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Sintered Cast Iron as a New Bearing Material

Part I: Production Process and Mechanical Properties

新しい軸受け材料としての鋳鉄焼結品
第一報 製造工程とその機械的特性

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Abstract

Recently developed sintered cast iron products are examined for its application to plain bearing. In this paper, the mechanical properties related to bearing performance are described. The influence of admixing additional graphite to cast iron powder on the mechanical properties of the sintered products is also investigated.

Introduction

Cast iron is known to have good antifriction properties since long and is also used quite frequently in some kinds of machine. But, no manufacturing method was available to produce porous cast iron bearings,while porous bearings from non - ferrous and also from ferrous metals could be produced by powder metallurgy. The main reason behind the difficulty in producing cast iron bearing from iron powder, was the trouble in uniform mixing of a big amount of graphite thoroughly.

However, the recent success in the reclamation of cast iron swarf by pulverizing it into powder and sintering the compact of the same to produce parts, indicated a big hope of its application to porous plain bearing manufacture [1]. A typical production process for bearing indicating the major steps can be observed in Fig. 1. It is supposed that the free graphite present in the structure would act as a solid lubricant, and at the same time the product being porous can be impregnated with a suitable lubricating oil. The resulting bearing may be called as self lubricating cast iron plain bearing.

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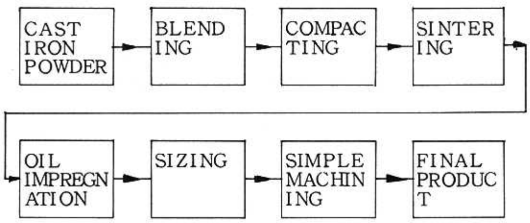


Fig. 1. Production process flow diagram

In addition to this, it is supposed on the basis of our experience that the problem may not exist in admixing extra graphite even upto a considerable amount in cast iron powder. On the other hand, it is very difficult to mix graphite more than 1wt% thoroughly in iron powder, and even if it is mixed during feeding through the hopper the graphite may float on the top surface. Thus, it is hoped that by adding a suitable amount of graphite to cast iron which may maintain the strength needed, a plain bearing for dry running applications may be possible.

Cast Iron Powder

The cast iron powder particles used in this investigation are shown in Fig. 2, and the mesh size distribution are shown in Table 1. The oxide content of such a powder is found to be 1900 ppm.

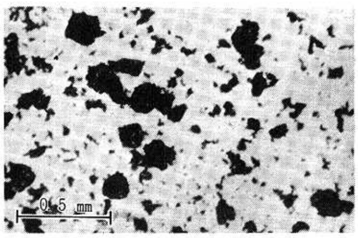


Fig. 2. Cast iron swarf powder particles

Table 1. Mesh size distribution and chemical composition of cast iron swarf powder

MESH SIZE DISTRIBU－TION	+ 60	60–100	100–200	200–300	− 300	
	4.3	20.9	42.5	10.4	21.9	
APARENT DENSITY	2.20 GRAM/CC					
FLOW RATE	79SECS/50 GRAMMS					
CHEMICAL COMPOSI－TION	C	Si	Mn	S	P	F
	3.55	2.69	0.45	0.01	0.02	BAL

Mechanical Properties

Strength

The radial crushing strengths of sintered rings with out-side diameter-30mm, inside diameter-15mm, and a height-15mm, for various compacting pressures and for two different sintering temperatures are shown in Fig. 3. The crushing strength as apparent from this result is increasing rapidly with the increasing

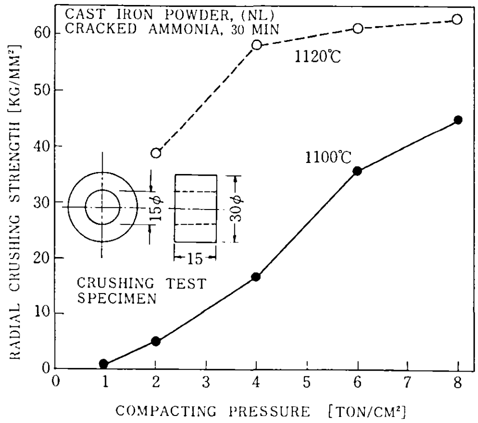


Fig. 3. Result of the radial crushing test (NL: no lubricant)

pressure and sintering temperature. This increase in the strength is however associated to the increase in the density and to the contrary a decrease in the porosity as shown in Fig. 4. But the production of a porous bearing that would be impregnated with a lubricating oil, requires to provide sufficient porosity as well as sufficient strength in the product.

