Heat Load Test for Graphite Filters by Electoron Beam Irradiation on the SPring-8 Front End

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1. Intoroduction

The Graphite Filters are used to cut the low energy part of the Synchrotron Radiation (SR) so that heat loads on Be windows and optics are redused.

In the SPring-8 Project Team, Heat Load Test for Graphite Filters were made with electoron beam irradiation facility.

And the Heat Transfer of Graphite Filters was simulated by Finite Element Analysis (ANSYS).

2. Experimental

2-1. sample

The sample of graphite filters was high oriented graphite foil with good thermal conductivity in the a-b plane (Table 1 [1]) .

Table 1

thickness [mm]	0.1	
thermal conductivity [W / m • ℃]	a-b plane c plane	600~1000 5
thermal expansion coefficient [10^{-6} / ℃]	a-b plane	0.96

2-2. Heat Load Test by electron beam irradiation

In the Heat Load Test , the graphite filter was held by a Cu holder with Au foil (Fig.1) , because the use of Au foil was good thermal conductivity from the graphite filter to Cu holder.

The graphite filters temperature was measured by a radiation thermometer (AVIO) and thermocouples (T/C) .

This heat load test were made with the Electoron Beam Irradiation Facility that reported by H.AMAMOTO et al [2].

The experimental condition is shown in Table 2

Table 2

degree of vacuum	1×10^{-4}~1×10^{-5} torr
cooling water temperature	23℃
cooling water flow	6 liter/min

2-2. Simulation of Heat Transfer on the Graphite Filters by ANSYS

We calculated the graphite filter's temperature dependence of heat power by ANSYS.

The analysis condition of ANSYS is shown in table 3 .

Figure .2 shows analysis model of ANSYS.

This analysis used SURF22(Surface Effect Elem ent) , because we considered the thermal radiation of graphite filters [3] .

Table 3

model	5X0.1X25 mm
element type	SOLID 70 (3-D Thermal Solid)
boundary condition	cooling temperature 27℃ atmosphere 27℃ electoron beam diameter ϕ 8
thermal radiation element type emissivity Stefan-Boltzman's constant geometrical factor	 SURF22(3-D Surface Effect Element) 0.52 5.67×10^{-8} (W / m^2 • K^4) 1.0

3. Result and discussion

The temperature of graphite filters as a function of heat power is shown Fig.3 .

The temperature in Fig.3 is measured by AVIO and T/C, and is calculated by ANSYS.

The relationship of those temperature to heat power are linear, but each temperature is different.

The temperature calculated by ANSYS is higher than the temperature measured by AVIO. This is cause of fewer node number (this node number is 4242.). Because when we tried to analysis with node number 25602, graphite filter's temperature was 1336℃,but when node number 4242 , graphite filter's temperature was 1384℃.

And the temperature measured by T/C is lower than the temperature measured by AVIO. This is cause of measuring point of T/C that was back side of graphite filters. As c plane thermal conductivity of graphite filters is more lower than a-b plane, the temperature measured by T/C was lower.

In electoron beam irradiation experiment, the graphite filters sublimated at about 2300℃ and about 2800℃. This is proved by vapor pressure curve of graphite [1]. According to the curve, when the degree of vacuum is 1×10^{-4} ~ 1×10^{-5} torr, graphite sublimate at about 2000℃.

Therefore, we consider that when heat power was over 285 W, the graphite filters became over 2000 ℃, and the graphite filters sublimated.

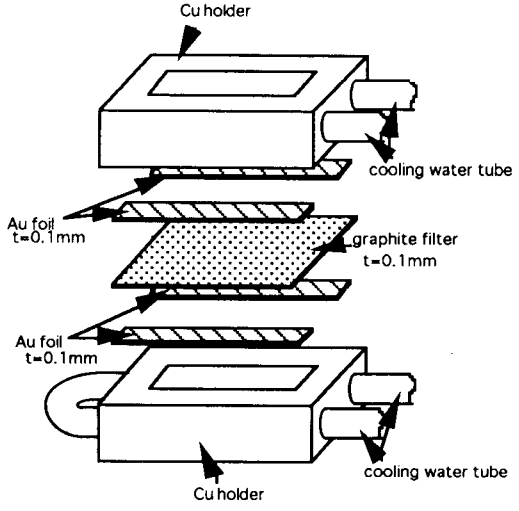

Fig .1 graphite filter with Cu holder

4. Conclusion

We obtained the following results by heat load test of graphite filters.

The graphite filters used in this experiment was sublimated over 2000℃.

And we think that the graphite filters became 2000℃, when heat power was 285W.

references

[1] H.Aoyagi, H.Sakae, Y.Sakurai,RIKEN SR Engineering Note,No.FE-004-95.

[2] Hidetoshi.AMAMOTO, Ario.NAKAMURA, Yoshiharu.SAKURAI and Hideo.KITAMURA, in this report.

[3] H.Sakae, Y.Sakurai,RIKEN SR Engineering Note,No.FE-008-93.

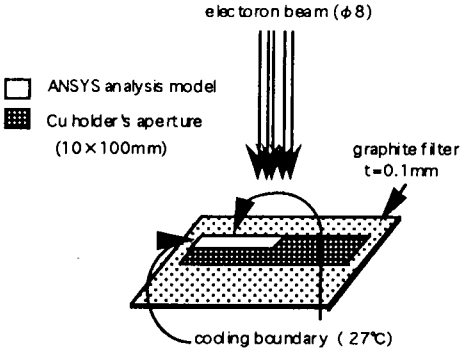

Fig .2 ANSYS analysis model

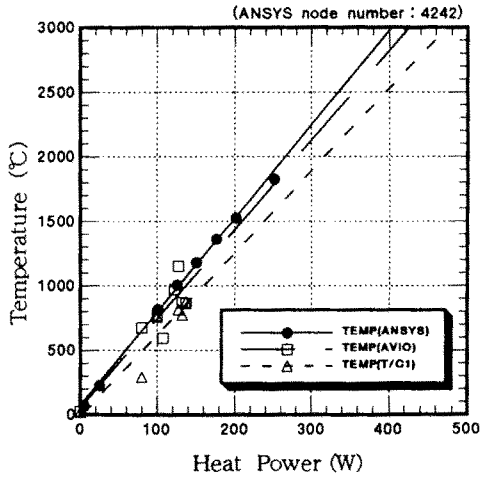

Fig .3 the temperature of graphite filters as function of heat power