§13. Folded Waveguide Test Antenna

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A folded waveguide(FWG) antenna can launch RF power in ion cyclotron range of frequencies (ICRF) in an accessible size of fusion experimental devices. The FWG antenna fabricated by Oak Ridge National Laboratory has a polarizing plate to launch fast wave in a small poloidal wave number spectrum[1). The electromagnetic RF field is parallel to its vanes. Then the antenna should be set with its vanes parallel to the magnetic field lines. The electromagnetic field pattern was measured analogous to that of a loop antenna. We propose a different approach where the polarizing plate is removed from the fast wave FWG antenna. The newly proposed FWG antenna should have a sharply defined wave number spectrum in the direction across the vanes. When the antenna is set with its vanes perpendicular to the magnetic field lines, the RF field pattern is suitable to excite a slow wave such as an ion Bernstein wave(IBW).

A test FWG antenna has been fabricated to acquire its basic characteristics. The dimensions are 40cm in width(w), 20cm in height(h) and 400cm in length. It has 6 folds with five vanes. It is made by thin copper plate. The movable back plate is equipped to provide cavity resonance in wide range of frequencies. The RF power from oscillator is supplied to the central vane through a hole of its side wall. The inner coaxial line attaches to the central vane with a sliding contact finger. Impedance matching is obtained by adjusting both positions of the movable back plate and the sliding contact finger.

Impedance matching conditions were examine for applied frequency, f and the test FWG antenna length, L. Figure 1 shows a relation between f and L in both cases with(open circles) and without (solid circles) polarizing plate. It is very reasonable that the higher frequency requires the shorter FWG antenna length. These experimental results are compared with calculated values. The FGW length to obtain resonant conditions is calculated for both cases as follow;

with polarization plate;

$$L = ((\frac{2f}{c})^2 - (\frac{1}{\alpha a})^2)^{-1/2} \quad (1)$$

without polarizing plate;

$$L = ((\frac{4f}{c})^2 - (\frac{2}{\alpha a})^2)^{-1/2} \quad (2)$$

Here c is a light velocity, a is a virtual length of unfolded waveguide, a=6h and α is a numerical factor, slightly smaller than 1.0, which compensates a, because of winding channel of FWG antenna. Experimental results agree with calculated values as shown in Fig.1.

We also measure Q value of test FWG antenna. The Q value is experimentally obtained from reflected power fraction with modulating frequency. In each impedance matching condition, Q value is measured as shown in Fig.2(by open circles). Q value tends to increase with applied frequency. Theoretical Q value is calculated with RF dissipated power by ohmic loss as follows:

$$Q\frac{\delta}{\lambda} = \frac{2}{\lambda^3\left(\frac{1}{a^3} + \frac{1}{Z^3} + \frac{2}{b\lambda^2}\right)} \quad (3)$$

Here δ, λ and b are a skin depth, RF wave length and b=w/6, respectively. The experimental Q values agree with calculated values as shown in Fig.2. Here a distance between RF feeding point and the movable back plate, L_{fb} is also plotted. L_{fb} becomes longer in low Q resonance condition.

Reference
1)Kumazawa, R., et al., Annual Report 1992-1993, 55.

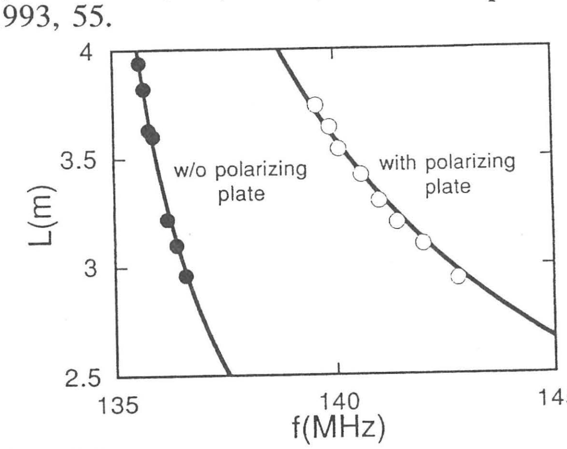

Fig.1 FWG Test antenna resonant conditions with and without polarizing plate.

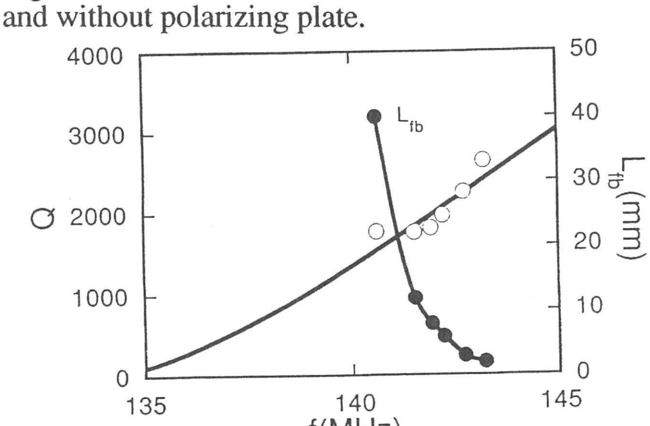

Fig.2 Q values and distance between the back plate and RF feeding point vs. applied frequency.