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OTTAWA December 1, 1945.

# REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1973.

Metallurgical Examination of Iron Powder.

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(Copy No. 5.)

Bureau of Mines
Division of Metallic
Minerals
-
Physical Metallurgy
Research Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch

OTTAWA December 1, 1945.

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### Origin of Material and Object of Investigation:

A sample of iron powder, weighing about one pound, was received from Mr. Karl Tewes, 6 Duprée St., Sorel, Quebec, on October 31, 1945.

This powder had been made from iron pyrites by means of hydrogen reduction and had been ground in a ball mill to required screen sizes. It had been processed in the same way as the sample that was reported on in Investigation No. 1931, September 8, 1945.

This iron powder was submitted for metallurgical examination and evaluation of its properties for powder metallurgy purposes.

Chemical and Physical Characteristics of Powder:

The chemical composition of the powder was determined, a screen analysis was carried out, and the flow rate and apparent density were determined according to standard procedure. The results were:

Chemical Analysis -

| | | Per Cent |
|---|---|---|
| Total iron | - | 96.6 |
| Carbon | - | 0.02 |
| Manganese | - | 0.04 |
| Silica | - | 0.94 |
| Phosphorus | - | 0.003 |
| Sulphur | - | 0.010 |
| Aluminium oxide | - | 0.30 |
| Calcium oxide | - | 1.09 |
| Magnesium oxide | - | 0.15 |
| Copper | - | 0.22 |
| Hydrogen loss | - | 0.27 |

Screen Analysis -

| +70 | +100 | +140 | +200 | +270 | +325 | -325 |
|---|---|---|---|---|---|---|
| 2.2 | 17.9 | 10.6 | 10.5 | 7.0 | 5.7 | 46.1 |

Flow Rate -

47 seconds (for 50 grams).

Apparent Density -

2.54 gm./c.c.

Compressibility Density -

100.5 gm./cu.in. at 80,000 p.s.i.

Compression Ratio -

2.43 at 80,000 p.s.i.

Mechanical Properties of the Sintered Compacts:

To test the pressing characteristics of the iron powder, it was mixed with 1 per cent by weight of Sterotex lubricant. The die walls were coated with a thin film of the same lubricant. A collapsible die was used as a mould and pressure for compacting was applied to one side only. Three compacts were made at 80,000 p.s.i. pressure. Due to lack of powder, other pressures were not investigated.

(Mechanical Properties of the Sintered Compacts, cont'd) -

The green compacts were sintered in a hydrogen atmosphere at 1000° C. for one hour.

Tensile test specimens, 0.188 inch in diameter and of $\frac{3}{4}$-inch gauge length, were machined from the sintered compacts.

The ultimate strength and elongation of the sintered compacts, pressed at 80,000 p.s.i., were determined on the tensile test specimens.

Tensile Strength -

15,400 p.s.i.

Elongation -

3 per cent.

Density -

6.10 gm./c.c.

Porosity -

22.5 per cent.

Microscopic Examination:

Examination of this powder under a binocular microscope disclosed it to be of an irregular, hackly shape, somewhat similar to powders produced by the reduction of mill scale. This hackly shape and the porous structure of the particle are shown in Figure 1, a photomicrograph (at 250 diameters) of powder particles mounted in lucite and polished.

The microstructure of the sintered test compacts is shown in Figure 2. The large black areas are voids. Some have been partially filled in by oxide. The grey areas are pearlite. It is suspected that sufficient carbon to form the pearlite has been introduced by the stearate lubricant.

(Figures 1 and 2 follow,)
(on Page 4.)

(Microscopic Examination, cont'd) -

Figure 1.

X250, etched in
2 per cent nital.

CROSS-SECTION OF POWDER PARTICLE.

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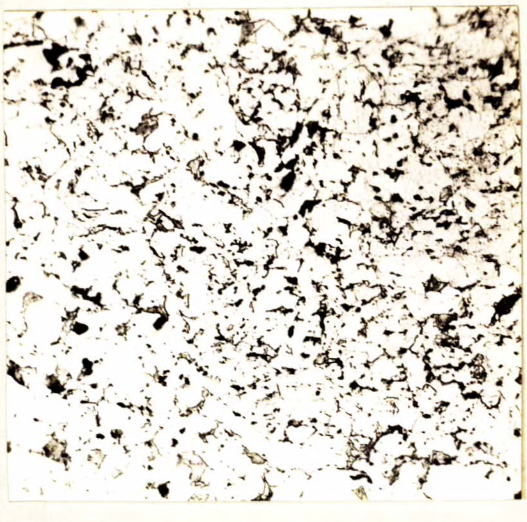
Figure 2.



X200, etched in
2 per cent nital.

POLISHED SECTION OF TEST COMPACT
PRESSED AT 80,000 p.s.i. AND THEN
SINTERED AT 1000° C. FOR 1 HOUR.

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DISCUSSION:

The total iron content of this sample is comparable to that found in similar iron powders of this class.

The impurities and their amounts present have an important bearing on the properties and behaviour of a powder for powder metallurgical purposes. The hydrogen loss determination shows that this sample is relatively low in reducible oxides. However, the non-reducible oxides, which would interfere with the sintering of the particles and which are generally abrasive to the surface of the die, occur in objectionable amounts. Thus the silica content is twice the amount usually allowed. Calcium oxide is present in a comparatively large percentage, which would not be acceptable. Magnesia and alumina also are indicated. These oxide impurities probably came from the gangue of the iron pyrites and have not been completely removed during the processing to the iron powder. The carbon, manganese, phosphorus and sulphur are below the limits set for these impurities. The small quantity of copper probably originated in the ore.

The screen analysis of the powder conforms with general specifications, with the exception of the slightly high minus 325 mesh screen fraction.

The flow rate is higher than the usually specified maximum value of around 35 seconds. This is undoubtedly due to the high percentage of minus 325 mesh material. The hackly shape of the particles would also tend to decrease the flow. The apparent density of the sample is in general agreement with iron powders of this type.

The tensile strength of the sintered material was below values usually obtained. This is due to the relatively high silica, magnesia and other oxide inclusions, as shown in the microstructure of the sintered bar. These impurities prevent proper bonding of the iron particles, producing

(Discussion, cont'd) -

weaknesses in the product. The low elongation recorded also supports this conclusion.

The compressibility density of the pressed powder is quite high, indicating that the particles compacted together very readily. This is, no doubt, brought about by the hackly shape and porous nature of the powder. The compression ratio figure, which is smaller than the average value of 3, also demonstrates its ease of compacting.

The per cent porosity and density of the sintered bar are in agreement with values generally occurring.

Thus, the chief disadvantage of this powder lies in its high oxide content. If this could be lowered and a corresponding improvement in the tensile strength of the product brought about, the powder would meet the customer's requirements.

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GTS:IHM:LB.