Distribution of Inorganic Impurities in Graphite Electrodes

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In most domestic graphite electrodes, the ash content is usually less than 0.2%. However, some Acheson 18'' electrodes have been found to contain larger quantities of ash. Moreover, the main component of the ash in the Acheson 18'' electrode was found to be iron. It would be very interesting to know the distribution pattern of inorganic impurities in graphite electrodes. However, the usual method of determining ash content[1] does not serve here.

In the present work, the distribution of inorganic impurities in many graphite electrodes was investigated by means of radiography, ash pattern technique and sulfur print technique.

Experimental and Results

Radiograph. — The arrangement for radiography is illustrated in Fig. 1. Flat specimens

1) JIS (Japan Industrial Standards) R 7202·3·3 (1952).

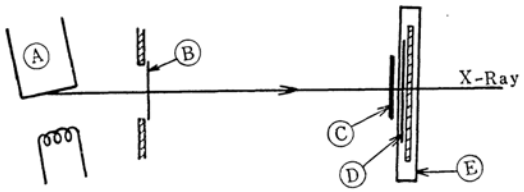


Fig. 1. Arrangement for radiography.
A: Anticathode B: Ni-filter
C: Specimen D: Ni-foil
E: Film cassette

1.0 or 1.5 mm. thick were made from Acheson 14", 18" and 30" graphite electrodes and from six kinds (A—F) of domestic 14" and 18" graphite electrodes. The surface of the specimen was polished with fine sand-paper, although the degree of polishing was found to have no remarkable effect on the radiograph. The distribution of a small amount of iron compound in the graphite product is detectable because the mass absorption coefficient of iron ($\mu/\rho=320$) is far greater than that of carbon ($\mu/\rho=5.50$), while a small amount of sulfur ($\mu/\rho=91.3$) or silicon ($\mu/\rho=60.3$) is very difficult to detect.

The texture of the graphite product, such as the shape and distribution of both grain and pore, can be revealed by a radiograph.

The radiographs of the Acheson electrodes and of some domestic electrodes are represented in Fig. 2a and Fig. 3 respectively. The radiographs for the domestic electrodes were taken from both central and peripheral parts, which are designated as C and P in Fig. 3.

Ash Pattern.—If the specimen was slowly burned out at 750°C on a porcelain plate, an ash pattern consisting of non-volatile impurities was obtained. The ash pattern was very fragile and had to be handled with great caution.

The ash patterns of the Acheson electrodes are shown in Fig. 2b. The ash patterns of these electrodes were found to correspond very closely to the patterns of their radiographs.

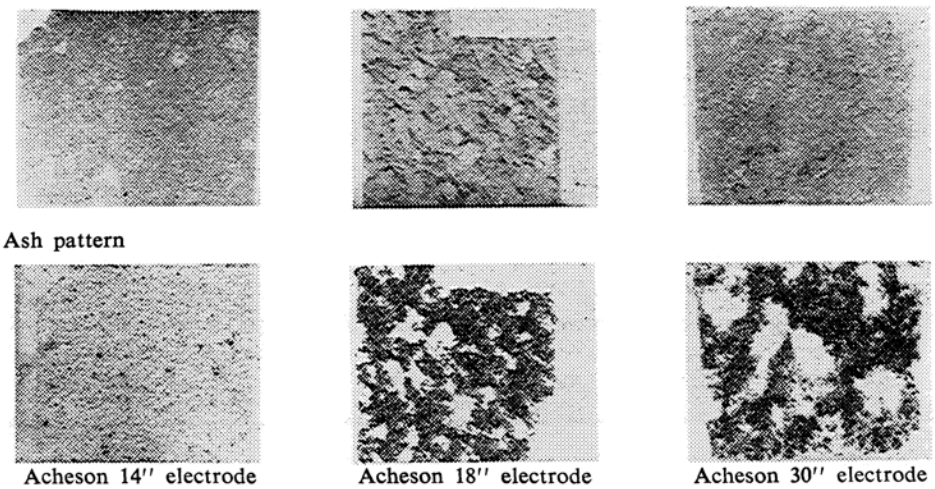
Sulfur Print.—The sulfur print technique, which is often used to detect sulfide in steel, was applied to the graphite electrode. The sulfur print of the Acheson 18" electrode is shown in Fig. 4. The pattern of the sulfur print of the electrode does not necessarily correspond to the pattern of the radiograph or to the ash pattern of the same electrode, because the sulfur print only reveals the sulfide distribution on the surface of the specimen plate. As for the Acheson 14" and the domestic electrodes, no sulfur print was obtained of them.

