FABRICATION OF DISK-AND-WASHER CAVITY

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Abstract

The Disk-and-Washer cavity for electron acceleration is under fabrication. We fabricated three units of test models made of OFC for real acceleration of electrons. In these test models, RF frequency was about 3MHz higher than operating frequency 2857MHz. Therefore, new precise model made of aluminum were fabricated for investigation of this frequency difference. These results and present states are described.

1 INTRODUCTION

1.1 Disk-and-washer structure

The Disk-and-Washer(DAW) structure has features in high stability, good vacuum properties and high shunt impedance. It is suitable for a high beta region of accelerator. Figure 1 shows the schematic picture of the biperiodic L-support DAW. [1]

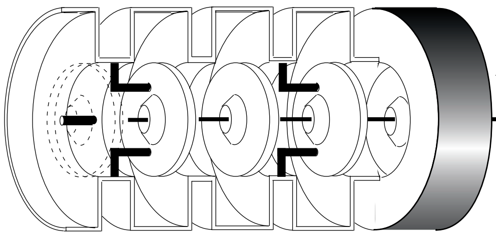

Figure 1: Disk-and-Washer structure.

A washer is fixed by two supports. Four supports are located on a disk with 90 degrees separation around the beam axis, which support two washers. A couple of supports fixes one washer, and the rest two supports fix the other washer.

A high power model of DAW consists of two 1.2m long accelerating tubes connected by a coaxial bridge coupler. The coaxial bridge coupler has an RF coupler, vacuum port, and three frequency tuners. An operating frequency is designed at 2857MHz so that it can replace one of three existing disc-loaded waveguide accelerating tubes. This DAW cavity is supposed to be installed the electron linac system.

1.2 Accelerating mode and coupling mode

In the DAW structure, two modes should be tuned to an operating frequency. One is an accelerating mode and the other is a coupling mode. In the accelerating mode, strong electric field is generated between the accelerating gap. Figure 2 shows the electric field distribution for these two modes.

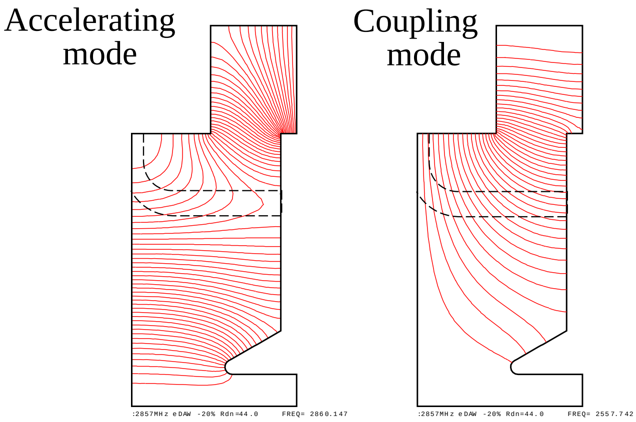

Figure 2: Electric field distribution calculated by SUPERFISH. Broken line shows a cross section of support.

The support shape is designed to minimize the effect on the electric field of accelerating mode; the support is roughly perpendicular to the electric field in Fig. 2.

2 MEASUREMENT OF HIGH POWER CAVITY

Basic dimensions of the DAW cavity have been studied by computer simulations and measurements of aluminum models (cold model). In the high power cavity, main parts of cavity are made of OFC. Three units of the high power cavity (OFC model) were made for fabrication test and measurement of properties. These models have water cooling paths, RF contacts and vacuum seals. A unit of cavity includes two washers, and is about 20cm long along the beam axis. These units were connected together and terminated by the endplates for cold measurement.

2.1 Accelerating mode frequency

Table 1 shows the measurement results of OFC model and aluminum model. The two models have the same dimensioned design. The OFC model was fabricated at the same shop as the high power model. It has water cooling paths, and all parts were brazed together. The measured accelerating mode frequency (fa) of OFC model was 3MHz higher than the operating frequency 2857MHz.

	Al model	OFC model
accelerating mode (fa) [MHz]	2857.4	2859.6

Table 1: Frequency difference between OFC model and aluminum model.

This result indicates the existence of a shape difference. This difference was not found by the inspection of dimensions throughout the fabrication process. The reason is discussed in the later section.

2.2 Dependence of the number of cavities

The measurement data showed the dependence on the number of cavities for the both modes. Figure 3,4 are the plots of both modes.

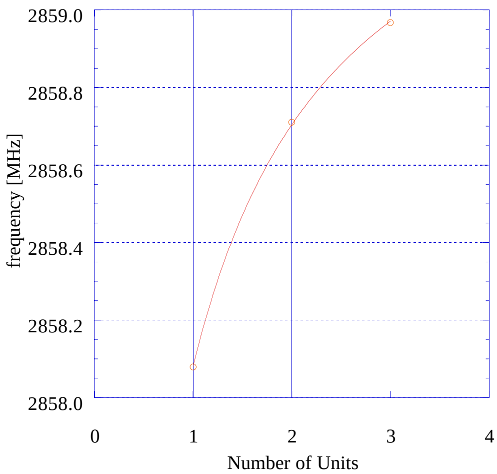

Figure 3: Dependence on the number of cavities in the accelerating mode. This curve is fitted with consideration of the effect of endplate.

