STUDY OF THE ACS CAVITY WITHOUT A BRIDGE CAVITY

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Abstract

One module of the Annular-ring Coupled Structure (ACS) linac, which has been installed in the linac tunnel of J-PARC to increase the beam energy up to 400 MeV, is composed of two accelerating tanks which are coupled by a bridge cavity. Although the bridge cavities can simplifiy the handling of the multi-tank system of the coupled cell linac, it is possible to feed the RF power into the each of tank directly with the power divider and the phase shifter instead of the bridge cavity. The rf properties of the ACS linac without a bridge cavity has been studied by using the low power model. The study results are summarized below.

INTRODUCTION

Japan Proton Accelerator Research Complex (J-PARC) is a high-intensity proton accelerator facility [1]. The linac of J-PARC uses the annular-ring coupled structure (ACS) linac as a CCL to accelerate the H^- ion beam from 191 to 400-MeV. One ACS module shown in Fig. 1 is composed of two accelerating tanks which are coupled by the bridge cavity. We can use the bridge coupled tanks as one cavity from the viewpoint of rf system.

As each of the tanks has 17 accelerating cells, one module has 34 accelerating cells. In this manner the bridge cavity simplifies the handling of the multi-tank system [2]. Figure 2 shows the cross sectional view of the ACS module.

The resonant frequency of the ACS is 972MHz.

Figure 1: An ACS module for J-PARC linac.

Although the bridge cavity system is useful to connect the multi-accelerating tanks like the side coupled linac of FNAL in USA [3], it is also possible to feed the RF power into the each of tanks directly without the bridge cavity. In this case, each of the ACS tanks must have the power input port independently. Furthermore the waveguide system requires

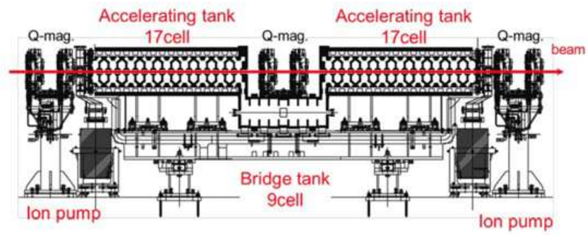

Figure 2: Cross section of an ACS module [1].

the power divider and the phase shifter. (The latter has been realized in the RF system for the SDTL of J-PARC as described in the appendix.)

Merits of the ACS without a bridges are as follows;

1. A cavity assembling become much easier;
2. An alignment of the tank is much easier;
3. Cavity installation is much easier;
4. RF power load of the input coupler decreases.

Demerits are as follows;

1. A number of cavity to be tuned doubles;
2. A phase shifter and a power divider are required.

This paper describes the study to realize the ACS system without bridge cavity.

ACS WITHOUT A BRIDGE CAVITY

When the ACS accelerating tank has no bridge cavity, it must have the extra port for the RF power input. Probably the power input cell is located at the canter of the tank as shown in Fig. 3 to make a power droop minimum.

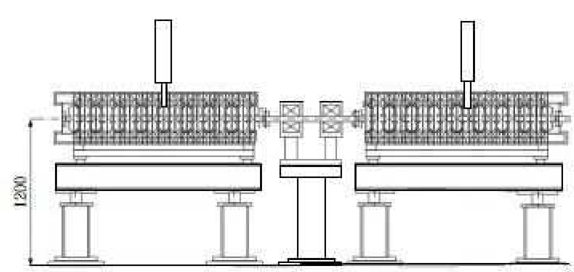

Figure 3: Schematic view of ACS without a bridge cavity.

Since the accelerating cell which has an iris to couple the wave-guide can not have the annular-ring coupling cell, the cell has the side coupled structure with a mirror symmetry for the middle plane of the gap. The neighboring accelerating cell is a hybrid cell which has a side coupled and an annular-ring coupled structure.

