BIPERIODIC 4-T SUPPORT DAW FOR ELECTRON ACCELERATION

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Abstract

The disk-and-washer (DAW) linac structure with particular biperiodic washer-support geometries was studied by MAFIA. For electron acceleration, the small Rc/λ DAW with 45° rotating biperiodic (quad periodic) 4-T supports is the one of good geometries, with smaller filling time, and fewer unwanted passbands.

Introduction

An electron linac and a storage ring (KSR)[1] are being assembled at the Accelerator Laboratory, Institute for Chemical Research, Kyoto University. For the first stage, the disk-loaded waveguides will be installed as the accelerating tube. Because of the limited size of the building, the available space for the linac is only for three of 3-m accelerator tubes. The available RF power from a klystron is up to 20 MW for each accelerator tube, and the output electron energy is expected to be up to 120 MeV at 0 mA. It is desirable to increase the injection energy of the storage ring, because of the shorter dumping time in the storage ring. A new accelerating tube with higher shunt impedance is required to achieve the higher accelerating gradient.

The DAW structure has outstanding features in high stability, good vacuum properties, high shunt impedance, and ease of fabrication.[2] It was found that the mode overlapping problem can be overcome by the biperiodic T-support configuration with the careful choice of the tank diameter. (See Fig. 1) There are two choices of the tank diameter of DAW linac structure with 4-T support geometry. The one is the larger option, in which the operating frequency drops between the two split TM_{11}(-like) mode passband, and the shunt impedance is higher. Another is the smaller one, where both TM_{11} mode passbands are above the operating frequency, and the mode density is smaller. The basic configuration studied is the extension of the PIGMI[3] geometries, except for the thicker washers and the 15% reduced tank diameter, which is the second option. The second option is selected because the smaller number of the unwanted modes and the shorter filling time are preferred. Because the cooling water channels should be machined in the washers, the washer thickness is changed.
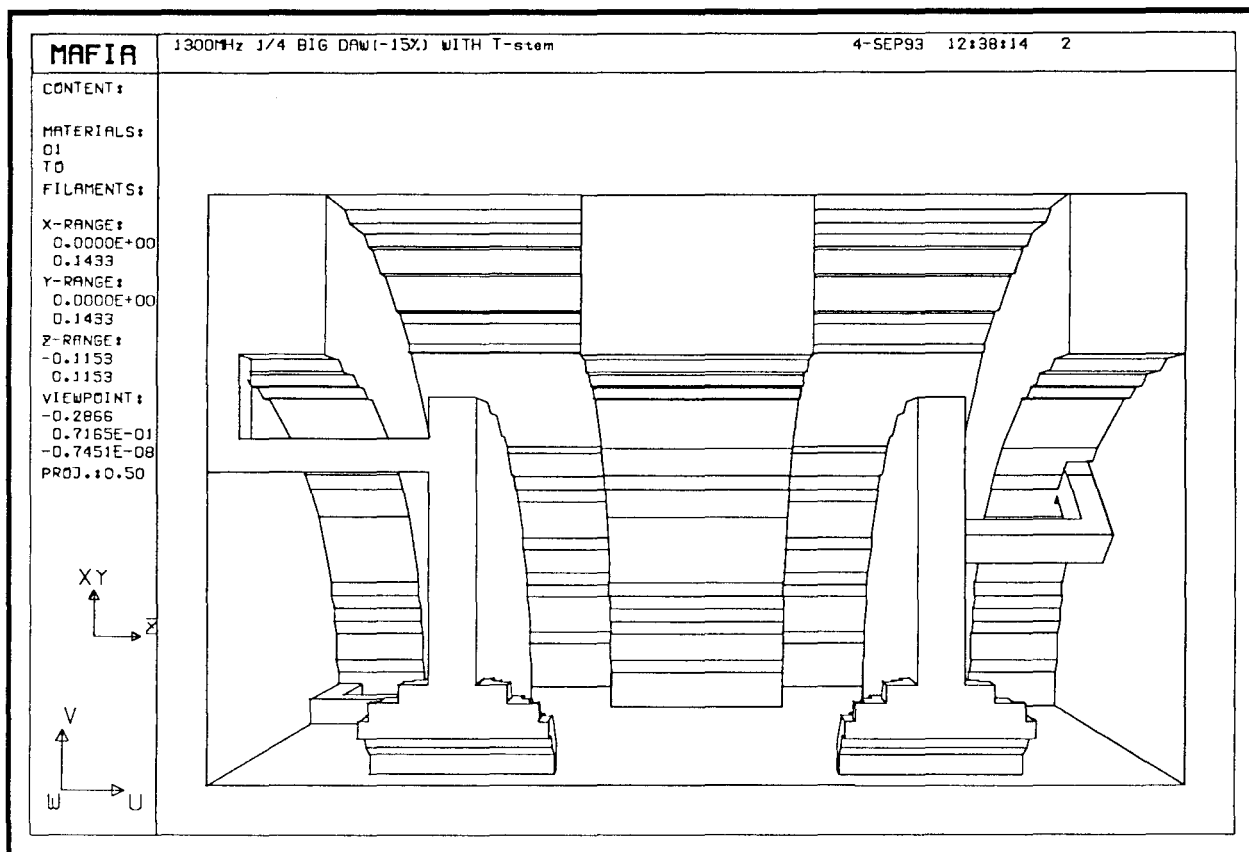

