HIGHER ORDER MODE COUPLER FOR TRISTAN ACCELERATING CAVITY

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ABSTRACT

A higher order mode coupler has been developed and installed in the TRISTAN accelerating cavity in order to reduce the coupling impedance of higher order modes like TM_{011}, TM_{021} and TM_{111} which are responsible for beam instabilities.

As designed the coupler lowers the Q value for TM_{111} to less than a third of the intrinsic value and also for other modes the Q values were estimated to drop by a factor of 1/2. The heat pipe built in suppresses the temperature rise due to induction heating at the antenna head.

Introduction

In the accumulator and the collider of the TRISTAN accelerator the beam acceleration is performed by 508 MHz RF cavities of an alternating periodic structure (APS)[1]. It is proved that the higher order modes such as TM_{011}, TM_{110}, TM_{021} and TM_{111} have significant coupling impedances and, therefore, large interactions with beam. It improves the stability and the intensity of beam to eliminate these interactions. For this purpose higher order mode dampers have been developed to employ for the reduction in Q values of higher order modes in the cavity. The damper consists of a higher order mode coupler installed in the cavity, an external load resistor and a transmission line between them. Higher order mode power picked up by the coupler is transported through the transmission line and absorbed by the load resister.

Structure

The coupler was designed to couple electrically to TM_{011}, TM_{021} and TM_{111} modes with a rod antenna inserted in the cavity from its side opening port (Fig. 1). It does not couple to the accelerating mode TM_{010} in this configuration. As illustrated in Fig. 2 the coupler is composed of this rod antenna, a vacuum flange, a transmission system, a power extraction terminal and cooling fins. The length of the antenna is chosen to get a loaded Q value less than a third of the intrinsic Q value with negligible influence on the accelerating mode. The antenna is followed by a 50 Ω coaxial line equivalent to WX-20D with a short-ended branch. The antenna and the inner conductor are, in a body, a single straight heat pipe running through the short end to the fins. The heat generated on the antenna surface is efficiently transferred by the heat pipe to the cooling fins. The distance between the cavity wall and the short end is set half the wavelength of the accelerating mode, and the position of the branching is determined so as to pass higher order modes to the extraction terminal but to impede the accelerating mode. The terminal port is provided with an impedance-matched vacuum-tight feedthrough and a BFX-20D rotatable coupling flange. The VSWR at the feedthrough is better than 1.05 over the range of 0 to 2.3 GHz[2].

Except for a few parts all the parts are made of oxgen free pure copper because of its high electric conductivity and low outgas. The parts were brazed in a vacuum furnace with gold-, silver- and copper-brazing alloys in several steps.

Characteristic and Performance

Detailed description of fundamental characteristics is found elsewhere[2].

The Q value for TM_{111}, originally 1.5×10^4 (or 1.7×10^4 in another cavity), is reduced to 3.4×10^3 (or 4.7×10^3) by a single damper on the middle cell of the cavity and to 2.6×10^3 (or 3.2×10^3) by double dampers. The insertion of the coupler shifts up the resonance frequency of the cell by 20 kHz, which is within tunable range. The stored energy in cells drops as shown in Fig. 3 according to the reduction in Q value by the damper. In the case of TM_{011}, though the identification of its submodes is difficult because of its narrow passband width, a Q value of 2.7×10^4 is changed down to 1.6×10^3 for a submodes with the highest impedance.

A cavity was operated off-beam with the couplers on so as to measure the leakage power of the accelerating mode and the temperature of the coupler. The result indicates that the coupling of the coupler to the accelerating mode, arising from the axial asymmetry, is - 45 dB and that every 100 kW input brings about 35 degree rise at the antenna where the heat generation is estimated to be 45 W on the basis of the calibration by simulation heating.

Fig. 4 presents a spectrum of the output power from the coupler on a cavity in the collider. On the condition of 10 mA beam current the extracted power was 1 × 10 W for TM_{011}, 9 × 10 W for TM_{021} and 6 W for TM_{031}. The experiments in the accumulator with higher current also proved that there was no problem in thermal and electrical performance.

Further in-beam study will start this autumn.

References

1. T. Higo et al., Proc. 1987 Particle Accelerator Conf. Washington D.C., U.S.A., March, 1987.
2. Y. Morozumi et al., to be published.

