THE INPUT COUPLER FOR THE KEKB ARES CAVITY

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Abstract

An input coupler with a disk-type coaxial ceramic window has been constructed for the KEKB ARES cavity system. A power test of the coupler has been carried out with the high-power model of the accelerating cavity of the ARES up to about 110kW rf-power. The coupling constant between the coupler and an energy storage cavity of the ARES has been measured. A test bench of the coupler is being constructed in order to carry out a test with a much higher rf-power.

1. INTRODUCTION

For the KEK B-factory(KEKB), the Accelerator Resonantly coupled with Energy Storage(ARES) is being developed[1]. The ARES requires about 400kW (508.8MHz, CW) rf-power per cavity with the full beam loading of the B-factory[2].

If the ARES is able to have two power feeds, one coupler has only to transfer 200kW rf-power. In this case we can use the existing input coupler for the Alternating Periodic Structure (APS) cavity of the TRISTAN ring in KEK. It is tested up to 300kW rf-power [3].

If the coupler can transfer more than 400kW rf-power, the total number of couplers can be reduced by a factor two. Of course the coupler has to have a big margin for the power. We thus started the development of an input coupler which could transfer 800kW (CW) rf-power, twice the value required for the ARES.

It is well known that the ceramic window is one of the most important parts of the input coupler and that the performance of the window is strongly correlated to the structure around the window. The most powerful coupler in KEK is the output coupler of the UHF (508MHz) klystron of TRISTAN. It can transfer 1.2MW (CW) rf-power and no catastrophic phenomenon has been observed yet at the maximum available power (1.2 MW) [4]. It has a disk-type coaxial ceramic window, whereas the coupler of the APS described before has a cylindrical ceramic window. Thus the coupler with the disk-type coaxial ceramic window is the best candidate for the input coupler of ARES even though the vacuum in an input coupler of an accelerating cavity is usually much worse than in a klystron output coupler.

2. DESIGN OF THE COUPLER

All the transition parts were designed by using the computer code "High Frequency Structure Simulator (HFSS)[5]" except for the loop. The dimension of the loop was determined by the measurement described in a later section of this paper.

The details of the design and the basic rf-properties of the coupler are described in the reference paper[6]. Therefore, the coupler design is only briefly described here. The rf-power comes from a klystron through a rectangular waveguide (WR1500). The rf-field mode in the rectangular waveguide is converted to the rf-field mode of the coaxial wave guide (WX152D) by a door-knob transition with a capacitive iris. It is shown in Fig. 1.

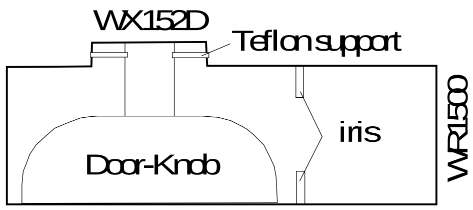
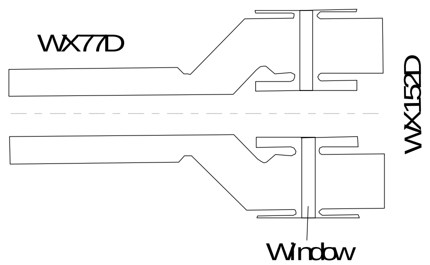


Fig.1 Schematic view of the door-knob transformer [6]

The ceramic window is in the WX152D coaxial waveguide. The ceramic window is same as the window used in the klystron output coupler. Because the coupler port of the ARES is designed for the WX77D coaxial waveguide, the WX152D is transferred to the WX77D. Figure 2 shows the schematic views of the waveguide with the ceramic window. Two types of an impedance matching section around the window have been developed: the choke type structure shown in Fig. 2-(a) (the klystron has this structure) and the under- and over-cut structure (under/over-cut structure) shown in Fig. 2-(b). The under/over-cut structure has the better rf-field pattern around the window in order to reduce multipactoring on the window[6].

The surface of the vacuum side of the window has a thin (about 10nm) TiN coating in order to reduce the secondary electron emission constant.