The result over here shows that by increasing the sintering temperature simply by 20℃, the strength goes up remarkably with a decrease in porosity.

Thus a proper control of sintering temperature is of prime importance to obtain required porosity and strength.

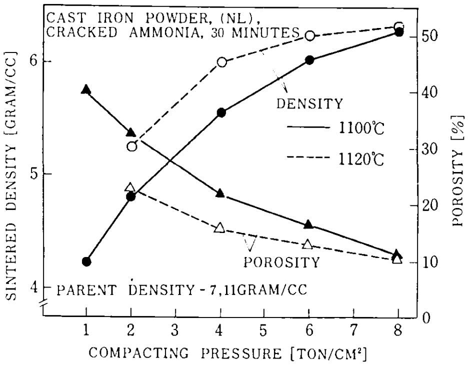


Fig. 4. Density and porosity of sintered cast iron product (NL: no lubricant)

Dimensional Accuracy

The dimensional changes during sintering in cast iron product are shown in Fig. 5. This result

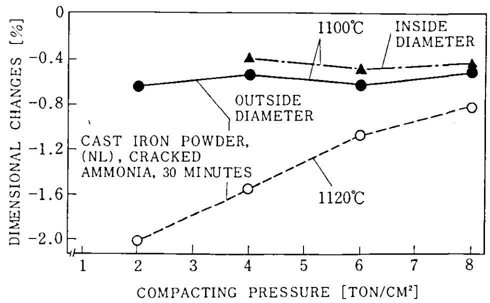


Fig.5. Dimensional changes occurring as a result of sintering (NL: no lubricant)

reveals that the shrinkage on the diameter is of the order of 0.6 percent or less at 1100℃, and the effect of compacting pressure on this is not so big. It is however clear that by increasing the sintering temperature to 1120℃, the shrinkage increases tremendously which would be a problem in practice. On the other hand, a big shrinkage indicates that at 1120℃, partial melting might have taken place which is supposed to cause closed individual pores.

In this case even if the porosity is high, the pores may not be interconnected that is desired and hence sufficient amount of oil impregnation may be difficult to achieve. So far as the dimensional accuracy is concerned, the spring back after the ejection of the compact shown in Fig. 6 indicates that the net change in the dimension from the die is very small corresponding to 1100℃. Furthermore, this small variation in dimension can easilly be controlled by sizing [2].

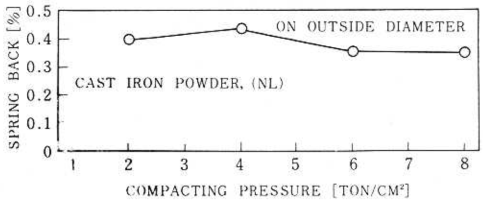


Fig. 6. Expansion of the compact after ejection from the die (NL: no lubricant)

Effect of Graphite Addition

The graphite which is a good solid lubricant when added to cast iron powder to increase its content, the sintered product suffers a considerable loss in strength. Therefore, to decide a suitable amount of graphite addition so that a sufficient strength is also retained, the effects of various amounts of addition on the tensile strength and dimensional changes are reproduced in Figs. 7 and 8 respectively [3]. It is clear from this result that though the

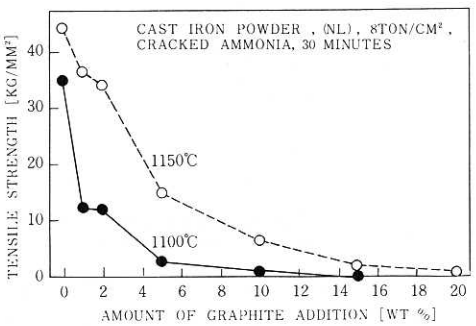


Fig. 7. Effect of graphite addition on the tensile strength (NL: no lubricant)

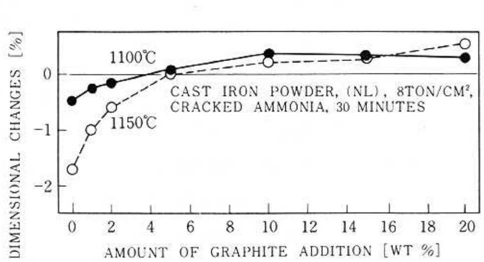
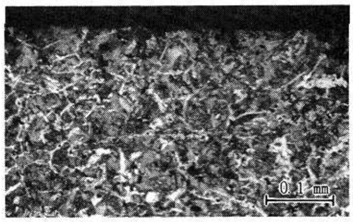


Fig. 8. Effect of graphite addition on the dimensional changes (NL: no lubricant)

increasing amount of graphite decreases the strength rapidly, upto an addition of 5 wt %, probably a sufficient strength seems to exist for normal bearing application.

