ISBN: 978-3-95450-203-5 doi:10.18429/JACoW-HIAT2018-WEPB13

A NEW RF STRUCTURE: BENT-VANE TYPE RFQ*

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Abstract

A new cavity structure of RFQ accelerator with bent vanes is proposed to meet the miniaturization requirement of low frequency accelerators. The new structure has a downsized cross section by bending vanes while keeping a certain vane lengths. It also possesses the advantages of simple cooling structure in low frequency field. The new structure has obvious advantages in reducing manufacturing difficulty of cavity, cutting down project cost, enhancing facility reliability and stability.

INTRODUCTION

Radio frequency quadrupole (RFQ) can accelerate, focus and bunch particle beam in the low energy field, which is generally used as an injector for high energy accelerator. Four-rod type and four-vane type are main RFQ accelerator structures. Four-rod RFQ is used in the low frequency field and four-vane RFQ is applied in the high frequency field [1]. However, the cooling structure of four-rod RFQ is quite complex so that it is difficult to design and machine cavity and the lateral dimension of four-vane RFQ is large in the low frequency band which increases machining difficulty and cost [2]. In addition, four vane with windows RFQ can decrease the cross-section length in the low frequency band, but its cooling structure is extremely complicated and the windows can directly influence mechanical strength of the cavity and electric field flatness.

In order to overcome the disadvantages of above three kinds of RFQ accelerators, a new RFQ structure is proposed called bent-vane type RFQ at Institute of Modern Physics (IMP), Chinese Academy of Sciences. It significantly reduces the lateral dimension of the cavity in the low frequency field and has a water-cooled system with a simple structure and sufficient cooling efficiency. The RF structure of bent-vane RFQ is presented in this paper.

THEORETICAL FOUNDATION

Considering an ideal four-vane RFQ with a cloverleaf geometry (Fig. 1), its equivalent circuit is shown in Fig. 2 [1]. According to the equivalent circuit, the cavity quadrant radius is

$$r^2 = \frac{16}{\mu_0(4+3\pi)\omega_0{}^2 C'}$$

where ω_0 is the resonant frequency, C' is the total capacitance per unit length and μ_0 is the permeability constant. This equation indicates that the lateral dimension can be decreased by increasing the capacitance at a fixed frequency.

Based on the discussion above, the vanes of four-vane RFQ are bent to increase the capacitance for reducing the lateral dimension of cavity. Hence, a new RFQ structure is proposed called bent-vane type RFQ, shown in Fig. 3.

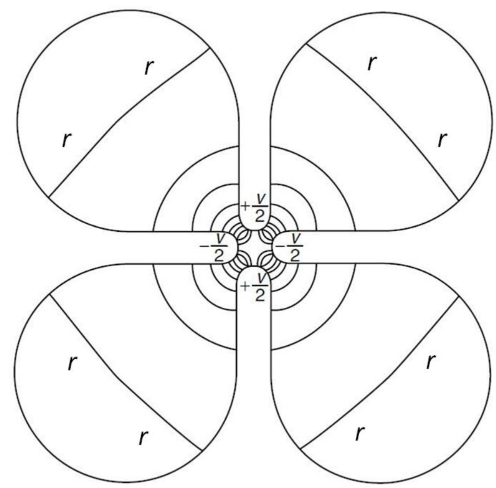

Figure 1: The ideal four-vane RFQ with a cloverleaf geometry.

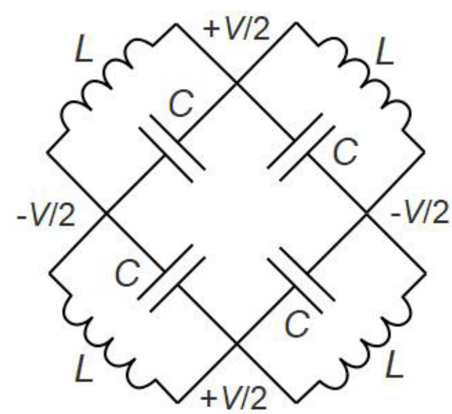

Figure 2: The equivalent circuit of the ideal four-vane RFQ with a cloverleaf geometry.