Fig. 1 The mesh plot of rotating 4-T support DAW by MAFIA

MAFIA and SUPERFISH calculation

Some T-support configurations cannot be measured in real cavities because of the termination problem. Because the cavity should be surrounded by the metal surfaces, only the mirror symmetry imposed by a metal surface is available in a real cavity. MAFIA [4] can analyze even some of such problems using only electric and magnetic symmetries. Figure 1 shows one example of the meshes used in such calculations. The rest of the problems that cannot be analyzed by using only electric and magnetic symmetries are the periodic boundary problem with cannot be analyzed by MAFIA of old release.

The 45° rotating 4-T support DAW geometry can be analyzed by MAFIA using just electric and magnetic symmetries. Two-cell geometry should be included in the calculations because the structure has quad-periodicity. The T-support has just "T"-shape not "Y", because of the simplicity. Firstly, the starting geometry was determined by SUPERFISH calculations so that the accelerating frequency and coupling frequency were equal to the operating frequency. The same geometry without the T-support was calculated by MAFIA, and then the nose shape and the disk radius were touched to give the right frequencies. Because the T-supports pushed up the coupling mode frequency, the washer radius and the disk radius were re-adjusted after the T-supports are included. The connection radius of the T-support on the washer was adjusted to give the even electric field distribution between each gap[5]. The notations of the DAW dimensions are shown in Fig. 2 and the dimensions are listed in Table 1. Figure 3 shows
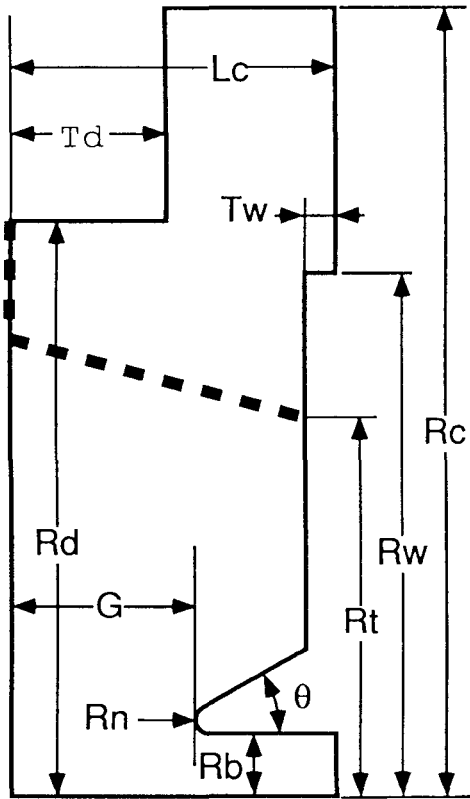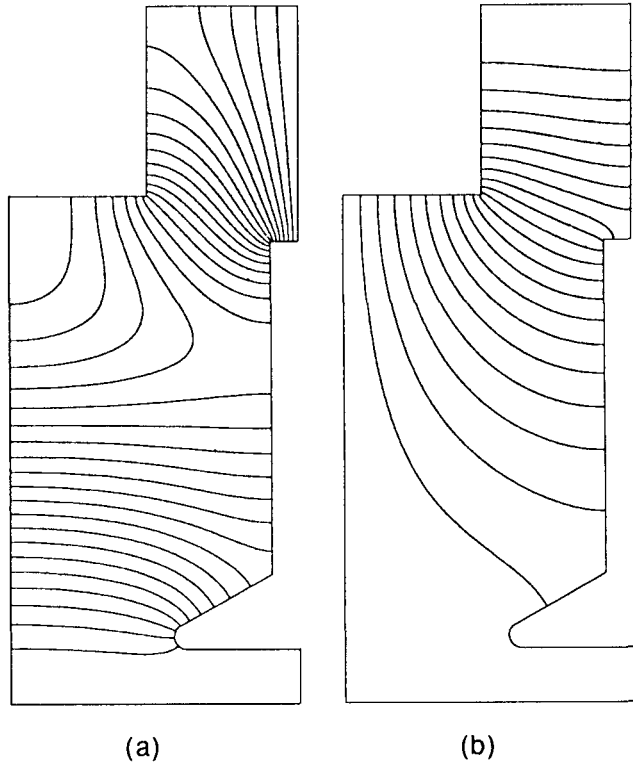

(a)   (b)

Fig. 3   Flux plots by SUPERFISH
(a) Accelerating mode (b) Coupling mode

Fig. 2 The DAW dimensions

Rc/λ	0.62	-
ß	1.0	-
Frequency	2.856	GHz
L=ßλ/4	2.624	cm
Rc (cavity radius)	6.523	cm
Rd (disk radius)	4.757	cm
Td (disk thickness)	1.253	cm
Rw (washer radius)	4.324	cm
Tw (washer thickness)	0.25	cm
θ (nose angle)	30°	degree
Rn (nose radius)	0.12	cm
Rb (bore radius)	0.513	cm
G (gap)	1.484	cm
ZT^2(MAFIA)	93	MΩ/m
facc (MAFIA)	2864	MHz
Qacc (MAFIA)	24000	-
fcpl (MAFIA)	2830	MHz
Qcpl (MAFIA)	11000	-
ZT^2(SF)	107	MΩ/m
facc.(SF)	2842	MHz
Qacc (SF)	26400	-
fcpl (SF)	2506	MHz
Qcpl (SF)	12600	-

Table 1   DAW cavity geometries. The shunt impedance was obtained by SUPERFISH results.

the SUPERFISH flux plots of the resulted DAW.

