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A New Cavity Structure for Medium Energy Proton

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Abstract: A new structure ACDTL (Annulus Coupled Drift Tube Linac) for proton β from 0.2 to 0.5 was studied. The structure owns some advantages such as convenient manufacture, loose requirement of the manufacture errors, small volume and big coupling k_1. Through the test, some characteristics of the structure are gained. It will be helpful for the future accelerator design when this structure is adopted.

Key words: ACDTL, Cold model, RF measurement

INTRODUTION

In the past, for the proton's velocity from $0.1c$ to $0.5c$, the best structure to accelerate proton is the traditional DTL (Drift Tube Linac). For the higher speed proton, the SCL (Side Coupled Linac) is chosen. Because of the big volume and bad accelerating efficiency for higher speed proton, the applied field of the DTL is confined. So some new structures such as BCDTL (Bridge Coupled Drift Tube Linac)[1], CCDTL (Coupled-Cavity DTL)[2] and SCDTL (side coupled DTL)[1] were presented. Now we present a new structure ACDTL. The structure owns some advantages such as convenient manufacture, loose requirement of the manufacture errors, small volume and big coupling k_1. In the accelerator design, ACDTL can be used in the same energy range as the structure mentioned above. They are of the same merit that the magnet can be moved out from the drift tube. Therefore, these structures can be machined to be small and have larger shunt impedance. In

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addition, it is also conducive to the accelerator maintenance.

1 DESIGN OF ACDTL

The ACDTL model is simulated by SUPERFISH code. Its working frequency is 1300 MHz. The geometrical β is 0.283. Fig. 1 illustrates the cold model of the ACDTL. In the accelerating cavity, there is only one drift tube. Between the neighbour accelerating cavities is the axial symmetric coupling cavity. In order to ensure the field symmetry, mechanical intension and the cooling of the drift tube, two stems are used. The radius of stem is optimized to gain larger shunt impedance.

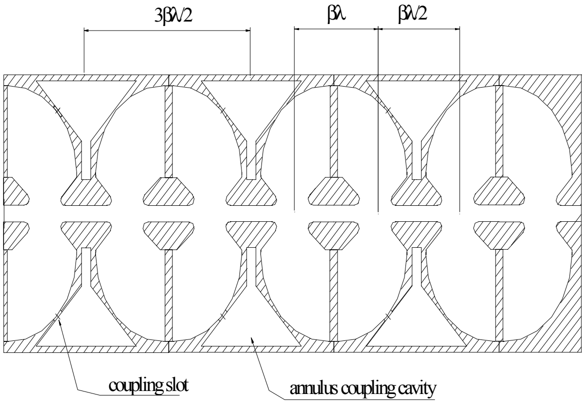

Fig. 1 Drawing of cold model

The parameters of coupling cavity in Fig. 2 are as follows: θ=45 degree, a=12 mm, b=51.5 mm, D=90 mm, d=7 mm. Through calculation, the coupling slot is located at r=35 mm where the magnetic field is bigger and change slowly and the electric field is smaller.

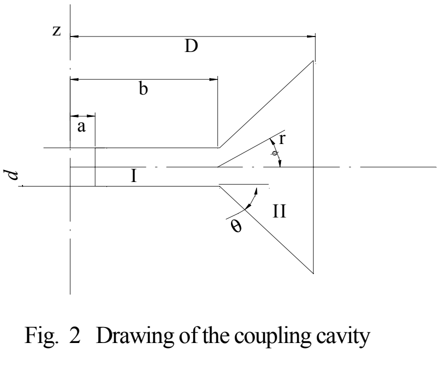

Fig. 2 Drawing of the coupling cavity

Obviously, It is magnetic coupling. In order to lower the transverse field asymmetry, there exists a 45 degree angle at azimuth direction between the coupling slot and drift tube stem. And at same time the coupling slots are staggered to reduce asymmetries. The width of coupling slot at the radial direction is 16 mm. The length of the coupling slot at azimuth direction is decided by the experiment. Bigger coupling slot area can produce bigger coupling k_1 and more stable field distribution, but it also gives rise to the power loss to make the shunt impedance decreased. So the real length of the coupling slot is gained through the experiment.