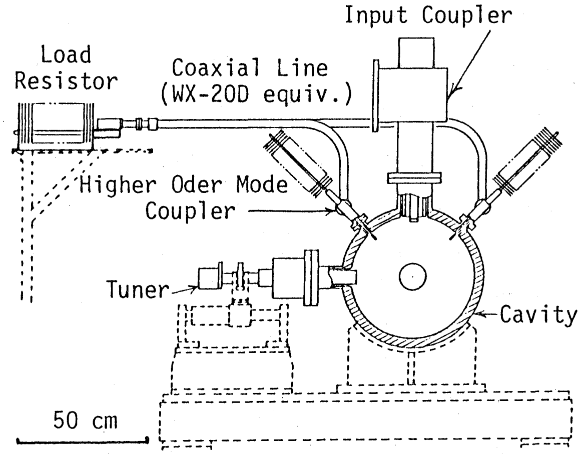

Fig.1 Higher Oder Mode Damper on Cavity

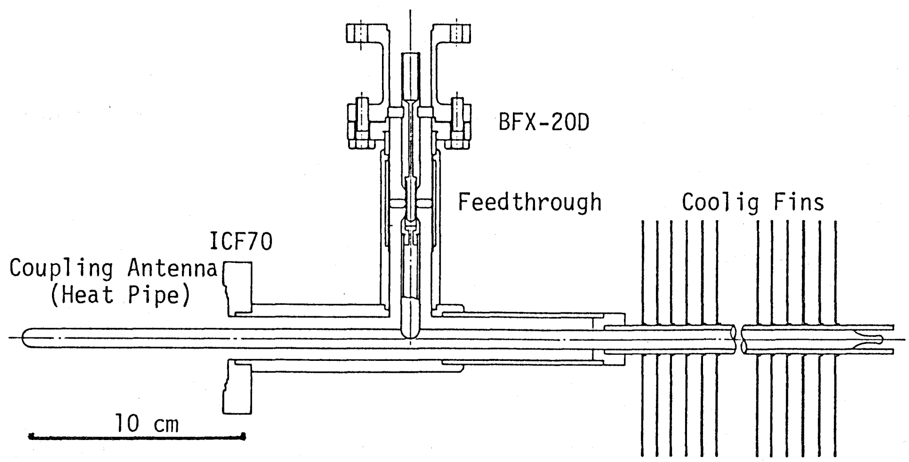

Fig.2 Higher Oder Mode Coupler

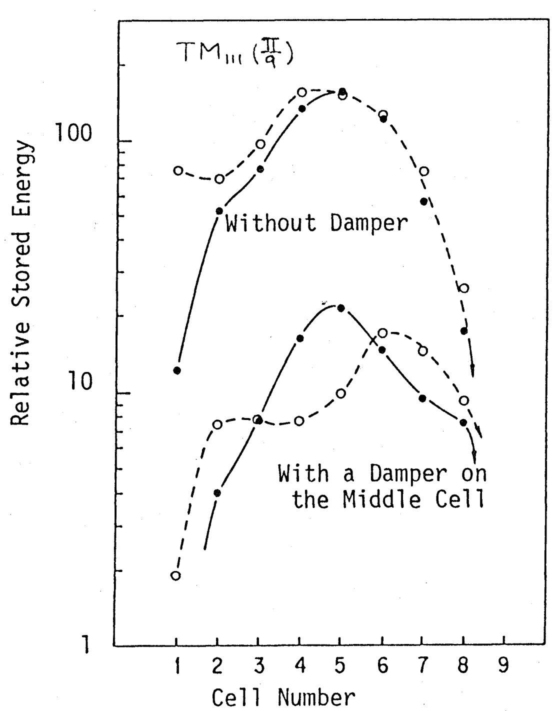

Fig.3 Damper Effect on Stored Energy

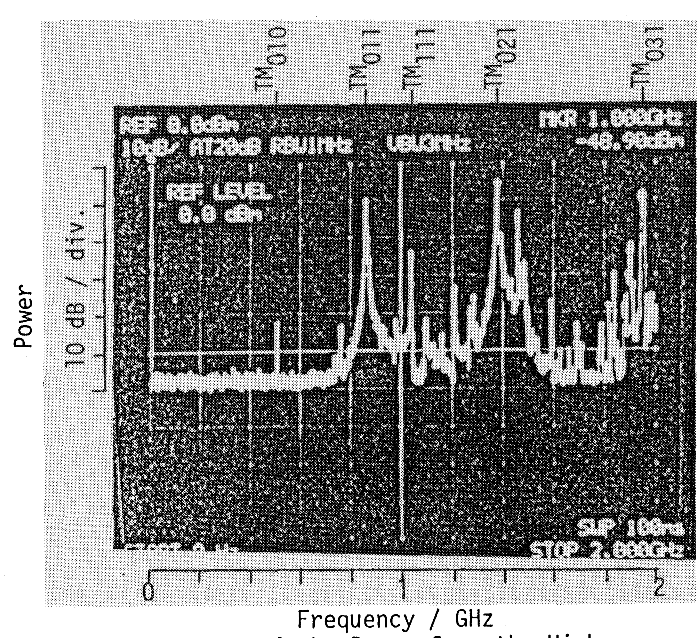

Fig.4 Spectrum of the Power from the Higher Order Mode Coupler