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Model

Half size model made of aluminum has been manufactured for the low power RF measurement. The model has 13 cells which consist of 5 full accelerating cells, two half gap accelerating cells, four annular-ring coupling cells and two side coupled cells. It is shown in Fig 4. The cross section is shown in the next figure (Fig. 5). In this figure, the orange colored cells have the side coupled structure. While the brown colored cells has the normal ACS structure. Each coupling cell has been designed to have the coupling constant of 5%.

Figure 4: Half size model of ACS with direct RF feed.

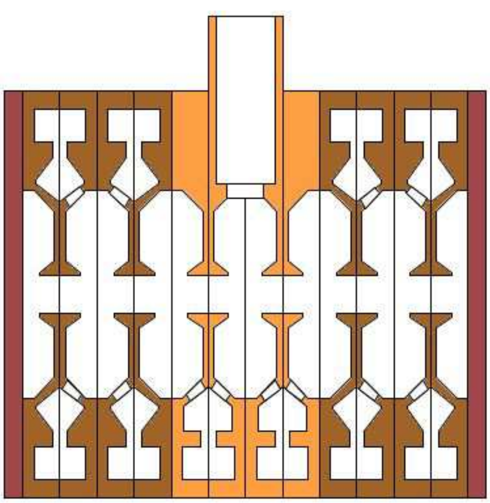

Figure 5: Cross section of the ACS model with direct RF feed.

The photo of the cell with the coupling iris is shown in the Fig. 6. The 7 holes around the accelerating cell are the dummy holes of the vacuum ports.

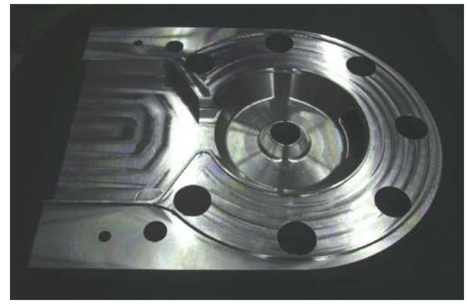

Figure 6: The center cell of the ACS model with a coupling iris.

Measured RF Properties

The dispersion curve of the model cavity has been measured. The results are shown in Fig. 7. The frequency of the $\pi/2$ mode is 1.947GHz which is 3MHz higher than the design value of 1.944GHz. The blue dots and line show the calculated data. In the calculation, three couplings constant are used as the fitting parameters. These are the coupling constant K_s between the center accelerating cell and side coupled cell, K_{as} between the side coupled cell and the accelerating cell which coupled to both of the side coupled cell and annular-ring coupled cell and K_a between the accelerating cell and the annular-ring coupling cell. The fitted values of them are described later.

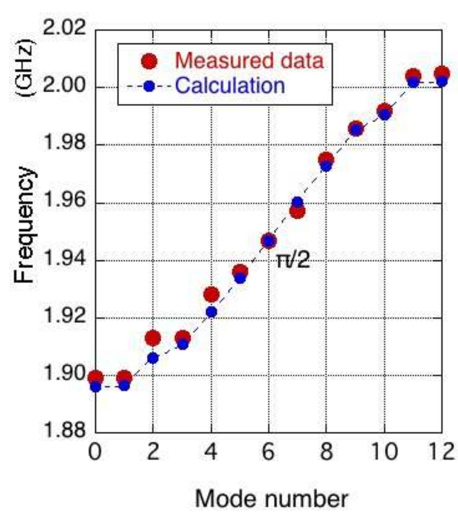

Figure 7: Dispersion curve of the ACS model cavity.

The field distribution along the beam axis has been measured by using the bead-pull method. The data is shown in the Fig. 8. The ordinate shows the field strength with an arbitrary unit. The average acceleration field for each gap are calculated by using the data. The results is shown in the Fig. 9. In order to reproduce the measured data in Fig. 9, K_s, K_{as} and K_a has been chosen 4.4%, 5.0% and

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5.6%, respectively. This calculated value is shown by the blue dot line in Fig. 9. AS an average field of the center cavity is about 10% higher than that of other cell, the design of the center cell must be modified. However measured data show that the model of the ACS tank without a bridge cavity works as a resonant cavity.