Discussion

The ash pattern of the Acheson 14" electrode consisted of a small amount of white and light ash which was distributed relatively uniformly. Some of the minute black particles in the ash pattern correspond to those on the radiograph, and these particles seem to consist of iron. An appreciable amount of impurities was found in the Acheson 18" and 30" electrodes. The ash content of the Acheson 18" electrode ranged from 0.2 to 2%, varying from place to place even in a single electrode. The main component of the ash was iron oxide (Fe_2O_3), which was identified by the X-ray diffraction method. From both the radiograph and ash pattern, impurities in the Acheson 18" electrode were found to exist in a fibrous

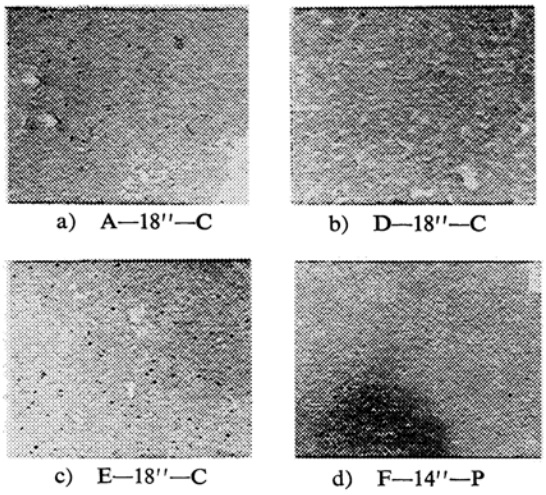
a) Radiograph

b) Ash pattern



Acheson 14" electrode Acheson 18" electrode Acheson 30" electrode

Fig. 2. Radiograph and ash pattern of Acheson electrodes (×1).



a) A—18″—C b) D—18″—C

c) E—18″—C d) F—14″—P

Fig. 3. Radiographs of domestic electrodes (×1).

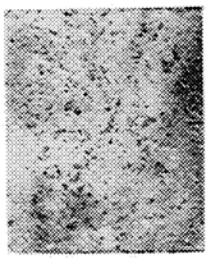


Fig. 4. Sulfur print of Acheson 18″ electrode (×1).

texture intermingled with fine coke powder or with coke derived from binder pitch in the interstices between the coke grains. The fibrous texture of the impurities suggests that they might have condensed from the vapor phase.

The average sulfur content of the Acheson 18″ electrode, which was determined by Eschka's method, was 0.55%, and the average iron content was 1.13%. The impurities in the electrode were gradually dissolved out by dilute sulfuric acid evolving hydrogen sulfide. The mole ratio of sulfur to iron in the electrode, the evolution of hydrogen sulfide, and the development of the sulfur print suggest that the main component of inorganic impurities in the Acheson 18″ electrode is iron sulfide.

In most domestic graphite electrodes, such as E–18″–C and F–14″–P, small black particles of impurities are distributed fairly uniformly all over the electrodes in a way similar to that in the Acheson 14″ electrode. In radiographs of some domestic electrodes such as A–18″–C, however, small clusters of impurities were found to exist in the interstices of the coke grains.

From radiographs of graphite electrodes, one can estimate the shape and the size distribution of coke grains and pores. On the radiographs of A–18″–C and E–18″–C, large coke grains and fairly large pores may be clearly observed. The central part of an eighteen-inch electrode was found to have a less compact texture than the peripheral part of the same electrode. This finding corresponds to the other experimental finding that the bulk density of the peripheral part of graphite electrode is larger than that of its central part[2]. Particularly, the central part of the electrode of D–18″ has an extremely loose texture, as is shown in the radiograph of D–18″–C. Eighteen-inch or larger-sized electrodes contain larger grains and have a less compact texture than 14″ electrodes.

Summary

The distribution of inorganic impurities in graphite electrodes was investigated by means of radiography, ash pattern technique and sulfur print technique. The pattern of the radiograph of an electrode corresponded closely with its ash pattern.

Radiography of graphite electrode was proved to be useful in showing not only the distribution of inorganic impurities in the electrode, but also the texture of the electrode, such as the shape and distribution of both coke grains and pores.

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2) F. E. Faris, L. Green and C. A. Smith, *J. Appl. Phys.*, **23**, 89 (1952).