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Oxidation Behavior of IG-11, IG-110 and IG-430 Graphites in Air Flow

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1. Introduction

In high temperature gas-cooled reactor (HTGR), graphite is used as a moderator and a reflector as well as a major structural component. During operation or in the event of an accident, subsequent graphite oxidation due to the graphite out-gassing or heat exchanger tube leakage results in changes in the physical and mechanical properties of the components [1]. For this reason, a lot of studies on oxidation have long been performed to understand the high temperature oxidation behavior and to find a proper countermeasure over the expected operating range.

In this study, the oxidation rates of IG-11, IG-110 and IG-430 nuclear graphites were determined at high temperature and evaluated in view of the grades and the oxidation mechanisms at different temperature range.

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2. Experimental

The material used in the present study is the Toyo-Tanso manufactured Grade IG-11, IG-110 and IG-430 isotropic graphite. Tests were performed in dry air with a flow rate of 4 L/min. at 600-900°C. The specimen used in this study was a cylindrical shape. The diameter of the specimen was 2.54cm and the height was 2.54cm. Table 1 summarizes the impurity content of the specimen. It is seen that the ash content of the IG-11 is much higher than the other two grades (IG-11: 200ppm, IG-110, 430: 10ppm). Figure 1 shows the test system.

Table 1. Impurity contents of graphites

Grade	Impurities (less than) (mass ppm)					
	B	Co	Cd	Ga	Li	Ash
IG-11	0.1	0.1	0.1	1	1	200
IG-110	0.1	0.001	0.07	0.05	0.01	10
IG-430	0.1	0.001	0.07	0.05	0.01	10

Tabel 2. Oxidation rate of graphite

Temperature	Oxdaition Rate(g/hour·m^2)		
	Graphite Grade		
	IG-11	IG-110	IG-430
600℃	4.10	1.90	1.62
700℃	63.21	53.25	28.43
800℃	218.18	182.56	211.78
900℃	284.44	299.30	265.46

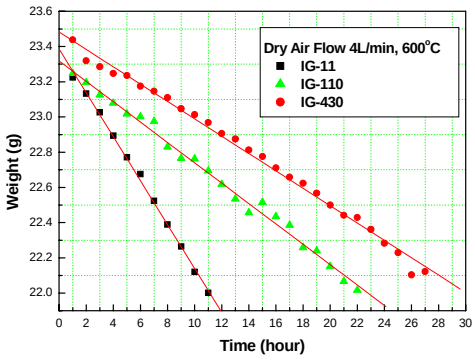
Figure 1. Test System for graphite oxidation

The test system consisted of a vertical tube furnace, balance, gas supplier and a computer for an on-line weight loss monitoring. In this study, the oxidation rates were calculated with a weight loss between 5% and 10%.

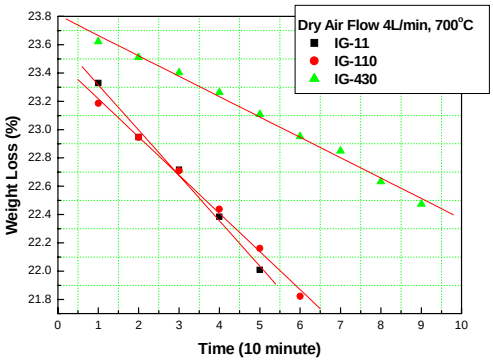
3. Results and Discussion

Table 1 summarizes the oxidation rate determined in the present study. It is seen that the differences between the IG-11 and the other two grades are apparent for 600 ~900 °C, a temperature range of in-pore diffusion oxidation mechanism [2]. The difference may be attributed to the differences in the impurity contents of the grades, Table 1. It is well known that, at low oxidation temperature range, the amount and distribution of catalytic impurities affects the oxidation rate [3]. It is worth to note that the differences in the oxidation rate decreases with the increase in the temperature from 800 °C to 900 °C, Table 2. This decrease in the oxidation rate may be attributed to the change in the dominating oxidation mechanism of the graphite [2].

Figure 2 shows the oxidation rate of each graphites at 600°C, 700 and 900°C. A sharp increase in the oxidation rate is seen from 700°C.



(a)



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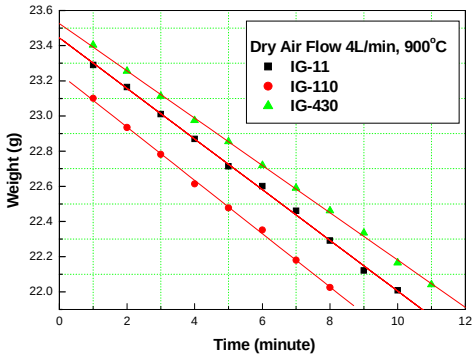

(c)

Figure 2. Oxidation rate at 600, 700 and 900°C, (a) 600°C, (b) 700°C (c) 900°C

Optical microscopy of IG-110 and IG-430 nuclear graphites has shown that the size and total area of the pores in IG-430 appeared somewhat smaller than those of IG-110 [4]. The oxidation rate difference between IG-430 and IG-110 at low temperature (in pore diffusion regime) was due to the pore contents of each graphites.

From the SEM observation of the oxidized surfaces, coke particles were exposed. The surface of the specimen after the test was shown in figure 3. There were rougher surfaces found in the high temperature tested specimens.

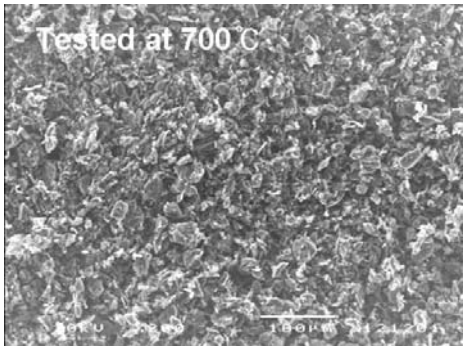

Figure 3. SEM image of the IG-430 surface after tested at 700°C

4. Conclusion

The oxidation rates of IG grade graphites were tested in dry air flow environment. The oxidation rates differences decreased with increasing temperature. This decrease in the oxidation rate may be attributed to the change in the dominating oxidation mechanism of the graphite. At low temperature (in-pore diffusion controlled regime), the IG-430 has the lower oxidation rate than IG-110.The coke particles were exposed at high temperature oxidation.

REFERENCES

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