RF STRUCTURE

In order to obtain suitable lateral dimension and quality factor of bent-vane RFQ, the cross-section profile of bent-vane RFQ is put forward with 13 independent variables, shown in Fig. 4.

* Work supported by Natural Science Foundation of China (Grant No. 11675236, 11475232 and 11535016)
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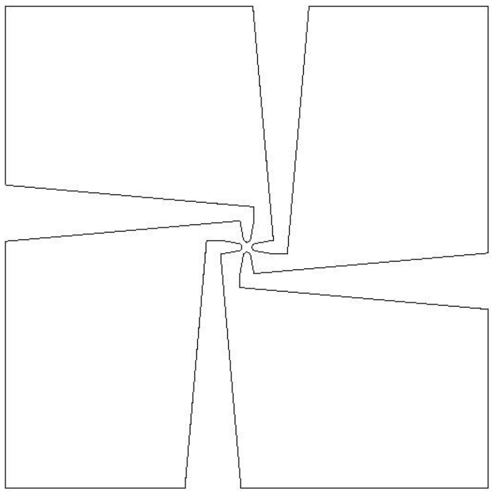

Figure 3: The schematic diagram of the bent-vane type RFQ.

r_0, ρ and α_1 are defined in the code RFQGen [3]. The other parameters can be optimized by ourselves using CST MWS [4]. Keeping frequency constant (81.25 MHz), it is explored that the other ten parameters have an impact on the lateral dimension, quality factor and shunt impedance of cavity, shown in Fig. 5 (only presenting four parameters). The optimization valves of the parameters of cross-section are listed in Table 1. The RF structure of bent-vane RFQ is shown in Fig. 6.

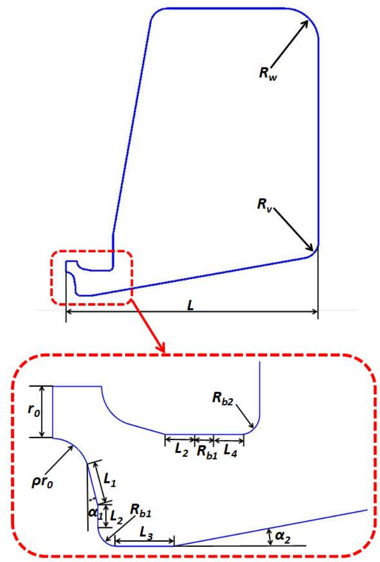

Figure 4: The cross-section of bent-vane RFQ.

