On the Electron Microscopic Structure of the Graphitic and Temper Carbon in Cast Iron

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Numerous investigations have been carried out on the nature of the graphitic and temper carbon in cast iron, and it is now generally recognized that 1) they are crystalline, and their crystals are hexagonal, 2) they consist of the α- and β-modifications and the proportion of the former is far larger than that of the latter which is about 5 pct, 3) their crystal structures are exactly the same as those found in graphites from other sources.

In 1922 Wever[1] measured the average size of the crystals consisting of the graphitic and temper carbon in cast iron by X-ray method as follows:

Graphitic carbon	100 Å
Temper carbon	20~50 Å.

According to the above result, the graphite flake and the temper carbon observable under the common microscope are the bodies consisting of the graphite crystals of ultra-microscopically small size. In olden times, when X-ray analysis was not adopted, the temper carbon was generally considered to be amorphous and a graphite flake observable under the common microscope was believed to be a single crystal by many metallurgists[2].

No objections have been raised yet against the Wever's above results on the nature of the temper carbon. In 1937 Gröber and Hanemann[3], however, published a different opinion to the Wever's result regarding the size of the crystals consisting of the graphite flake observable under the common microscope. They confirmed that the primary graphite flakes in cast iron are individually single crystals after studying their structures under the polarizing microcope, and gave a strong evidence for the old consideration above mentioned.

In 1950 De Sy[4] showed an interesting electron photograph of a graphite nodule in the ductile cast iron. We can recognize from his photograph that a graphite

nodule of this kind probably consists of the blades of graphite crystallites of pretty large size.

The present investigation was carried out to confirm qualitatively the size of the crystals of the kish graphite and the graphitic and temper carbon in cast iron under the electron microscope.

The raw materials, from which the sample of the graphitic and temper carbon was extracted, were as follows:

1. Gray cast iron of high purity.
2. Ductile cast iron.
3. Black heart malleable cast iron of high purity.
4. Black heart malleable cast iron of commercial made.

Raw material 1 was preprared by furnace cooling after melting Kenjiho pure white pig iron in a graphite crucible, raw material 2 by adding Fe-Si-Mg alloy as nodulizer in molten Swedish pig iron, and raw material 3 by annealing only at about 900°C. a white cast iron casting which was made by melting together Kenjiho pure white pig iron and Armco iron.

The structures of these raw materials under the common microscope are shown in photos. 1~4.

The turnings of the raw materials were dissolved in acid in order to extract the sample of the graphitic and temper carbon contained in them. Special care was paid in this case to raise the purity of the carbon samples, in which the ash content was about 0.2 pct. The kish graphites from the molten pig iron manufactured in a blast furnace and in an electric furnace, were also adopted as sample. They were all individually scaly form of the size over 2 mm.

The electron photographs of these carbon samples were taken after ultrasonic dispersion in water suspension as shown in photos. 5~10.

The magnifications of these photographs are 15,000~20,000 diameters. On the photographs of the magnifications of such order, the crystals of the size of 100 Å and 50 Å should be observed respectively at the size of 0.15~0.21 mm. and 0.08~0.11 mm. The photographs show, however, that the size of the graphite crystals of the carbon samples observable under the electron microscope is far larger than that measured by Wever.

Although it is doubtfull that the graphitic and temper carbon in cast iron consist of only crystals of such large size, the author believes from the results of the present investigation that 1) if the graphite flakes in cast iron observable under the common microscope are not individually single crystals, the proportion of the graphite crystals of the size far larger than that measured by Wever will be large, 2) the temper carbon in cast iron observable under the common micro-

scope will consist of the graphite crystals of the size far larger than that measured by Wever, 3) the graphite nodules in ductile cast iron observable under the common microscope contain the graphite crystals of pretty large size in large proportion. The last conclusion well coinsides with the result of the De Sy's experiment.

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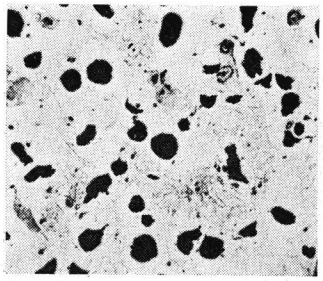
References

1) F. Wever: Mitt. Kaiser-Wilhelm Inst. Eisenforsch., 4 (1922) 81.
2) A. Ledebur: Handbuch der Eisenhüttenkunde, Bd. 1 (1902) 309.
3) H. Grober and H. Hanemann: Arch. Eisenhüttenwes., 11 (1937) 199.
4) De Sy: Metal Progr., 57 (1950) 774.

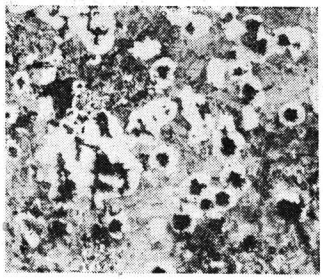
×100

Photo. 1
Gray cast iron of high purity.