(a)



(b)

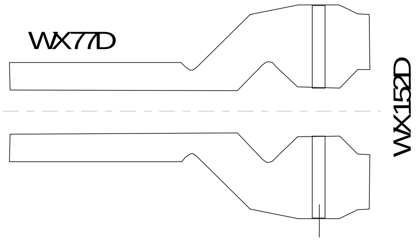


Fig. 2 Schematic view around the window [6]
(a) the choke structure
(b) the under/over-cut structure

3. POWER TEST OF THE COUPLER

The first power test of the coupler has been carried out using the high-power model of the accelerating cavity of the ARES. The cavity was already tested up to about 150kW (CW) output power of the klystron with the coupler of the APS. The coupler has been replaced by a new one. The conditioning history of the new coupler with the under/over-cut structure is shown in Fig. 3. The maximum output rf-power of the klystron was 140kW. It corresponds to about 110kW input rf-power to the cavity because of the losses in the long transmission lines from the klystron to the cavity.

The first power test has succeeded without any problem except for the cooling near the loop described below. Furthermore, no difference could be observed between the coupler with the choke structure and the coupler with the under/over-cut structure at this stage.

Figure 4 shows the power losses in the WX77D coaxial waveguide of the coupler with the loop. The WX77D wastes about 4% of available rf-power. The losses in the WX77D can be explained by a penetrated magnetic field from the cavity into the coaxial waveguide and the coupler port. (The coupler port has a choke structure, thus there is a gap between the outside of the coupler and the inside of the port.) It made a local heating problem of the coupler because of insufficient cooling power for the WX77D. The pressure of the cooling water for the window is a few kgf/cm^2, because the copper sleeve of the window is very thin (1mm). The cooling water was supplied by a small circulator with a compact chiller during the test. By comparisonthe pressure of the cooling water for the cavity is 10kgf/ cm^2 and the chiller of the water has sufficient power. Therefore the cooling system of the WX77D waveguide has to be separated from that of the window and be connected with the cooling system of for the cavity..

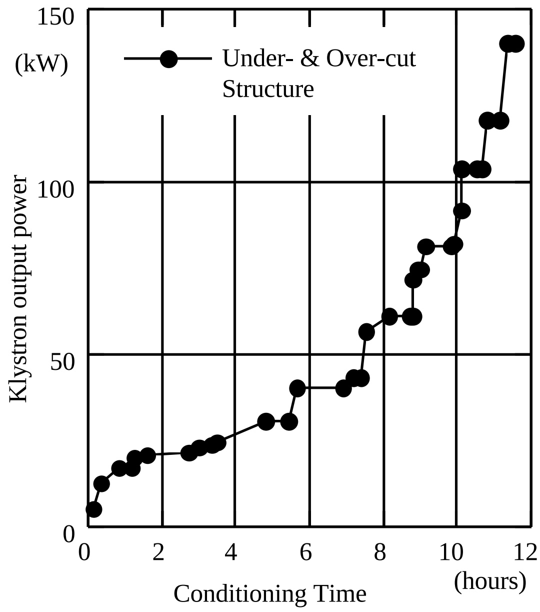


Fig. 3 Conditioning history of the coupler with the under/over-cut structure

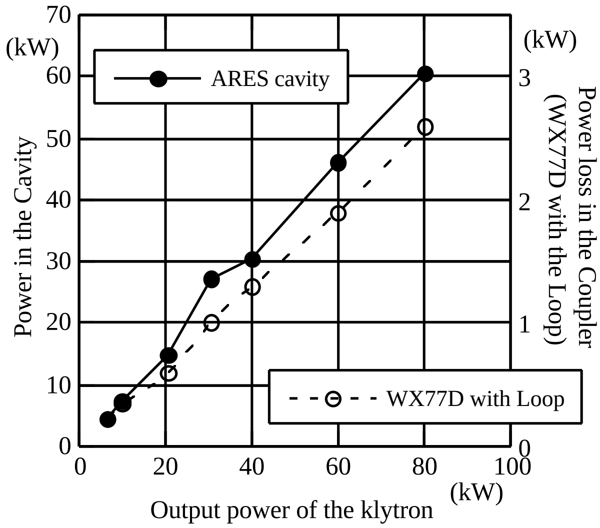


Fig. 4 Power dissipation in the cavity and the coupler Data were measured using the coupler with the under/over-cut structure.

4. LOOP COUPLING CONSTANT

First, the developed couplers were supposed to be connected to the accelerating cavity of the ARES and it was confirmed by measurement that the coupler of the APS has sufficient coupling with the cavity. Thus the loop of the new coupler was same length as the coupler of the APS. Finally we decided that rf-power should be fed from the energy storage cavity. The diameter and the height of the energy storage cavity are about 1.1m and 1.2m respectively and the rf-mode of the cavity is the TE_{013} mode. However the accelerating cavity is much smaller, 440mm in diameter and 260mm in the gap length, and its rf-mode is the TM_{010} mode. Consequently we measured the coupling constant between the coupler and the energy storage cavity by changing the loop size in order to get the adequate coupling strength. The relation between the coupling constant and the loop size is shown in Fig. 5. Abscissa is the length of the loop described in the next figure. Because the required coupling constant is about 6, the loop length has been decided to be 22mm for the next coupler. (The loop size of the first coupler is 12 mm.)