On the other hand, though the strength decreases with the increase in the graphite content the dimensional variation is becoming narrower, and corresponding to 5 percent addition almost no change in dimension can be observed. The microstructures including the edge of the specimens of cast iron and the so called similar material produced from a mixture of iron powder and 3.5wt percent of graphite are shown in Fig. 9. By comparison, is indicated

(a) Cast iron powder



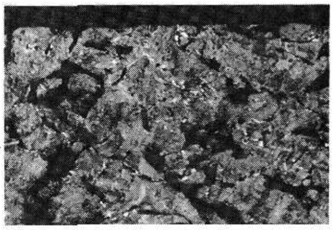
(b) Iron powder + 3.5 % graphite

Fig. 9. Comparison of the micro structures of sintered cast iron and the sintered mixture of iron powder + 3.5 percent graphite (Mixed lubricant, 8 ton/cm², 1125 ℃, 30 min., $N_2 + 3H_2$)

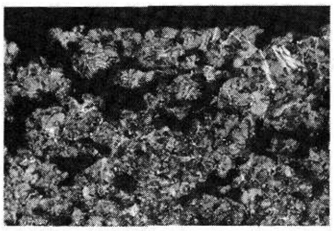
that though it is possible to get sintered product from a mixture of iron powder and a big amount of graphite, a severe decarbonization during sintering causes the graphite to diasppear from quite a deep into the surface of the specimen. The absence of graphite near the surface would cause the product to behave like an ordinary sintered ferrous powder product. On the contrary, a sufficient amount of graphite in the form of small pockets in the matrix near the surface can be observed in the sintered cast iron product, which is supposed to act as *solid lubricant*.

The microstructures shown in Fig.10. indicates the effect of increasing graphite content on the metal matrix. The increasing amount while results in more graphite in the matrix, a rapid decrease in the strength as already stated earlier can be confirmed from the increasing discontinuity in the

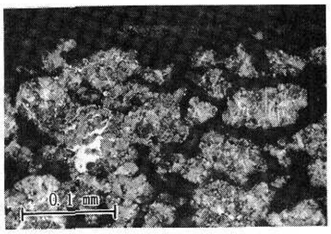
(a) Cast iron powder



(b) Cast iron + 5% graphite



(c) Cast iron + 10% graphite



(d) Cast iron + 20% graphite

Fig. 10. Effect of graphite addition on the metal matrix (8 ton/cm², 1150℃, 30 min, $N_2 + 3H_2$)

metal matrix. However, there is some possibilty of using even a product with graphite content of 10 wt percent as its microstructure indicates interconnected metal matrix. This microstructure is similar to a bearing material produced for dry sliding (without oil lubrication) reported by Shaw and Knopp [4].

The material was produced by hot pressing from a specially prepared powder and it showed good antifriction properties. But from their data, the iron base bearing material with about 12 percent carbon seems to have lower strength than the one explained in this report produced simply by sintering with same amount of carbon.

Conclusion

The following points may be mentioned in conclusion as a result of the above discussion:

(1) Since the raw material is the machining swarf (a byproduct, the scrap), the final powder is considerably cheaper than iron powder.

Furthermore, the difficulty of admixing of additional graphite is automatically overcome.

(2) The sintered product is superior in strength than the parent cast iron itself and at the same time it is porous. This porosity facilitates the oil impregnation of these products to produce self lubricating cast iron bearing, which has been difficult until now.

(3) Since the addition of even upto 10wt percent graphite shows interconnected metal matrix in the sintered structure with sufficient strength, there is a big possibility of using such material for dry running bearing application, where oil is either undesirable or the temperature is too high to retain the oil.

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3) Ibid

4) Shaw J.D. and Knopp W.V., "A New Oil − less Bearing Material", Product Engineering, Jan., 1957, pp 203 − 205.