2 ACDTL COLD MODEL TEST

The cold model is made of aluminium. The basic unit consists of two half-accelerating cavities and a full coupling cavity.

The influence of the coupling slot is examined. Because the coupling slot lies in the strong magnetic field, so it can decrease the cavity frequency. But the decreasing value is difficult to calculate accurately. So the relations among the coupling k_1 and coupling slot area and frequency f are measured. Fig. 3 gives the relation between the k_1 and coupling slot area. In Fig. 4, f_1, f_2, $f_{\pi/2}$ mean accelerating cavity frequency, coupling cavity frequency and working frequency, respectively. So Fig. 4 shows that the same coupling slot produces the different change on f_1, f_2, $f_{\pi/2}$. The coupling slot can decrease the

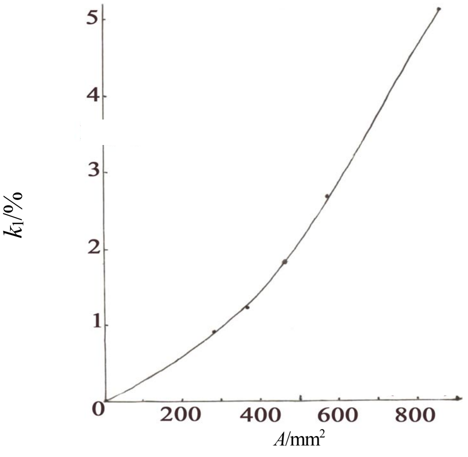

Fig. 3 k_1 verse coupling slot area

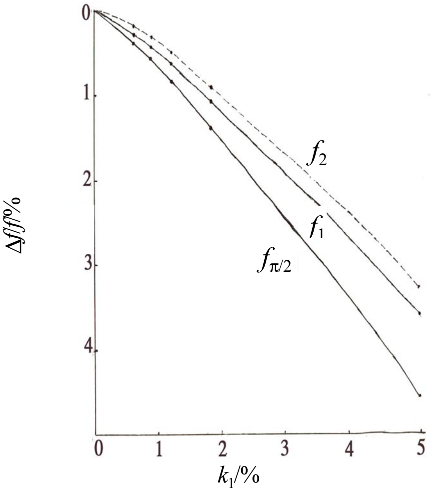

Fig. 4 $\Delta f/f$ verse k_1

quality factor Q and shunt impedance of the cavity. Although bigger coupling slot area can make working mode stable, it also increases the power loss. At last, the coupling k_1 of ACDTL model cavity is about 5%.

Using the network analyzer 8753C, the ACDTL model is tuned. Before tuning the whole model, we tune the basic unit firstly. Fig. 5 displays signal picked from the coupling cavity variation before and after the basic unit tuned. The lower picture of Fig. 5 indicates that the working frequency of the coupling cavity's neighbour accelerating cavities is equal. If the working frequency of a basic unit is tuned at 1300 MHz, the working frequency of two units is a little lower than that of one unit. So the working frequency of the basic unit should be adjusted a little higher than the working frequency of the whole model.

After the basic unit is tuned, the whole model will be tuned. As a biperiodical structure, the ACDTL has an accelerating cavity passband and a coupling cavity passband. Between the two passbands, there is usually a stopband. Through adjusting accelerating cavity passband or coupling cavity passband, the stopband can become smaller. The best result is stopband equal to zero. Fig. 6 displays the variation of dispersion curve before and after tuned. Fig. 7 shows the frequency spectrum of the model with half/full termination.

