A study on the oxidation characteristics of nuclear graphite

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1. Introduction

Graphite has been used widely in nuclear reactors especially in high temperature, since it shows a chemical stability, high thermal conductivity, corrosion resistance, good machinability, and has good mechanical properties at high temperatures. Also, graphites, has ideal properties for nuclear reactor.is an excellent solid moderating material with irradiation performance.

However, grapite is easily oxidized under air at above 450°C, result in degradation of the mechanical and thermal properties of graphite. Such as air and water ingress cause the graphtie to be oxidized

Therefore, the oxidation graphite is a one of the important analysing factor for nuclear reactor's safety and lifetime

The graphite oxidation behavior is controlled by three different regimes. They are the chemical regime, the the in-pore diffusion controlled regime and the boundary layer controlled regime (Luo Xiaowei, 2004; O'Brien et al,. 1988)

At low temperature, oxidising gas and graphite react very slowly. The oxidized depth of grapite is very large. Oxidation mechanism is mainly chemical reaction mainly at low temperatures. In contrast, at high temperature, oxidising mechanism is boundary layer reaction. The surface of graphite is severely attacked with oxygen. But it does not attack interior graphite body.

In this paper, oxidation of nuclear graphite(IG-110) was undergone by heating temperatures, airflow rate. And CO_2 concentration was observed by oxidation temperature

2. Experimental

The nuclear graphite was IG-110 produced by TOYO Tanso Co. Ltd., Japan. IG-110 was an isotropic, fine-grained nuclear graphite. The dimension of specimen was 6mm*6mm*6mm.

The apparatus used for thermogravimetric analysis was TG-SDTA 851e model (Mettler Toledo Company). That is working from ambient to 1600°C

The appartus for detecting CO_2 concentration was STA-MS-Skimmr model (NETZSCH).

The oxidation experimet was performed at 600, 700, 800, 900, 1000, 1100, 1200, and 1300°C. The oxidant was dry air (water content <2ppm). The atmosphere was kept with N2 until the target oxidation temperature. The first oxidation test was performed to 1200°C for detecting CO_2 concentration. The second oxidation test was performed at 10ml/min and kept for 12hrs at each temperature. The third oxidation test was performed in a varius air flow rate (10, 60, 200ml/min) at 600, 800, 1000°C.

3. Results and discussion

Fig. 1 shows the CO_2 concentration of nuclear graphite (IG-110) up to 1200°C. and oxidation weight nomalized by comparison with the starting specimen weight. It was found that oxidation amount and CO_2 concentration increase with temperatures. The oxidation started from approximately 450°C. And the oxidation amount increase rapidly with temperature increase. But CO_2 concentration increased from above 450°C to apporoximately 950°C severely. Above 950°C, the CO_2 concentration was increased slightly.

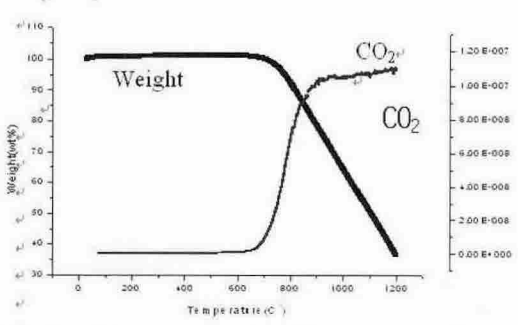

Fig. 1 TG curves and CO_2 concentration of nuclear graphite specimen as a function of temperature.

Fig. 2 shows the graphite oxidation rate at each temperatures. The oxdiation rate was increased exponentially from 600°C to 1000°C. Above 1000°C, the oxidation rate shows only a little difference. This different oxidation rate was due to three-oxidation regime.

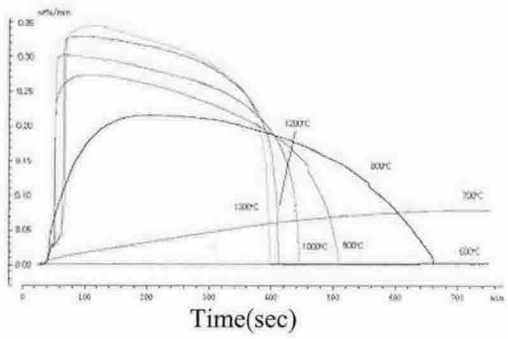

Fig. 2 Oxidation rate of nuclear graphite specimen as a function of times(sec)

Fig. 3 shows change of the weight loss amount. When the airflow rate is changed. The oxidation amount was affected with airflow rate at higher temperatures more than at lower temperatures. Because oxidation was occurred on graphite surface mainly at high temperature, which was boundary layer reaction.

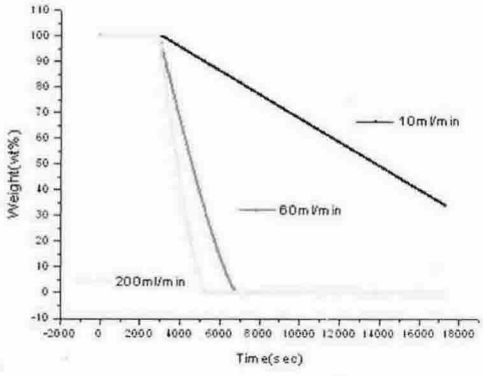

Fig. 3 TG Curves of nuclear graphite specimen as a function of airflow rate(at 1000°C)

4. Conclusion

Oxidation amount and CO_2 concentration increase with temperatures. CO_2 concentration was increased from above 450°C to apporoximately 950°C exponentially. Above 950°C, the CO_2 concentration was increased very small. The oxidation rate was increased with different pattern due to three-oxidation regime at each temperature. The oxidation amount was affected with airflow rate at higher temperatures than lower.

References

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