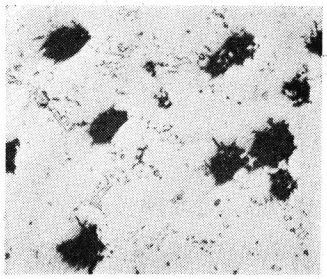
×100

Photo. 2
Ductile cast iron.



×100

Photo. 3
Black heart malleable cast iron of high purity.



×100

Photo. 4
Black heart malleable cast iron of commercial made.

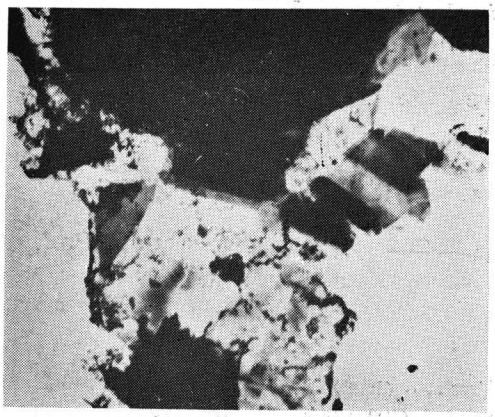


Photo. 5 ×15,000
Kish graphite from blast furnace pig.

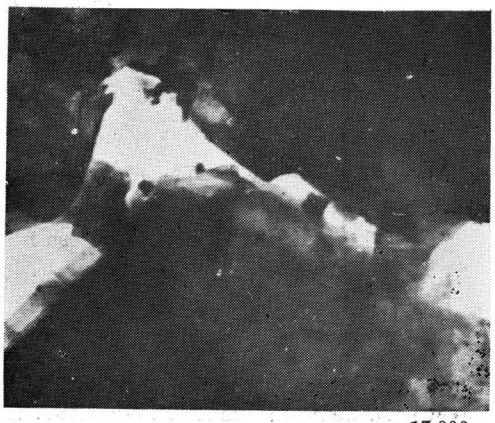


Photo. 6 ×15,000
Kish graphite from electric pig.

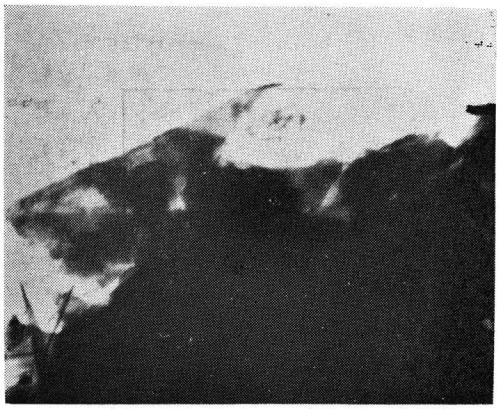


Photo. 7 ×15,000
Graphite from gray cast iron of high purity.

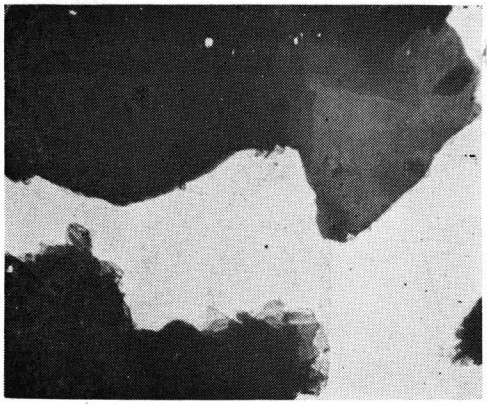


Photo. 8 ×20,000
Graphite from ductile cast iron.

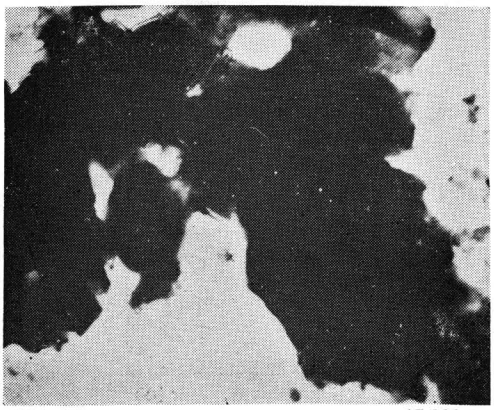


Photo. 9 ×15,000
Temper carbon from black heart malleable cast iron of high purity.

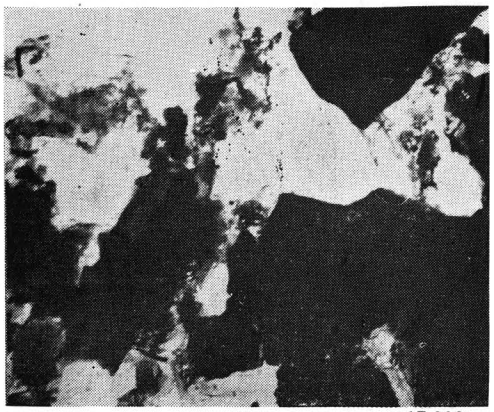


Photo. 10 ×15,000
Temper carbon from black heart malleable cast iron of commercial made.