§50. Recycling Control for LHD by Using Carbon Sheet Pump

Suzuki, H., Sagara, A., Ohyabu, N.

Carbon Sheet Pump(CSP) has been proposed to be installed on the vacuum vessel wall of the Large Helical Device(LHD) in order to reduce the hydrogen recycling and thereby improve the energy confinement[1]. The CSP of C/C composite with temperature below 200C° can absorb high energy hydrogen particles such as charge exchange fast neutrals. The saturated hydrogen particles can be removed simply by heating the carbon sheet above 800C°. One of the requirement on the CSP design for LHD is that the temperature of the vacuum vessel must be maintained to be below 70C° to avoid excessive heat flux to the LHD superconducting magnet system.

The first design of CSP for LHD is presented, and a successful demonstration of heating the CSP was carried out . In the proposed design for LHD, the CSP panels are installed on the vacuum vessel wall near the divertor plates at the small major radius side of the torus, where the flux of charge exchange fast neutrals is expected to be high. A total area of the CSP is as large as 60m^2 with a total pumping capacity of 10^{23}H-atoms. The incident flux is estimated to be $\sim 10^{15}/cm^2s$. Therefore the CSP can pump hydrogen particles for ~100 seconds.

During the plasma discharge, the carbon sheets are heated up by the radiative heat flux from the plasma which is expected to be below 0.1MW/m^2. In the case of the carbon sheet with 1.5mm thickness, its temperature can reach up to 200C°, a critical temperature for effective pumping Therefore, although only a very thin surface region is needed for trapping the hydrogen particles, more than 1.5mm thickness is required. In terms of heating the carbon sheets, thinner sheets are favorable. Thus the thickness of the carbon sheet determined to be about 2mm. In this case, the carbon sheet can be heated up to 800C° with electric power density of 8W/cm^2.

The temperature of the vacuum vessel must be maintained to be less than 70C° to avoid excessive heat flux to the superconducting magnet system. Thus, the CSP is designed as shown in Fig.1. The backing plates of stainless steel minimize the heat flux to the vessel wall and also serve the paths of the return current for the Joule heating.

In order to demonstrate and confirm the design properties of the CSP for the LHD, a small sample of the CSP are tested. The test sample consists of a carbon sheet of 1.5 mm thickness, backing plate of 1mm thickness, a water cooling system and a stainless steel plate with 15mm thickness which simulates the vacuum vessel wall. The carbon sheet of the test sample was heated up to higher than 800C° for about 100 seconds by the direct Joule heating of 30A electric current. Fig.2 shows the time evolutions of the temperatures of the carbon sheet and the 15mm stainless steel plate of the test sample along with the predicted evolutions. It is confirmed that the temperature of the 15mm stainless steel does not exceed 70C°, agreeing with the design prediction.

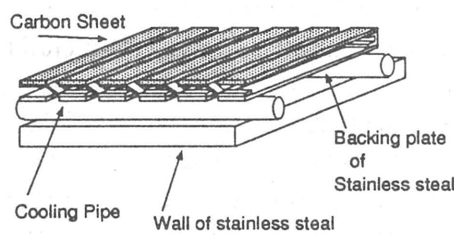

Fig.1. Design of the CSP

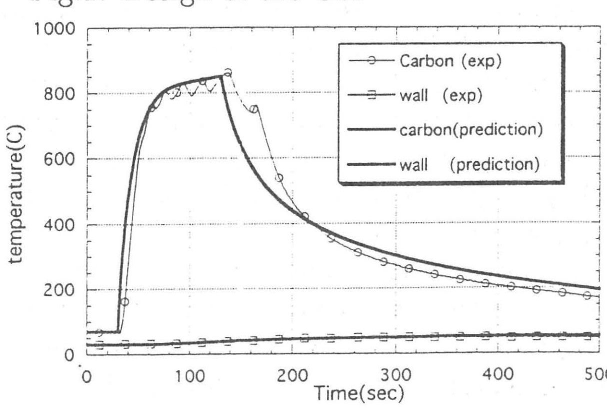

Fig. 2. Time evolutions of the temperatures at Carbon sheet and the wall

Reference

[1]A.Sagara et al. J. Nucl. Mater. 220/222 ('95) 627