§13. Development of Calorie Meter Chip for Neutral-Beam Shine-Through Measurement on LHD

Osakabe,M., Takeiri,Y., Tsumori,K., Takanashi,T., Oka,Y., Kaneko,O., Asano,E., Kawamoto,T., Akiyama,R., Kuroda,T.

The estimation of the beam deposition is essential in determining a confinement of plasma, not only because the beam input power is necessary but also because the impact of beam fueling profile on the confinement scaling was recently reported[1]. For high energy neutral beam, the experimental estimation of beam deposition is necessary since the ambiguity in the cross section of the ionization due to the multi step ionization process arises[2].

On LHD, calorimeter arrays consist of 30 tips are going to be installed on the NB armor. The 25 of tips (type-A in Fig.1) are ordinal ones, which could only measure the time-integrated input power. The rest 5 tips (type-B in Fig.1) are specially designed one which can evaluate the time dependent input power onto the tip. Figure 2 shows the concept to obtain the time dependent input power using a type-B tip. The input power (q_{in}) is evaluated from the temperature at point-A(T_a) and -B(T_b);

$$q_{in} \cong q_{out} + C_p\rho\left(\frac{x_a + x_b}{2}\right)\frac{\partial T_a}{\partial t} \quad , \quad ---(1)$$

$$\text{where } q_{out} \cong -\kappa\frac{T_b - T_a}{x_b - x_a} \quad . \quad ---(2)$$

These equations are based on one dimensional thermal conductivity equations;

$$q = -\kappa\frac{\partial T}{\partial x} \text{ and } \frac{\partial q}{\partial x} = -C_p\rho\frac{\partial T}{\partial t} \quad ,$$

where q is heat flux, T is temperature, κ is thermal conductivity, ρ is density, and C_p is specific heat at constant pressure.

The verification of this method was done by calculation. Figure 3 shows the result of the calculation. The result indicates that this method can estimate the input power with the ambiguity of less than 15%, if the temperature at each point can be measured correctly. Experimental evaluation of this method is necessary and is planned using the H^--beam at the NBI test stand.

References
1) H.K.Park, Nucl. Fusion **34** (1994) 1271
2) R.J.Janev, Nucl. Fusion **29** (1989) 2125

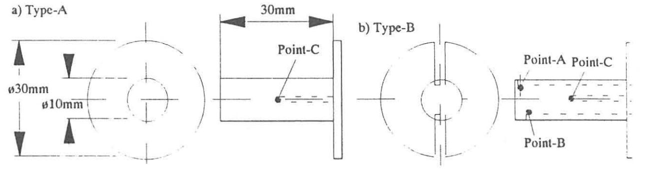

Fig.1 Schematic drawing of molybdenum calorie meter tip for LHD beam shine-through measurement. (a)Type-A and (b) Type-B.

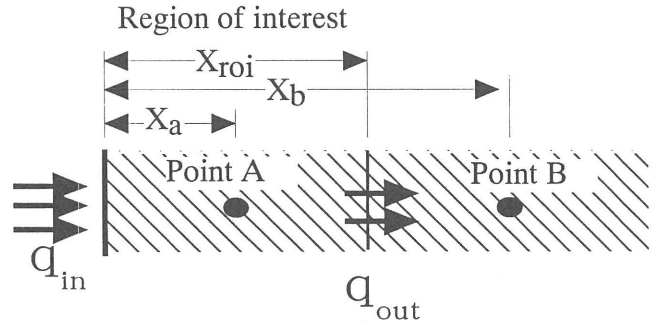

Fig. 2 Schematic drawing of the principle of the time dependent input power measurement

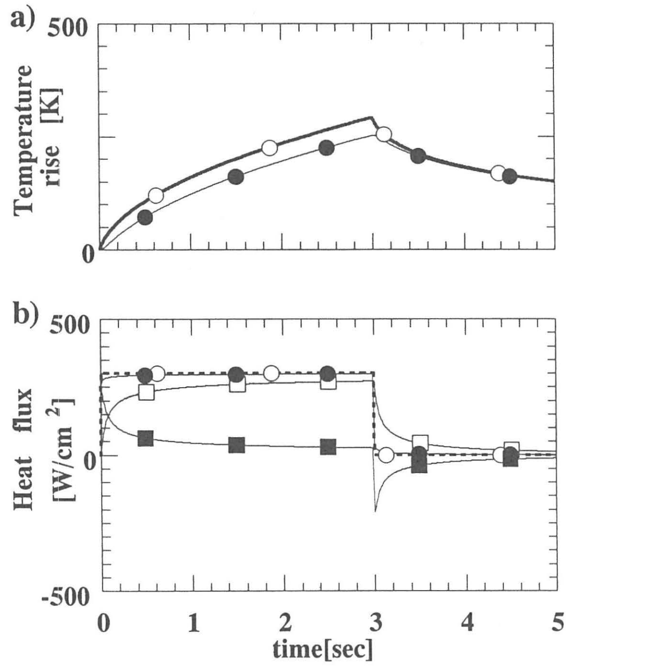

Fig.3 a) Calculated temperature rise at point -A (line with open circles) and -B (line with closed circles), as indicated in Fig.2. b)The dashed line with open circles shows the input power assumed in the calculation (300W/cm²). The line with closed circles shows the input power estimated from the temperature at Point -A and -B. The line with open squares shows the stored heat (per unit area) in the region of interest, while the line with closed squares does the outgoing heat flux from the region.