COMPACT WAVEGUIDE-TYPE CAVITY INPUT COUPLERS FOR SHIELDING CERAMIC WINDOW AND BALANCED APERTURE FIELDS

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Abstract

For high-power operation of charged particle rf accelerators, the input coupler windows must withstand enormous stresses due to charging induced by the high-energy charged particle beam passing by and high rf power passing through. Since most couplers use a single coupling aperture, harmful asymmetrical rf kick on the beam at the coupler-cavity interface exists. If this problem is solved by dual coupling, the size of the structure becomes a problem. The above problems are considered common to both normal conducting and superconducting rf accelerators. In superconducting structures, since the frequency of operation is usually around 1 GHz, compactness of the coupler is also a great concern for the cryostat design. Two new waveguide coupler designs that may solve the above-mentioned problems are discussed.

1 INTRODUCTION

Various input couplers have been used in accelerating cavity structures of existing accelerator facilities. The couplers are under extreme stresses since the accelerators always demand the highest field gradient possible with near maximum input power. Coaxial couplers are known to be more reliable than the waveguide types in terms of power handling and multipacting. They have been tested and used in Tesla Test Facility (TTF) for high peak power [1] at DESY. Coaxial couplers lately developed at the KEKB [2] and the APT projects [3] can handle very high rf power. However, the complexity and cost in construction are higher than the waveguide type. For large-scale linear collider applications, technical and financial concerns constrain high-performance, low-cost input coupler development. For superconducting cavity input couplers, one more constraint on the coupler design is their size. Expensive cryomodules usually do not prefer bulky waveguide structure for the dual input coupler that is desired for balanced feeding for minimum distorted field on the beam.

A design of single input waveguide coupler has been used at CEBAF in Jefferson Lab successfully. Dual input S-band waveguide couplers have been developed [4]. The balanced dual input coupler designs have improved beam properties. Waveguide couplers are considered to have lower loss and better mechanical stability, compared to the coaxial couplers. However, the more important factors for designing the cavity coupler are to have symmetrical fields and ceramic windows that are shielded from direct exposure to the beam.

For blocking the illumination on the ceramic by the beam, some waveguide cavity coupler designs employ “chicane” or waveguide bends [1]. These approaches may work for rf coupling but the desired simplicity is not achieved. And the symmetrical feeding for balanced field is still a goal to achieve.

2 INPUT COUPLER DESIGNS

Two new waveguide-type input coupler designs are discussed. The designs aim for compactness with symmetrical fields and window protection. They are considered relatively simple to construct and mechanically stable. Near-perfect symmetrical feeding is considered possible without using bulky waveguide power splitter. The coupler structures use evanescent waves at the end of the feed waveguide. The beam-pipe area is physically excluded from the feeding waveguide structure.

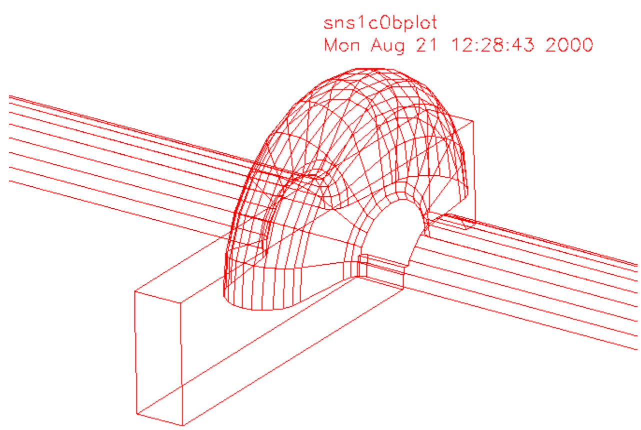

Fig. 1: Half structure of waveguide cavity input coupler with dual slots on the beam pipe. Coupling slots are on the beam pipe.

2.1 Coupling through Beam Pipe

Most superconducting cavities use couplers that have a coupling aperture on the beam pipe. The proposed coupler structure is shown in Fig. 1. In this case a low- beta (β=0.61) superconducting single-cell cavity for 805 MHz is used. The two slots are placed in a beam pipe symmetrically close to the wall of the cavity cell. The two slots are separated by a part of the beam pipe at the waveguide center so the metal part blocks the direct illumination of the window by the beam. The metal part between the slots in the waveguide may be considered as an inductive post or divider for two narrow waveguides connected in parallel for the dominant TE_{01} mode. Each narrow waveguide would have a much higher cuttoff frequency. However, it is considered that coupling through the evanescent mode is still possible, because the slots are located only a short distance from the main waveguide.