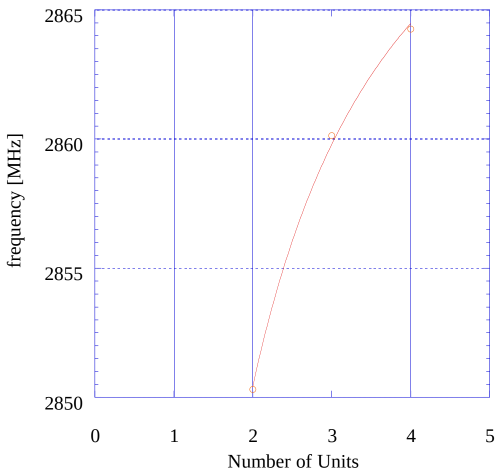

Figure 4: Dependence on the number of cavities in the coupling mode.

Because the OFC units have slightly higher frequencies than those of the endplates, the frequency converges to the intrinsic frequency of the OFC model units. The dependence was not found in the aluminum model. The fitting curve in Fig. 3 is based on above assumption. The equation for the curve is

$$f = m_1 + \frac{2m_2 N}{2N+1}, \qquad (1)$$

where f is frequency, N is the number of cavities and m_1, m_2 are fiting parameters. The high power model consists of 24 units (48 cells), and thus the convergence value of frequency was estimated as 2859.6MHz at $N = 24$ (See Table 1).

Figure 4 is the plots of coupling mode frequency. Measurement of the coupling mode frequency in not as easy as the accelerating mode frequency. The coupling mode frequency has strong dependence on the number of cavities, because of the termination problem. We assume that the frequency has dependence on $\frac{1}{N}$ for fitting the plots. The equation for the curve is

$$f = m_1 + \frac{m_2}{N}. \qquad (2)$$

The coupling mode frequency is estimated as 2876.3MHz at $N = 24$

3 NEW ALUMINUM MODEL MEASUREMENT

For investigation of the frequency difference, a new aluminum model (G2-model) was fabricated at the same shop as OFC model. Because, OFC models were already brazed and their supports and washers can not be exchanged. This new aluminum model is called ”G2-model”, and the old aluminum model is called ”G1-model”. We suppose that G2-model has the same properties of OFC models. The parts of G2-model are fixed by screws for replacement. The support parts were taken from the stock of the original OFC parts, because the curvature of support was considered to be critical for the frequency. Changing washers and/or supports, we measured the frequencies. These results are discussed in section 3.2 and 3.3.

3.1 G2-model properties

G2-models are expected to have the same properties as OFC model, because G2-models were produced through the same process as OFC model except for the material and the method of fixing the parts. Accordingly, we carried out the same measurement as the OFC model on G2-models. Table 2 shows the comparison between two models.

	G2-model	OFC model
accelerating mode (fa) [MHz]	2863.0	2859.6
coupling mode (fc) [MHz]	2873.0	2876.3

Table 2: Frequency difference between G2-model and OFC model.

These results are the extrapolated values at 24 units, because the data of G2-model shows the dependence on the number of cavities.

3.2 Support effect

The frequencies were measured, while G1-model supports were replaced by those of G2-model. Table 3,4 show the frequency variation that comes from the shape difference.

Original

	Frequency (fa) [MHz]
G1-model	2857.5
G2-model	2860.7

With the supports of G2-model (OFC supports)

	Frequency (fa) [MHz]
G1-model	2857.7

Table 3: Support effect for accelerating mode.

Original

	Frequency (fc) [MHz]
G1-model	2815.6

With the supports of G2-model (OFC supports)

	Frequency (fc) [MHz]
G1-model	2811.3

Table 4: Support effect for coupling mode.

Original

	Frequency (fa) [MHz]
G1-model	2857.5
G2-model	2860.7

With the washers of G2-model

	Frequency (fa) [MHz]
G1-model	2860.6

Table 5: Washer effect for accelerating mode.

Original

	Frequency (fc) [MHz]
G1-model	2815.6

With the washers of G2-model

	Frequency (fc) [MHz]
G1-model	2818.1

Table 6: Washer effect for coupling mode.

These results indicate that the support effect is not so large on the accelerating mode frequency. This is because the dimensions of the supports are designed to minimize the effect on the electric field of accelerating mode (See Fig.2).

3.3 *Washer effect*

The frequencies were measured again, while G1-model washers were replaced by those of G2-model. Table 5,6 shows the results. From these results, the effect is larger than the support.

From these results, the frequency difference is due to washers. The G1- and G2-model washers have the same dimensions on the design, and the dimensions of washers were checked by the final inspection of the production. The curvatures of the noses and the corners, however, cannot be measured precisely.

Because the accelerating mode frequency is sensitive to the nose shape, it may be the source of the frequency difference. The source of the frequency difference should be identified for establishment of the washer inspection methods. We are investigating the methods for washer noses.

4 CONCLUSIONS

Based on the accumulated data, the dimensions of cavity are optimized by correcting the dimensions except the washer part. In this optimization, we assume that massproduced washers have the same properties as OFC-model.

From the view point of the correction, there are two problems to fix the dimension of cavity.

- Convergence of frequency
- Washer effect

For correction of the dimensions, we have to know the coefficient of the parameters and the current frequencies. The frequencies are estimated by extrapolating from a few data, which causes some ambiguity.

We are expecting that the difference of frequency can be corrected by measuring the properties of individual washers. The inspection methods before unit brazing is being considered.

5 ACKNOWLEDGEMENTS

The power model units ware manufactured through collaborations with Mitsubishi Heavy Industries, LTD.

6 REFERENCES

[1] ‘Disk-and-washer structure with biperiodic support’, Nucl. Instrm. and Meth. in Phys. Res. A 348(1994)15-33