STUDY OF HIGH EFFICIENCY LINEAR ACCELERATOR STRUCTURE

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Abstract

A new type of traveling wave linear accelerator structure has been studied. This accelerator structure is based on the disk loaded structure increasing coupling slots on the disk. It has high shunt impedance, high Q value, high group velocity and low attenuation. Therefore this accelerator structure with the traveling wave resonant ring has high efficiency. Specially, for CW linacs or for the large beam current linacs, using this accelerator structure its efficiency can be reached as high as 90%.

The study was performed by means of computer codes SUPERFISH and MAFIA. The theoretical and experimental results of this study are presented.

Structure and Calculation

It is well known that for a disk-loaded accelerator structure parameters of shunt impedance R, group velocity Vg, Q value and attenuation α are functions of apeature 2a. They are shown on Fig. 1. If one wants to reduce apeature very small to get high R, it is impossible because of Vg and α changing rapidly that the energy can not propagate from one cell to the next cell. Our idea is that we punch some coupling slits on disks to increase the coupling. It makes the structure have the high shunt impedance R, high Q value, high group velocity Vg and low attenuation α. Its structures are shown on the Fig. 2. At first we calculate the type (a) using SUPERFISH code. The symbols a, b, D and t are as usual , rc is the radius of the center of the coupling slit and Δr is the width of the coupling slit. The Fig. 3, Fig. 4, Fig. 5 and Fig. 6 show the results of calculation.

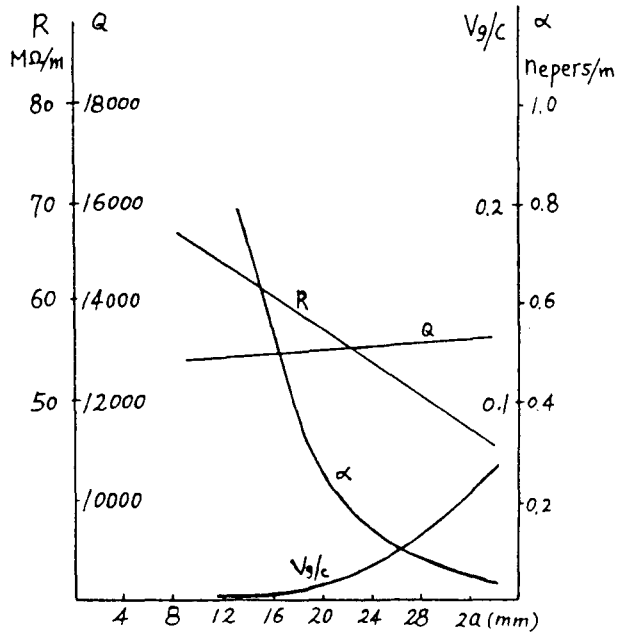
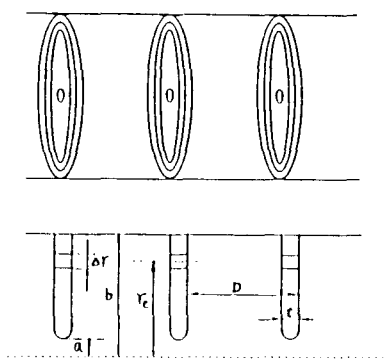
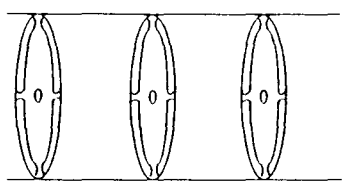


Fig. 1 Parameters of disk loaded



Type (a)



Type (b)

