Fracture Characteristics of Nuclear Graphite IG-11

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1. Introduction

Nuclear graphite has a good thermal conductivity, high melting point, high chemical stability, and with excellent resisting on both irradiation and corrosion. Nuclear graphite also has a superior ability to withstand neutron investigation than any other metal or ceramic materials. Han[1] studied the fracture characteristics of nuclear graphite IG-110. In this study, fracture characteristics of isotropic graphite IG-11 were studied using compressive test and four point bending test.

2. Tests and Methods

2.1 Properties of graphite IG-11

In this study, the isotropic graphite IG-11 of Japan ToyoTanso was investigated. The material properties of isotropic graphite were shown in Table I. IG-11 get the density of 1.77 g/cm^3, Young's modulus of 9.8 GPa, bending strength of 39 MPa, and compressive strength of 78 MPa.[2]

Table I: Properties of Isotropic Graphite[2]

Material	Density (g/cm^3)	Hardness (HSD)	Bending strength (MPa)	Compressive strength (MPa)	Tensile strength (MPa)	Young's modulus (GPa)
IG-11	1.77	51	39	78	25	9.8
IG-12	1.78	55	39	88	28	10.8
IG-15	1.90	60	54	103	29	11.8
IG-19	1.75	60	38	88	25	9.5
IG-43	1.82	55	54	90	37	10.8
IG-45	1.88	55	60	110	40	12.0
IG-56	1.77	57	43	88	27	10.3
IG-70	1.83	58	47	103	31	11.8

2.2 Compressive test

In order to measure the compressive strength of graphite IG-11, the cylindrical specimens along ASTM C695-21[3] standard with 19 mm diameter and 38 mm length were prepared. The equation (1) was used to calculate the compressive strength.

$$C = \frac{W}{A}$$
$$C : CompressiveStrength\,(Pa)$$
$$W : FractureLoad(N)$$
$$A : Square(m^2) \qquad \text{.....(1)}$$

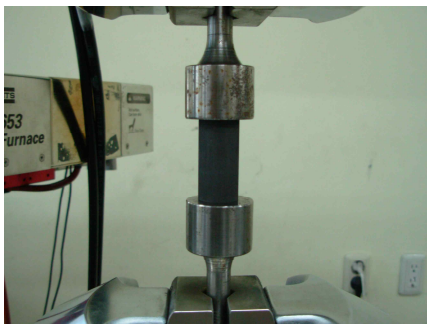

Fig. 1. The specimens of isotropic graphite IG-11 compressive test by MTS-810.


Fig. 2. Fracture shape of IG-11 graphite.

Fig. 1 shows the isotropic graphite mounted in the load frame for testing using the MTS-810. The tests spent 10 minutes and in order to prevent the specimen to spring out using the thick paper wrap the specimen. Fig. 2 shows the fracture form of the specimen. The test were done with 10 specimens.

2.3 Bending test

In order to measure the bending strength of graphite IG-11 four point bending test was done. According to ASTM C651-91[4] standard, the beam specimens with 90 mm length, 20 mm width and 10 mm thickness were prepared. Span gap was 40 mm and equation (2) was used to calculate the bending strength.

$$S = \frac{P \times L}{W \times D^2}$$
$$S : BendingStregnth(Pa)$$
$$P : FractureLoad(N)$$
$$L : SpanLength(m)$$
$$W : Width(m)$$
$$D : Thickness(m) \qquad \text{.....(2)}$$

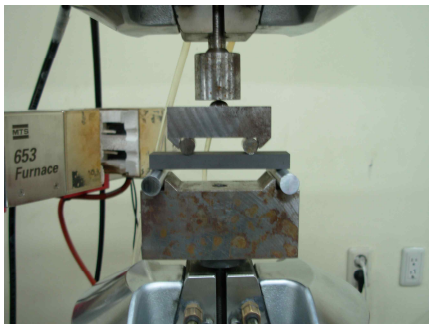

Fig. 3. Four point bending test of IG-11 graphite by MTS-810.

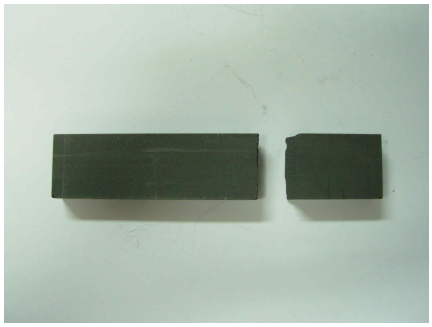

Fig. 4. Fractured shape of IG-11 graphite under four point bending.

Fig. 3 shows the mounted IG-11 specimen in the load frame under four point bending test. Test velocity was 0.1 mm/min and after 7 minutes the specimen was fractured. Fig. 4 shows the fractured form of the specimen.

3. Results

In Han[1] study of graphite IG-110, the compressive strength was about 76 MPa and the bending strength was about 37 MPa. Fig. 5 shows the for 10 specimens compressive test result.

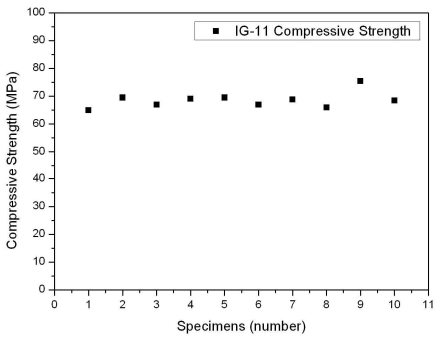

Fig. 5. Compressive strength of IG-11 graphite.

The maximum compressive strength was 75.4 MPa and minimum value was 64.9 MPa and the mean value was 68.3 MPa.

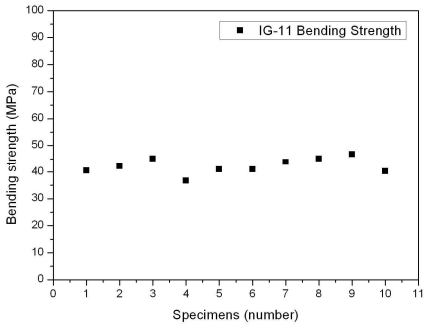

Fig. 6. Bending strength of IG-11 graphite.

Fig. 6 shows the four point bending strength. The maximum bending strength was 46.7 MPa and minimum value was 36.7 MPa and the mean value was 42.2 MPa.

4. Conclusions

In this study, compressive test and bending test of nuclear graphite IG-11 were conducted. In compressive test, the mean value of compressive strength was 64.9 MPa and it smaller than the value 78 MPa which provided by Japan ToyoTanso. On the contrary in bending test, the mean value of bending strength was 42.2 MPa and it larger than the value 39 MPa which also provided by Japan ToyoTanso. The reason for these results were machining status and test method.

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