THE PERFORMANCE OF A 3-CELL APS CAVITY AT HIGH POWER OPERATION PART I

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Abstract

The performance of a 3-cell APS (alternating periodic structure) cavity at high RF power operation was studied in order to investigate the practicability of coupled cell structures of standing wave type for high energy proton (and ion) linacs. The experimental setup, procedure and preliminary results are presented in this report.

Introduction

The coupled cell structure of standing wave type is one of the most efficient and practical accelerating structures for high energy proton linacs, considering its high shunt impedance (compared with the shunt impedance of the drift tube type accelerating structure, which continuously decreases as the proton energy increases) and control problems of phase and amplitude of the electromagnetic fields in the accelerating cells. At present we are studying and optimizing the accelerating structure which will be used for a high energy proton linac by using several computer codes such as SUPERFISH [1] and MAFIA [2] for numerical solutions of the Maxwell's equations. However, it is necessary to experience and check out practical problems about the high RF power operation of accelerating cavities at an earlier stage of research and development. The problems are electric field breakdown phenomena, the amount of field emission current, electron induced gas desorption rate η from the cavity wall and their aging rates etc. For this purpose, a 3-cell APS test cavity was constructed from the spare parts for the 18-cell APS cavities of the TRISTAN main ring [3]. The structure of the accelerating and coupling cells of the 3-cell APS test cavity is the same as the 18-cell APS cavity and described in Ref. [3,4] in detail.

Experimental Setup and Procedure

The experimental setup for the high power test of the 3-cell APS cavity is shown in Figure 1. As shown in Figure 1, every accelerating cell has a tuner plunger in order to adjust the resonant frequency (the accelerating mode frequency = 508.58 MHz) of each accelerating cell and make the electromagnetic fields in the coupling cells as small as possible. After the tuner adjustment, the three tuner plungers were connected to a common bar and driven at the same amount. An input coupler was attached upwards to the middle accelerating cell. This input coupler is the same as used for the 18-cell APS cavity in the TRISTAN main ring [3]. A manifold pipe was attached to one of the beam hole flanges (the right one in Figure 1). Vacuum gauges, quadrupole mass spectrometers and an angle valve were attached to this manifold pipe. The cavity was pumped by a turbo molecular pump (300 l/sec) attached downwards to the angle valve. An ionization chamber was located on the beam axis, about 1.5 m apart from the center of the middle accelerating cell in order to measure the amount of the X-ray radiation due to field-emitted electrons. When the η measurements at the inside wall of an accelerating cell were performed, an arm and lever system movable in vacuum with a tungsten filament attached to the end of the lever was set into the accelerating cell through the other beam hole (the left one in Figure 1). The η measurements at the inside wall of a coupling cell were also performed by another small arm and lever system attached to a monitor port of the coupling cell. The η measurement system and the results will be reported in detail by H. Mizuno et. al in this meeting on linear accelerators.

After the tuner adjustment and setup were completed, the Q value of the test cavity was measured and its unloaded Q value was found to be 38500, which is 91 % of the Q value (42450) calculated by using SUPERFISH. The actual shunt impedance ZT^2 of the APS cavity was estimated to be about 22 MΩ/m [3], which is about 80 % of the calculated value of 26.7 MΩ/m by SUPERFISH.

Before the RF processing, any pre-treatment for the cavity such as bakeout was not performed. The RF processing was performed in pulse operation, where the pulse duration was 1 msec and the duty cycle was 10 %. As the RF power source, a 800 kW CW klystron was used. This klystron is one of the high power CW klystrons developed for the TRISTAN RF power source [5]. The pulse operation was performed by modulating the input RF amplitude of the klystron. The cavity was water-cooled and the water flow rate was 150 l/min. By keeping the pressure level in the cavity below 10^{-6} Torr, the RF processing was automatically carried out by a personal computer and a CAMAC control system. Depending on the pressure level in the cavity, the peak RF power was increased, or hold, or decreased by the control system.