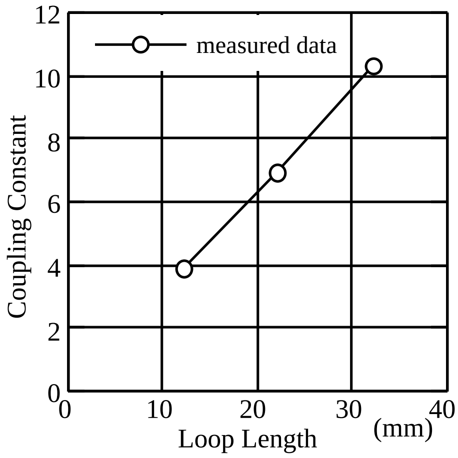


Fig. 5 Measured Coupling Constant of the loop to the energy storage cavity.

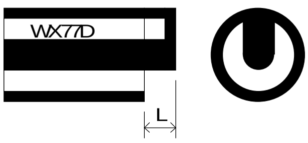


Fig. 6 Schematic view of the loop.
" L" is the loop length. Thickness of the loop is 5 mm.

5. TEST BENCH OF THE COUPLER

The input coupler could be able to transfer the 800kW (CW) rf-power, which is twice required power. Thus a coupler test bench which could transfer 800kW (CW) rf-power is now under construction.

The concept of the test bench is the following:(1) the test bench consists of a cavity with two coupler ports, two input couplers to be tested and a dummy load;(2) the cavity does not accumulate rf-power, it just transfers the rf-power from one coupler to another one terminated by a dummy load. The cavity thus has to have a high unloaded Q-value and a low loaded Q-value in order to have a large coupling constant and a low power dissipation in it.

The schematic view of the test bench is shown in Fig. 7. A small cavity was designed to couple strongly with a small loop of the coupler. The cavity has an effective size 78x200x270mm. It has two electrodes in its center. MAFIA calculation gave a Q-value of 9000 for the unloaded cavity and the measured loaded Q-value with the coupler is about 100. Thus the coupling constant for one loop is about 45. Total expected power dissipation in cavity is about 9 kW when the input rf-power is 800kW. The assembling and debugging of the bench is in progress.

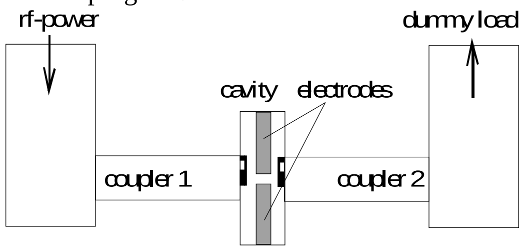


Fig. 7 Schematic view of the coupler test bench (Scale is not correct.)

6. CONCLUSION

Input couplers with a coaxial ceramic window have been developed for the ARES cavity. There are two types of coupler: the coupler with the choke structure and the coupler with the under/over-cut structure. The couplers have been tested up to about 110kW rf-power without any trouble using a high-power model of the accelerating cavity of the ARES as a dummy load. At this power level, there was no difference between the two types of the coupler. The coupling constant between the coupler and an energy storage cavity of the ARES has been measured. A test bench of the coupler is being constructed in order to carry out a test with a much higher rf-power.

REFERENCES

[1] T. Kageyama, et al., 'The ARES Cavity for the KEK B-Factory', in this conference.
[2] K. Akai, E. Ezura and Y. Yamazaki, 'Design of the KEKB RF System', contributed paper of PAC95, Dallas.
[3] M. Akemoto, 'High-power input coupler with a cylindrical alumina window', Proc. IEEE Part. Accel. Conf., San Francisco, California 1037 (1991)
[4] S. Isagawa, et al., 'Development of high power CW klystron for TRISTAN', Proc. IEEE Part. Accel. Conf., Washington D.C. 1934 (1987)
[5] HP Part No. 85180A., HP Corp.
[6] F. Naito, et al, 'Input coupler for the KEKB normal conducting cavity', contributed paper of the PAC95, Dallas