SPring-8 Front End Experimental Report for Heat Transfer of Water-Cooled Channel

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1. Introduction

Insertion devices of SPring-8 generate photon beamwith very intense heat flux levels. There is the serious heat problem in the SPring-8 front end.

In the SPring-8 Project Team, the expriments of water-cooled channel for Slit, Mask, Absorber were carried out ,as one of Front End R&D.

Therefore, the cooling channel achieving heat removal enhancement are constantly investigated. In APS Front End, the use of conductive copper wool filled the tubes where the filler is brazed to the tube walls.

We checked on the cooling effects of the relation with sorts of copper wire mesh, porosity, and coolant rate. It is also important to have lower pressure loss in the cooling channel. We checked the pressure loss.

Cooling experiments were made on three models of copper wire mesh with the Electron Beam Irradiation Facility at RIKEN.

We chose the three kinds of copper wire mesh that are commercially available. We prepared copper test pieces where filled copper wire mesh in the cooling channel. We applied electron beam to the test pieces in the electron beam irradiation facility. We got the data of temperatures-rises on the test pieces. And we analysed the transfer coefficients between the coolant and cooling channel walls.

With this analysis, it is shown that the use of the copper wire mesh can yield 2-fold increases over plain tubes.

2. Models for experiments

Particular data regarding all test pieces tested in the experiment are shown in Table 1. All test pieces have 150mm length coolant channel with 8mm ϕ ,or 10mm ϕ dia. They are made of copper. We prepared the electron beam mask of 6mm ϕ dia.

As the experiment parameter, we changed kinds of mesh, weight of filling and coolant rate.

We obtained the data of surface temperature, coolant pressure, and total heat power.

The heat transfer coefficients were calculated, using the ANSYS program for the finite element analysis with surface temperature data.

Table 1

symbols	kinds of mesh	weight of filling	remarks
S3.9	Shield tape	3.9 gram	ϕ 8 test piece
G3.9	Wire demister	3.9 gram	
D2.9	Wire gauge	2.9 gram	
G7.3	Wire demister	7.3 gram	ϕ 10test piece
G14.6	Wire demister	14.6 gram	brazing to the
D4.4	Wire gauge	4.4 gram	tube walls
D8.8	Wire gauge	8.8 gram	

The copper test pieces filled into the copper wire mesh have itself around the rod(1mm ϕ copper wire) . The rod fixed on the end of the copper wire mesh by brazing.

3. Results

The use of the copper wire mesh, which is not brazed to the tube walls, yields 1.5~3.0 fold increases over plain tubes. And pressure loss increases just 0.1~0.5 kg/cm^2 (1.2 m/s, 150 mm).

On the other hand, the use of the copper wire mesh, which is brazed to the tube walls, yields 1~3.0 fold increases. There is no effect of brazing on heat removeal enchancement. But pressure loss increases a lot. It was 0.3~1.6 kg/cm^2 (1.2m/s,150mm).

Brazing to the tube walls has not advantage of just filling in. A brazing is accompanied by high pressure drops. It is very diffcult to use a brazing with high pressure drops .

4. Conclusion

The results were used to estimate the heat transfer coefficients in the models. The use of the copper wire mesh can yield 2-fold increases the heat transfer coefficient over plain tubes. The use of the copper wire mesh can increase the heat transfer coefficent in the cooling wall. Especially, wire guage(D) is preferable. Besides, pressure loss is under 1.0 kg/cm^2.

This result apply to Front End element design at SPring-8. We expect the use of the copper wire mesh to succeed the increase in the heat transfer coefficient.

In the case of cooling tube where filled in the copper wire mesh,

1) Heat transfer coefficient 1.5～3.0 fold increases over plain tubes.
2) In proportion as the heat transfer coefficient increases, the pressure losses will be rise.
3) There is not the advantage of brazing on the tube walls.

Therefore, kinds of the copper wire mesh and filling quantity are designed under the balance of the heat transfer coefficient and the pressure losses. However, there is a limite for filling quantity against the pressure losses.

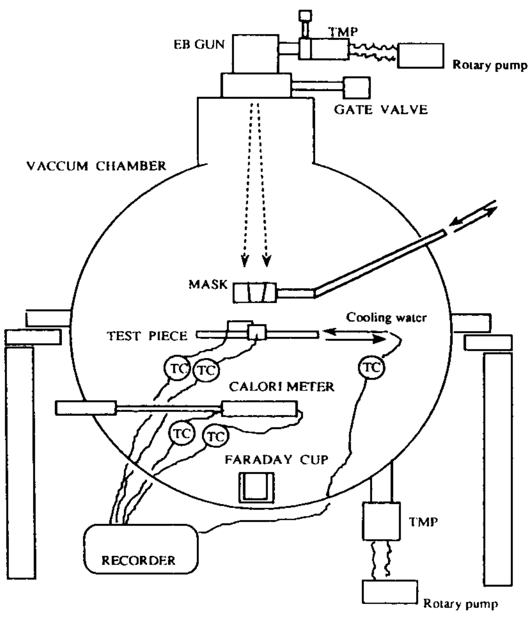

Fig.1 Electric beam irradiation facility

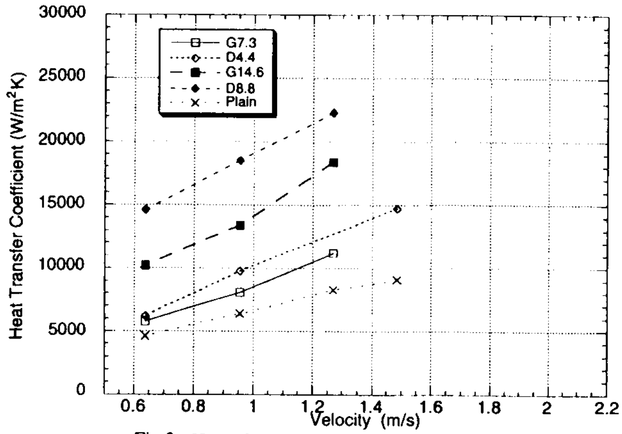

Fig.2 Heat Transfer Coefficient vs. Velocity
(ϕ 10 test piece with brazing)

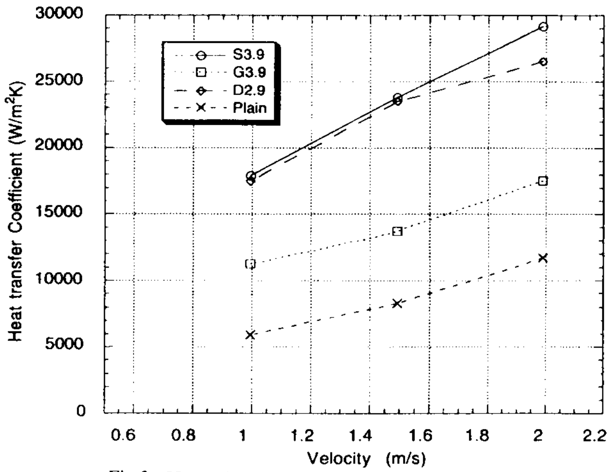

Fig.3 Heat Transfer Coefficient vs. Velocity
(ϕ 8 test piece)