Fig. 2 Structure of test cavities

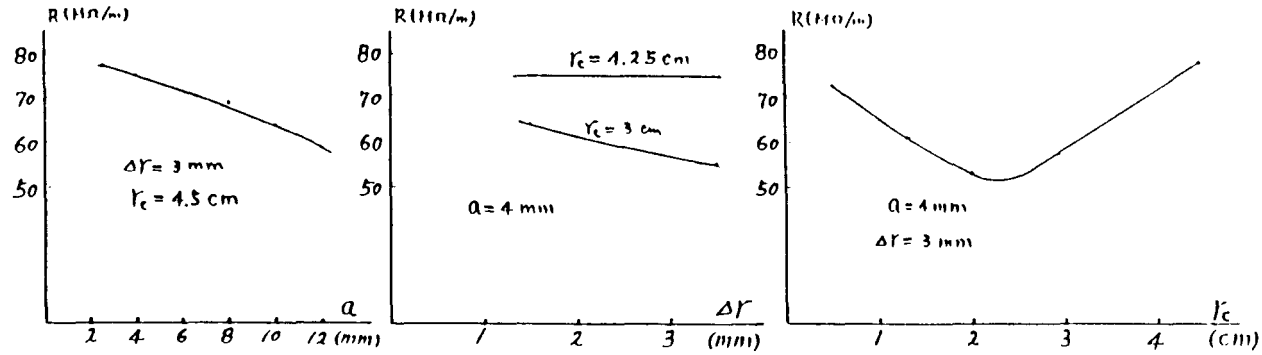


Fig. 3 Shunt impedance as functions of a, Δr and rc

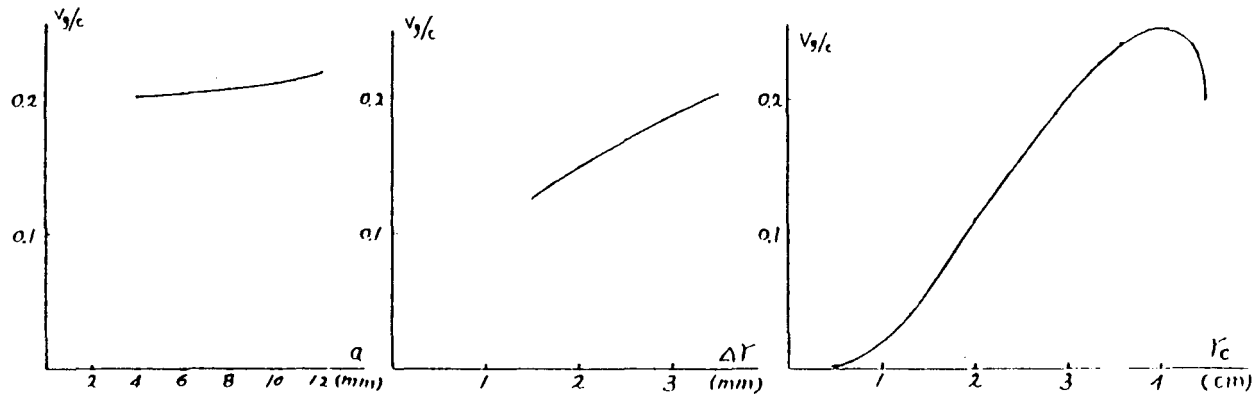


Fig. 4 Group velocity as functions of a, Δr and rc

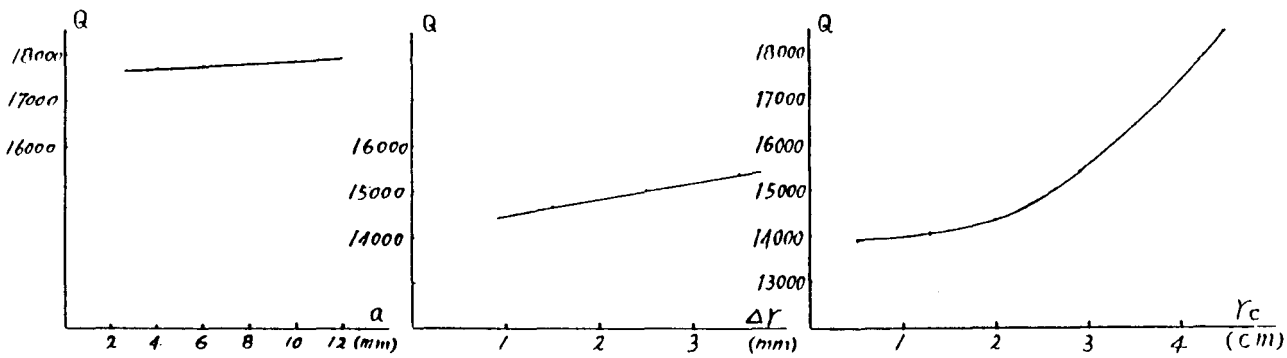


Fig. 5 Q value as functions of a, Δr and rc

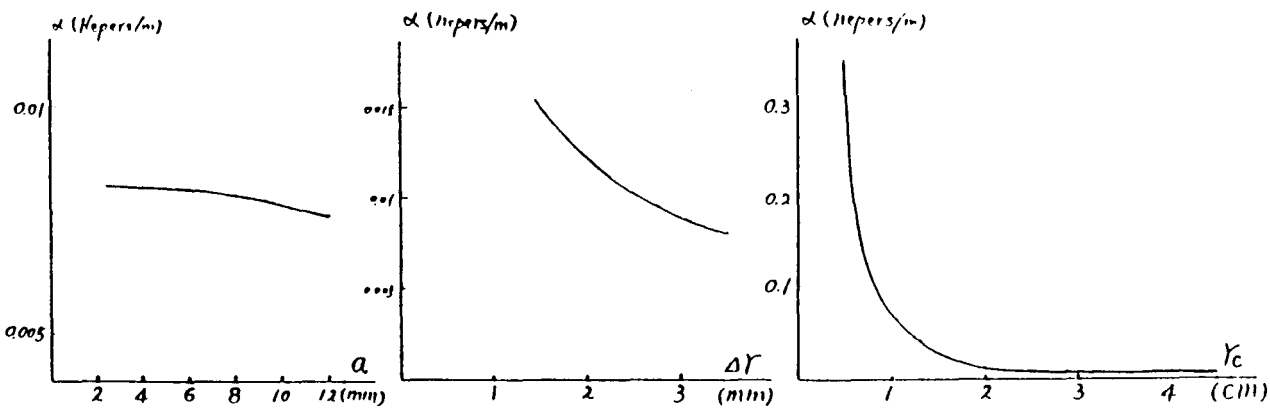


Fig. 6 Attenuation as functions of a, Δr and rc

Fig. 3 shows the shunt impedance R as functions of a, Δr and rc. R increases with decreasing a; R has a minimum when the coupling slit located at the middle of the disk and a maximum when the slit located at the side of the disk; when Δr increasing R decreases except that R is a constant nearly when the slit located at the side of the disk.

From above results we found that the structure in which the coupling slit located at the side of cavity ($rc=b-\Delta r/2$) is the best. It has high shunt impedance, high group velocity, high Q value and low attenuation. The accelerator using this structure has high efficiency. So we call it HELAS (High Efficiency Linear Accelerator Structure). The parameters of HELAS are shown on the Table 1.

Table 1. Parameters of HELAS

a mm	Δr mm	R MΩ/m	Vg/C	α neper/m	Q
2.5	3.0	77.32	0.2040	0.00824	17760
4.0	3.0	75.10	0.2040	0.00821	17760
6.0	3.0	71.32	0.2058	0.00818	17790
8.0	3.0	66.60	0.2083	0.00806	17820
10.0	3.0	61.30	0.2126	0.00787	17860
12.0	3.0	56.08	0.2198	0.00763	17910