Experimental Results

Since the experiment is still being continued, only the preliminary results are presented. At present, the cavity has been RF processed without any serious trouble upto the RF peak power of 200 kW, which corresponds to the field gradient of 2.2 MV/m. It took about 16 hours to achieve the above field gradient. The final pressure level in the cavity with the RF peak power of 200 kW was 5.0×10^{-8} Torr. The relation between the amount of X-ray radiation and the RF peak power was measured after the RF processing upto 200 kW. The result is shown in Figure 2. The relation is expressed in the simple form of $I = 2.2\times10^{5}P^{8.7}$ where I is the amount of X-ray radiation (R/h) and $\hat{P}$ is the RF peak power (MW). It is expected that further RF processing of the cavity should reduce the amount of X-ray radiation due to field emitted electrons. Its aging rates must be measured at further stages in this high power test.

References

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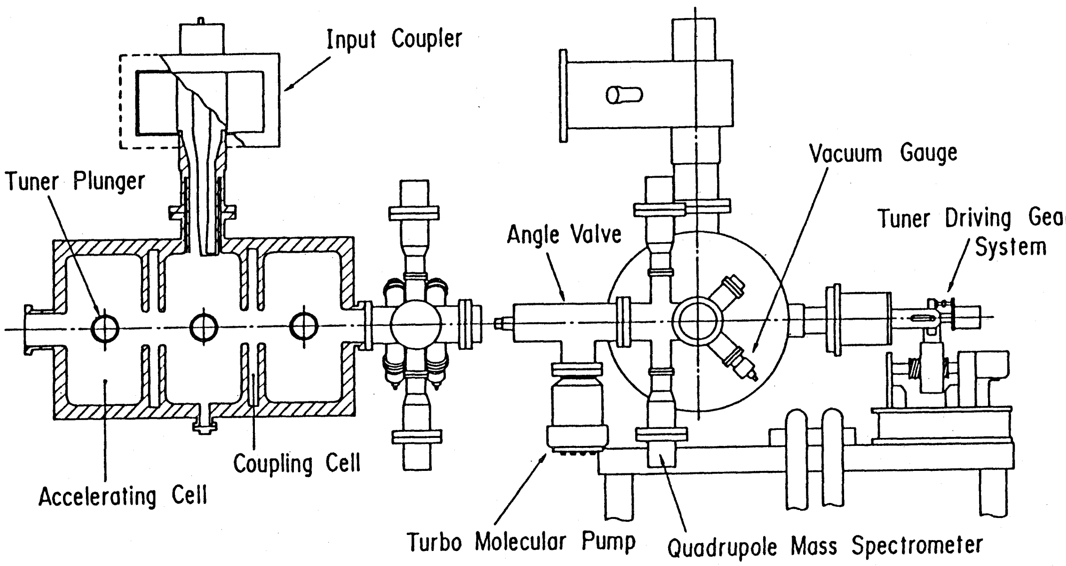

Figure 1
the setup for the high power test of the 3-cell APS cavity

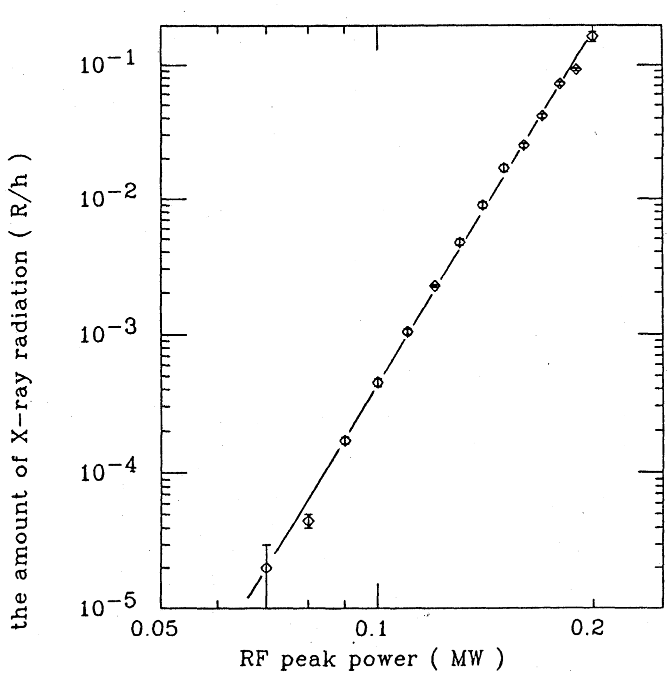

Figure 2