§14. Development of a Millimeter Wave Transmission Mirror for Axi-Symmetric Heating over a Wide Cross Section

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A role of electron cyclotron resonance heating (ECRH) in the GAMMA 10 tandem mirror is creating the plasma confining potential. Present important issues are high potential creation with high power microwave injection and controlling the radial potential profile. Axi-symmetrization of the heating radiation profile led to good plasma confinement [1]. To achieve the above issues, it is necessary to radiate microwave power to the resonance surface with a controlled beam profile. Since the present beam cross section is too narrow to cover the whole plasma region, the improvement of confinement due to potential creation is achieved only in the region with a small radius. Thus, the present objective is axi-symmetrization and extension of the heating profile on the resonance surface.

To achieve the objective, a new mirror placed on the mid-way of the microwave propagation was designed. The microwave beam obliquely injects onto the mirror with a large angle. We had used the mirror-designing method developed in NIFS, however, there is a limit for it to be applied to a mirror design with a large injection angle. Thus, we extended the method and built up an algorithm of designing mirrors to control radiation profiles of millimeter waves and to apply to wide area radiations with large injection angles.

We further developed a computational code to calculate the electromagnetic field radiated from a surface where a source field was given. It calculates Huygens-Kirchhoff integral and includes the diffraction effect. The field profile of microwave reflected by the mirror is also calculated with the induced current method. With this algorithm, we have designed a mirror which achieved a wide and axi-symmetric heating profile on the GAMMA 10 plug-ECRH resonance surface.

In March, 2004, a new gyrotron with 28GHz frequency and 500 kW output power will be equipped. The microwave beam radiated with a Gaussian beam from the gyrotron couples to a corrugated waveguide with HE_{11} mode and is delivered into the GAMMA 10 vacuum vessel. Since the generation and propagation modes are different from the present ones, a new antenna system should be designed. We gave the electromagnetic field on the open end of the antenna waveguide for HE_{11} mode and calculated radiation beam. To obtain an almost Gaussian beam on the resonance surface, a mirror was determined with the code in the condition that e-folding radius of the power density is 7 cm. Figure 1 shows the shape of a designed mirror. Figure 2 shows the calculated radiation distribution on the resonance surface. It is almost axi-symmetric and the e-folding radius is about 7 cm, which satisfied our design goal.

Low power test of the designed antenna system was carried out in atmosphere. The profile of temperature increment of an absorber due to the radiated power was measured with an IR camera. It agreed well with the result of the calculation.

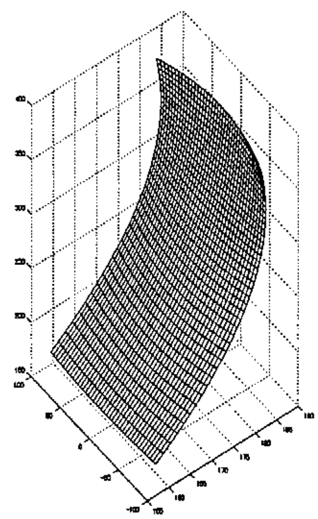

Fig. 1. Shape of the designed mirror

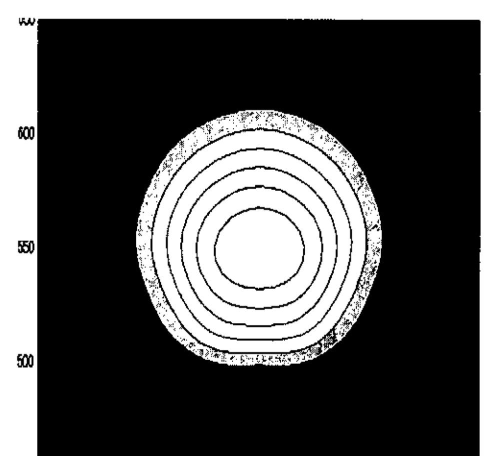

Fig. 2. Microwave power density distribution on the resonance surface obtained with the designed mirror

Reference
1) Yatsu, K. et al., J. Plasma Fusion Res. **74** (1998) 844.