by Kawasaki Steel

Kawasaki Steel has developed the following new products for the past decade; they were briefly described in Chapter 2.

(1) Ni-Mo-based partially alloyed iron powder for ultra-high-strength parts (KIP Sigmalloy 2010)[2]
(2) Cr-based iron powder for as-sintered high strength parts (KIP 103V)[8]
(3) Atomized iron powder with precision-controlled Si content for high dimensional accuracy
(4) Copper segregation-free iron powder
(5) Highly flowable segregation-free iron powder with wax lubricant
(6) Iron powder which improves machinability of sintered parts

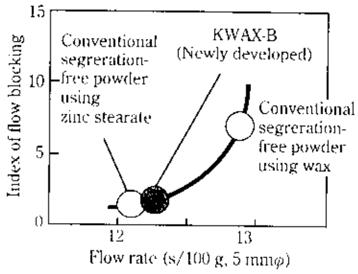

Fig. 3 Flowability of newly developed segregation-free iron based powder with wax lubricant compared with conventional segregation-free iron based powder

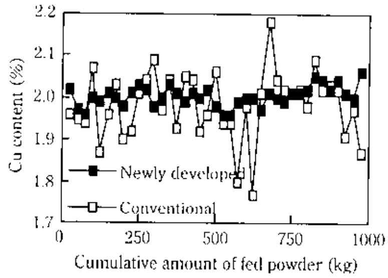

Fig. 4 Difference of scatters of Cu content during feeding between newly developed copper segregation-free iron based powder and conventional segregation-free iron based powder with a composition of Fe-2Cu-0.8C

This chapter describes the technological details of highly flowable segregation-free iron powder with wax lubricant and copper segregation-free iron powder.

3.1 Segregation-Free Iron Powder with Wax Lubricant

The types of lubricants besides binders added to segregation-free iron powder are roughly divided into zinc stearate and wax. Zinc stearate has the problem that the zinc oxide formed during dewaxing adheres to the sintering furnace. In the case of wax, however, this problem does not occur and sooting on the surface of sintered compacts is less apt to occur. However, wax tends to decrease flowability.

Therefore, Kawasaki Steel has developed a new product called KIP Cleanmix KWAX-B with much better flowability than the conventional wax-based segregation-free iron powder. **Figure 3** shows the flowability of KWAX-B expressed by index of flow blocking from the hopper as a function of flow rate. Impacting blows were imparted to the top surface of a hopper, having a size of 100 mm × 100 mm × 100 mm with a hole of 2.5 mm in diameter, filled with 1 kg of segregation-free iron powder and the index of flowability from the hopper was evaluated by the number of impacting blows made till the powder was discharged. This figure indicates that KWAX-B has good flowability almost comparable to that of segregation-free iron powder using zinc stearate. Furthermore, KWAX-B has powder properties, such as compressibility, ejection force, and sintered properties as good as those of the conventional segregation-free iron powder.

3.2 Copper Segregation-Free Iron Powder

In the conventional segregation-free iron powder, it is difficult to prevent the segregation of copper powder although that of graphite powder can be prevented. To solve this problem, Kawasaki Steel has developed copper segregation-free iron powder. **Figure 4** shows scatter in the copper content of compacts when 1 t of segregation-free iron powder with a composition of Fe-2Cu-0.8C was fed by a screwed tube-type feeder. In the newly developed product, the standard deviation of analyzed copper content decreased from 0.080% to 0.024% with a decrese rate of 70% as compared with the conventional segregation-free iron powder. Scatter of dimensional accuracy also decreased by about 20%.

4 Conclusion

The final objective of iron powder for powder metallurgy is to manufacture high-accuracy parts mere by means of a simple process of compaction and sintering. It is necessary to develop technologies for achieving this target.

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