Calculating with different boundary conditions, the dispersion curves are obtained. The dispersion curves for the in-lined 4-T support configuration are also obtained for the comparison. The in-lined 4-T support has just bi-periodic symmetry and the mesh geometry to be solved is only the half of the rotating one.

Results and Discussion

The calculated dispersion curves are shown in Fig. 4. Because of the smaller number of cells in the problem, there are fewer points on the dispersion curves of the in-lined support geometry. The dipole modes in both geometries are degenerated and there is only one passband for each mode. Below the operating mode frequency, the in-lined 4-T support geometry has two quadrupole mode passbands $TE_{21}E\perp$ and

$TE_{21}E//$, which are close to the operating mode frequency. The quadrupole modes in the rotating 4-T support geometry are degenerated and the frequency difference is almost as large as that of the TM_{11} mode passband. The broken lines in Fig. 4 show the line where the phase velocity v_p matches the speed of light. The lower dipole mode passband (TE_{11}) crosses this line around its $\pi/2$ modes. This effect on the beam break up should be investigated further.

The calculated shunt impedance by MAFIA is 87% of that by SUPERFISH. The final shunt impedance depends on the surface finish of the fabrication process. Because the DAW linac will be operated in the standing wave mode, the filling time should be small as the replacement of the disk-loaded waveguide. The filling time of the proposed geometry is calculated as $\tau = Q/\omega = 1.3~\mu S$, and then the RF pulse width may have to be elongated.

Conclusion

The DAW structure with rotating 4-T support with smaller tank radius seems to be a good candidate of the linac structure for the electron acceleration. Two of 1.3-m long accelerator cavities with 24-washers each will have the shunt impedance of about $200M\Omega$. They are coupled together with a coaxial bridge coupler, where an RF feed slot and a vacuum evacuation port are located. Frequency tuners are also installed in the bridge coupler. In the inner-conductor of the bridge coupler, a current monitor may be installed. A cold model with 24-washers made of Aluminum will be fabricated for the confirmation of the calculation and the determination of the detailed dimensions.
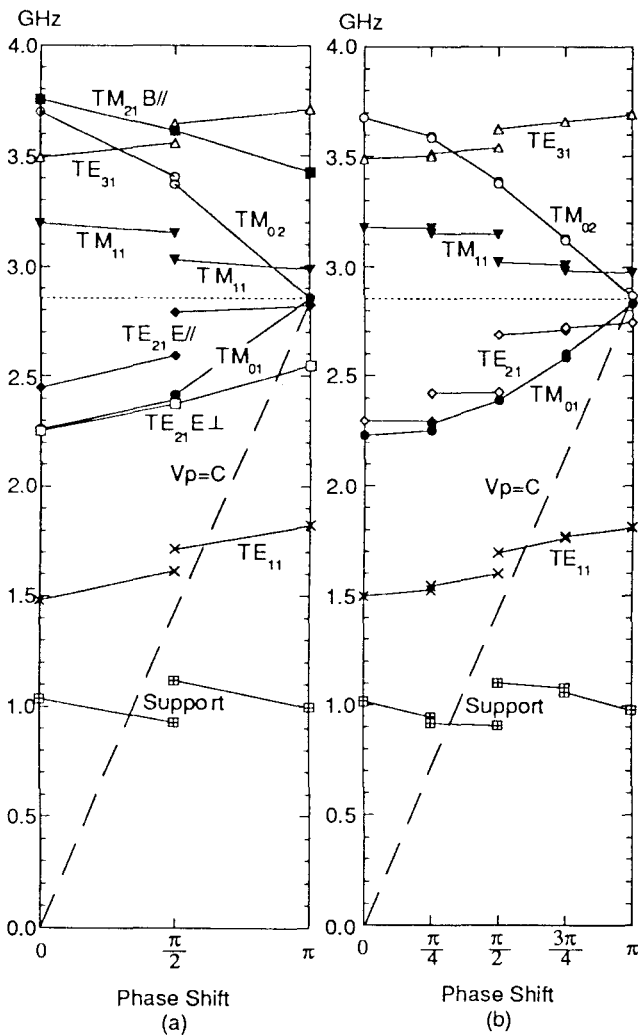
Acknowledgment

Fig. 4 The calculated dispersion curve of the DAW. The dotted line shows the operating frequency. The broken line shows the phase velocity is equal to the speed of light. (a) In-lined 4-T (b) Rotating 4-T

References

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