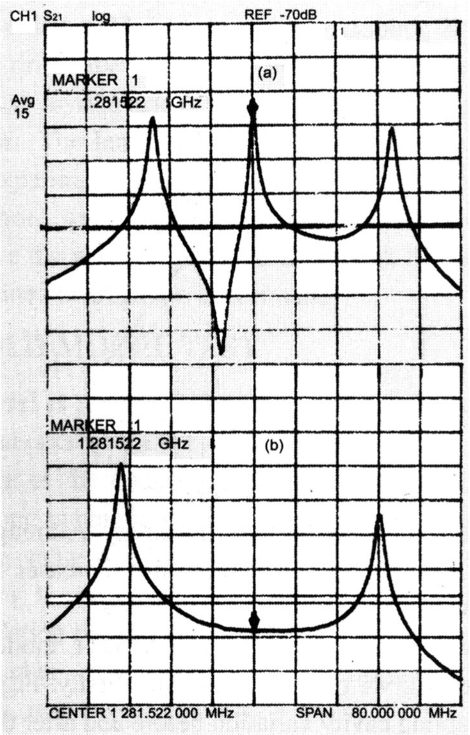

Fig. 5 The signal before and after tuned the unit

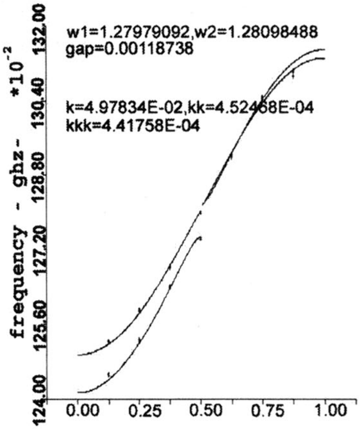

Fig. 6 The dispersion curve of the model

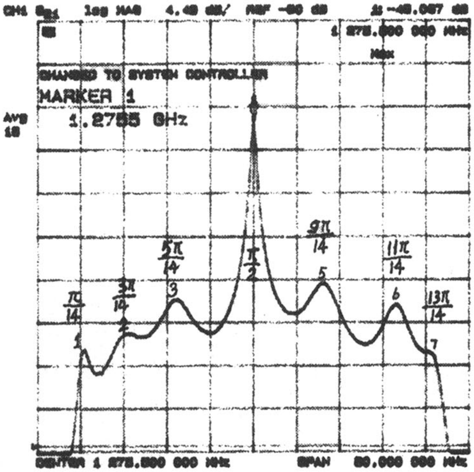

Fig. 7 The frequency spectrum of the model

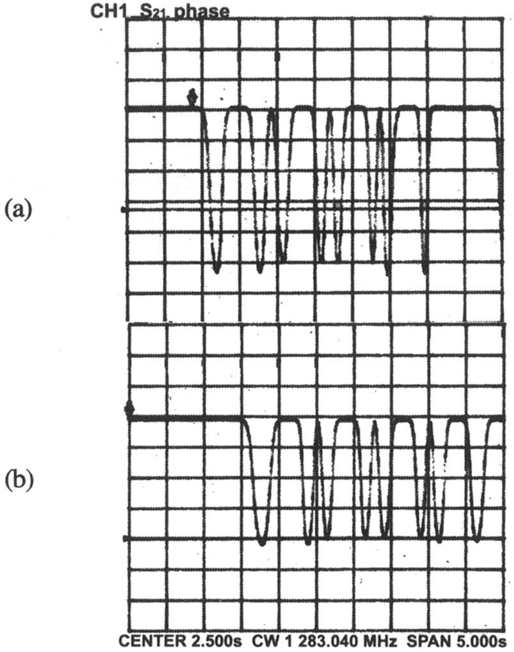

Fig. 8 Measured field profile in the whole model

The field profile is measured with bead perturbation method. The bead is a metal sphere with 3 mm diameter. Fig. 8 shows the measured field profile in the whole model along axis with full/full end cavity. When the working frequency of the both end cavities is decreased a little, the field profile of the model is improved. This can be seen from the lower picture of Fig. 8.

3 SUMMARY

A new structure ACDTL is presented. Using the cold model, the parameters of the new structure are measured. Because of its symmetry, ACDTL can be easily manufactured. However, it seems that this structure will be difficult to cool. So it can be used as an accelerator with lower duty factor, weak pulsed beam.

ACKNOWLEDGEMENT

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一种新中能质子加速结构的研究

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摘　要： 提出一种新的环耦合漂移管结构，它用于加速 β在 0.2～0.5 的质子。这种结构易于制造、加工公差要求低、体积小、可得到较大的耦合系数。采用这种结构，将有利于未来加速器的设计。

关键词： 环耦合漂移管　冷模型　射频测量