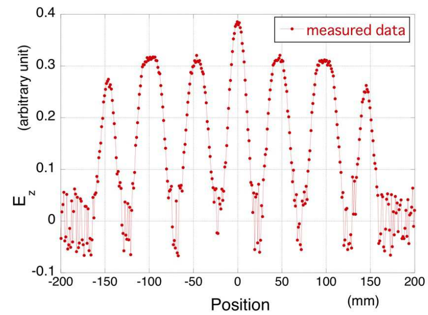

Figure 8: Measured field distribution of the ACS model.

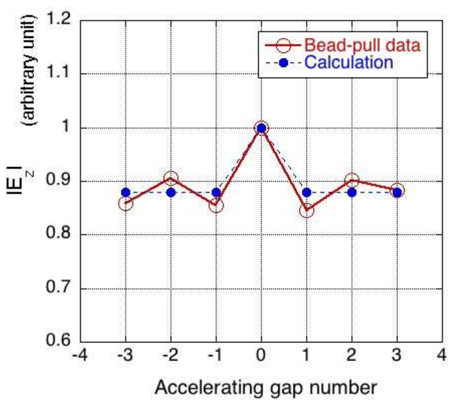

Figure 9: Half size model of ACS with direct RF feed.

CONCLUSION

The ACS without a bridge cavity has been investigated. It has the direct rf power input port at the center accelerating cell. The basic rf properties have been measured by using the model cavity. The measured data proved the feasibility of this scheme. However the following subjects must be investigated in the next step to realize the cavity:

1. The port position of the movable tuner;
2. Correction of the coupling constant of the side coupled cell;
3. Correction of the non-uniformity of the E_z by tuning the accelerating gap;
4. Correction of the coupling constant of the side coupled cell;
5. Water cooling scheme around the input iris.

APPENDIX

For the normal ACS module with a bridge coupler, the rf power is fed into the center cell of the bridge cavity. From the view point of the rf source, the module can be managed as a single cavity. Thus the waveguide system of the ACS is simple as shown in Fig. 10.

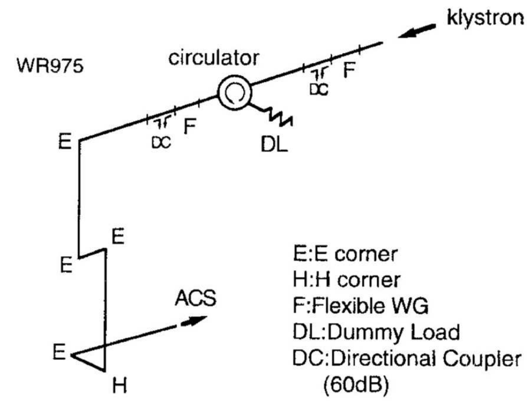

Figure 10: Waveguide system of an ACS module [4].

For the SDTL (Separated-type DTL [4]) of J-PARC, two paired tanks are fed the rf power from one klystron. The rf power is divided by the power divider and the phase balance between the both tanks are tuned by the phase shifter. The waveguide system for the SDTL is shown in Fig. 11. The ACS without a bridge cavity probably uses the similar waveguide system like that of SDTL.

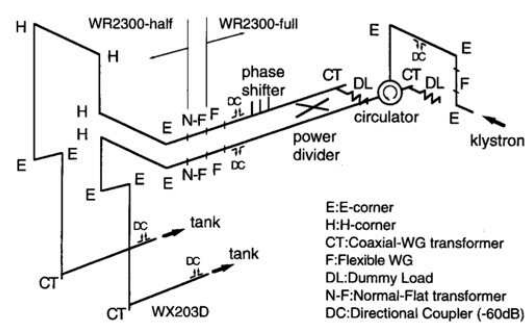

Figure 11: Waveguide system for the pair of SDTL tanks [4].

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