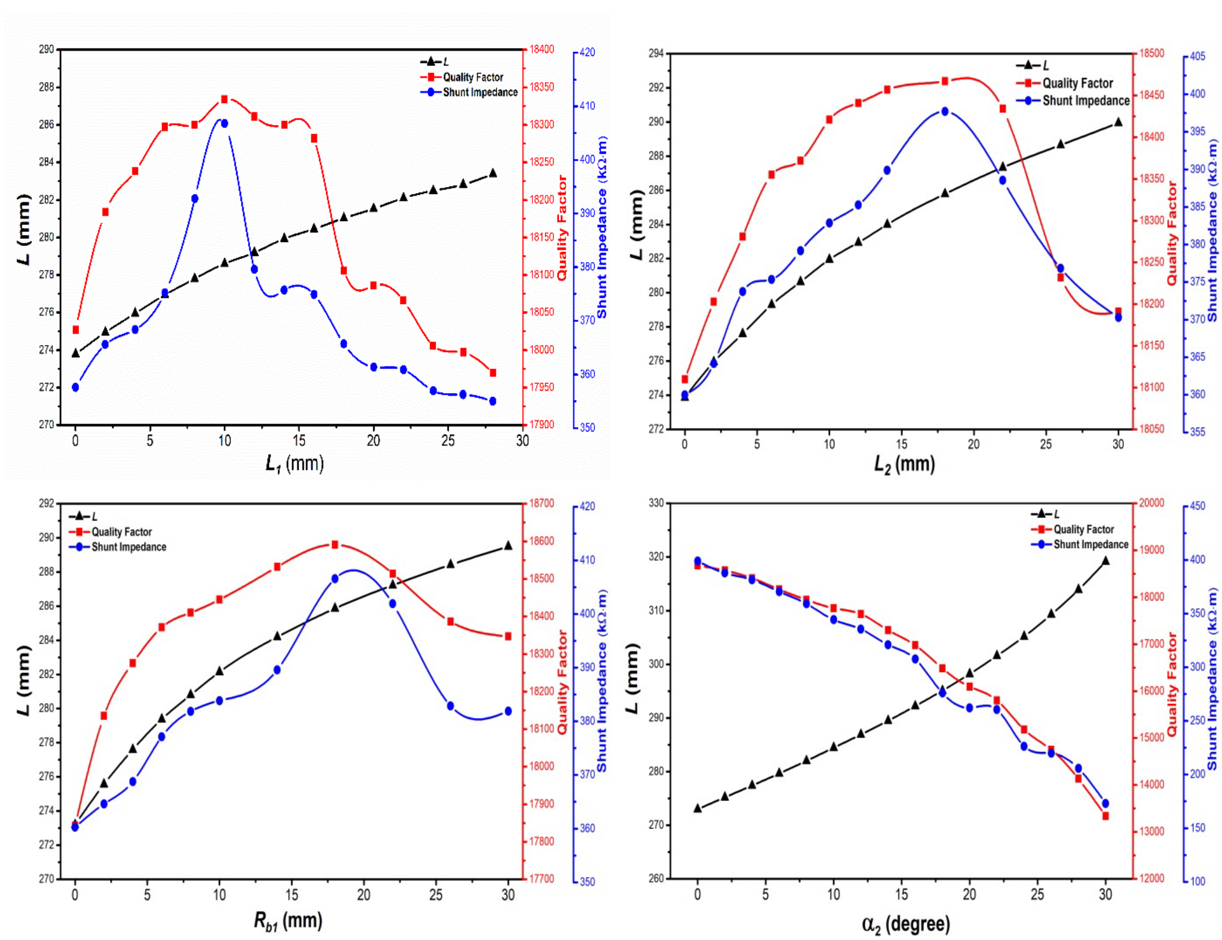

Figure 5: The variation of the lateral dimension, quality factor and shunt impedance of bent-vane RFQ as the functions of the parameters of cross-section profile (only presenting four parameters).

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Table 1: The Cross-Section Parameters of Bent-vane RFQ

Parameter	Value	Parameter	Value
r_0	5.347 mm	L	279 mm
ρ	0.75	R_v	20 mm
α_1	10 Deg.	α_2	5 Deg.
L_1	10 mm	R_w	40 mm
L_2	5 mm	L_4	10 mm
R_{b1}	5 mm	R_{b2}	5 mm
L_3	10 mm		

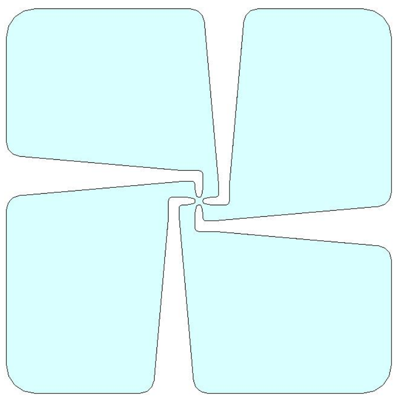

Figure 6: The RF structure of bent-vane RFQ.

CONCLUSION

A new RF structure of RFQ accelerator is proposed called the bent-vane type RFQ. The new structure has a downsized cross section by bending vanes while keeping a certain vane length. It also has the simple cooling structure. The research cavity frequency is 81.25 MHz. The cross-section profile is defined with 13 independent variables. The optimization valves of the parameters of cross-section are verified to the RF structure of the bent-vane RFQ.

ACKNOWLEDGEMENTS

This work is supported by the National Natural Science Foundation of China (Grant No. 11675236, 11475232 and 115350).

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