Because SUPERFISH can not calculate the three-dimension cavity shown on Fig. 2 type (b). We use MAFIA code to calculate it. In order to compare we calculate three types cavities (including type (c)-disk loaded). The results are shown on the Table 2.

Table 2. Results of Calculation

Type	(a)	(b)	(c)	Code
Vg/C	0.2348		0.0078	SUPER
	0.1904	0.2400	0.0035	MAFIA
R	75.10		62.2	SUPER
	51.30	33.5	51.5	MAFIA
Q	18510		13900	SUPER
	12200	12340	9990	MAFIA
α	0.0069		0.23	SUPER
	0.0124	0.0103	0.86	MAFIA

From Table 2 we can see that there are some difference results between by MAFIA and SUPERFISH calculation. According to MAFIA calculation the shunt impedance R, group velocity Vg and Q value are lower than that by SUPERFISH calculation.

Results of the experiment

A set of test cavities (type (a), disks supported by dielectric poles, Δr = 4mm, a = 4mm) has been manufactured. The ratio of the shunt impedance R to Q, Q value and frequencies of various modes are measured. The results are shown on Fig. 7 and Table 3. We can see that R/Q, Q value and frequencies measured are agreeable to that calculated by SUPERFISH code. Only Q value is lower than calculated. There are some dielectric losses. It is reasonable.

If we use the HELAS with traveling wave resonant ring to design a CW linac, the efficiency of the accelerator can get as high as 90%. It is very useful.

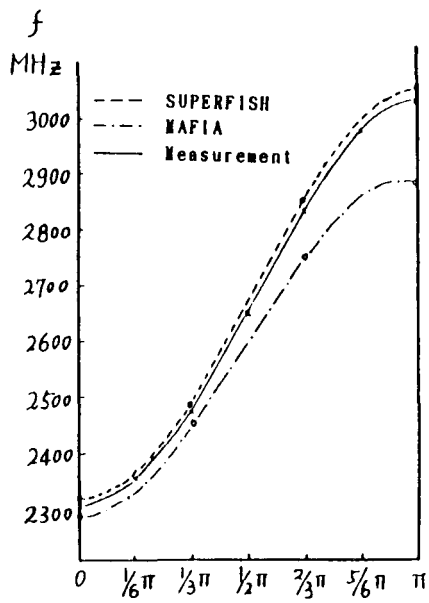


Fig. 7 Brillouin diagram of HELAS

Table 3. Results of experiment

	Ro/Q	Vg/C	Q
SUPERFISH	4057.2	0.2348	18510
MAFIA	4204.9	0.1924	12200
Measurement	3982.9	0.2300	13250