2.2 Cavity Sidewall Coupling

A design similar to the previous one is discussed in this section. The two-slot configuration shown in the previous design can be modified to have magnetic coupling directly to the end cell of the cavity through the side-wall, as shown in Fig. 2. Here, a standard S-band disk-loaded cavity is shown. The slots are placed symmetrically with respect to the beam pipe. However, since the coupling is made through the end wall of a cell, the waveguide must be attached close to the cavity cell to make the wall thickness relatively thin. If this approach is used with a bell-shaped cell (shown in Fig. 1), the waveguide cross section will not be rectangular at the end of the waveguide nor in the two narrow end sections.

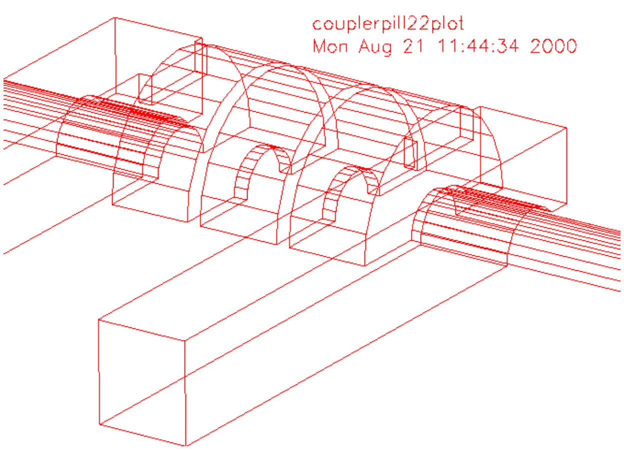

Fig. 2. Upper half of waveguide cavity input couplers with dual slots for a three-cell S-band structure. Coupling slots are on the wall of the end cavities.

3 SIMULATION

The coupler structures are simulated using Agilent HFSS code to see the rf properties. Figure 3 shows the electric and magnetic fields at around the input coupling slots of the structure shown in Fig. 1. It can be seen that the fields are fairly uniform at the aperture although higher magnetic field exists at the metal part separating the slots in the middle of the waveguide. Excitation of the accelerating mode field inside the cavities was confirmed in the both designs.

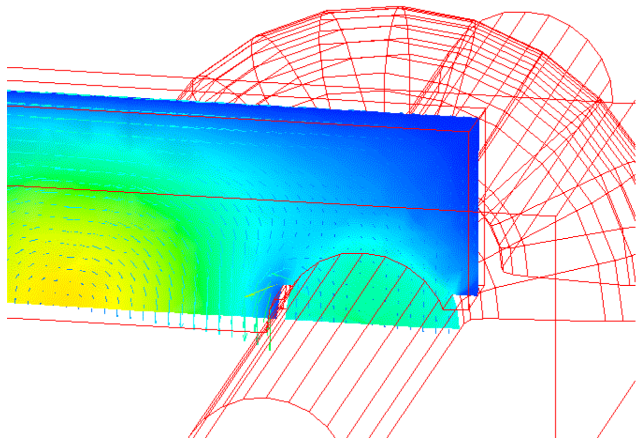

Fig. 3. Electric and magnetic fields in the feed waveguide and at the coupler aperture of the structure shown in Figure 1. Arrows show magnetic field and spectral plot shows the electric field.

4 CONCLUSION

Two relatively simple waveguide input coupler designs for accelerating cavities are proposed. They seem to shield the ceramic windows from illumination by the beam and to excite balanced fields at the coupling apertures while keeping the overall coupler size small. Along with the above advantages, the two designs are considered cost effective. For realization of high-performance, high-power couplers using the above designs, further investigation is needed through more simulations and prototyping efforts.

5 ACKNOWLEDGEMENT

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REFERENCES

[1] “Transparencies from the TESLA Meeting” TESLA Collaboration, May 1-3, 1999 at DESY
[2] S. Mitsunobu, et. al., “Status and Development of Superconducting Cavity for KEKB,” *Proceedings of the 1997 Particle Accelerating Conference, PAC97*, May, 1997, pp. 2908-2910.
[3] E. N. Schmierer, et. al., “Development of the SCRF Power Coupler for the APT Accelerator,” *Proceedings of the 1999 Particle Accelerating Conference, PAC99*, March 1999, pp. 977-979.
[4] G. Bowden, “A Compact RF Power Coupler for the NLC Linac,” *Proceedings of the 1999 Particle Accelerating Conference, PAC99*, March 1999, pp. 3426-3428.