DESIGN OF DC POTENTIAL INPUT INTO H-TYPE RESONATOR

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The using of electrostatic potential is one of possible methods to realize more efficiently beam acceleration and focusing in low energy ion linac. For example, the additional beam focusing can be realized if dc potentials are supplied to the same electrodes which are used to excite RF field. But the input system of dc potential can make worse electro- dynamic characteristics of H-type resonator. In this paper the optimal design of dc potential input into H-type cavity is suggested.

PACS: 29.17.w, 29.27.Bd

1. INTRODUCTION

Nowadays a number of papers appeared, where it is suggested to use RF field jointly with dc potential in resonator of accelerator.

In [1] it was considered undulator linear accelerator with the electrostatic undulator (UNDULAC-E). The beam acceleration and focusing in such system are realized by the force which is to be driven by combination of two non-synchronous spatial harmonic (RF and electrostatic field). In UNDULAC with electrostatic undulator it is possible to accelerate ribbon ion beam.

In [2] it was suggested to use the dc field with sequence of potential between drift tubes for increasing of focusing efficiency of low energy beams. Supply of electrostatic potential to even drift tubes was designed through blocking capacity. The efficiency of beam focusing increased using of such structure.

Also, was undertaken several attempts of using dc field for the multipactor breakdown control.

The efficiency of intensive low energy ion beam focusing can be increased by using of electrostatic potential. In the same way it is reduce possibility of electron avalanche appearance as a result of resonance condition violation.

In this article a several different types of the electrostatic potential inputting into resonator are studied.

This article deals with two interdigital H-type resonators: conventional IH-resonator (see Fig.1) and double IH-resonator (also called H funneling resonator) with frequency 150 MHz and π mode of oscillation. These structures will be compared by electrodynamics efficiency: quality Q and shunt impedance R_{sh}.

2. IH RESONATOR

The computer simulation of RF field distribution in common IH-resonator was done and electrodynamics characteristics of structure were calculated. The general view of resonator is shown in Fig.1.

Q-factor and shunt impedance of resonator without dc input are Q=10940 and R_{sh}=100 MOhm/m.

Further several types of dc inputs into resonator were studied. The first stage is the degenerated capacitor (see Fig.2,a). One of the vanes there is attached to even drift tubes and has no galvanic contact with resonator.

The capacity design in Fig.2,b is formed by wider sides of two parallel vanes. One of them is attached to the even drift tubes and has no galvanic contact with resonator. Another is attached to resonator and has no contact with drift tubes.

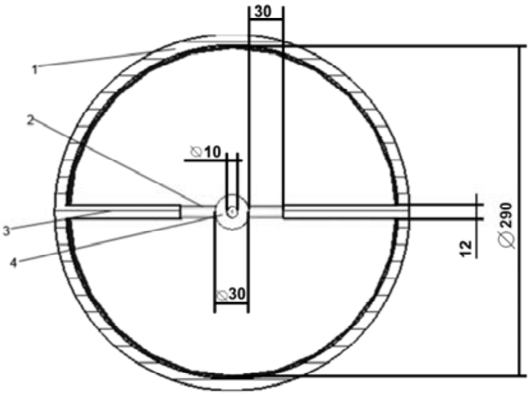


Fig.1. IH-resonator without electrostatic potential input. Front view: 1 – resonator; 2 – tube holders; 3 – vanes; 4 – drift tubes

The design in Fig.2,c is similar to Fig.2,b, but the capacity at Fig.2,c is constructed by the sides of three parallel vanes. Two of them are attached to the resonator and has no contact with drift tubes.

The construction showed in Fig.2,d is a plane capacitor. One of its plate is a T-shaped vane, to which the even drift tubes are attached, the second plate is the resonator’s side.

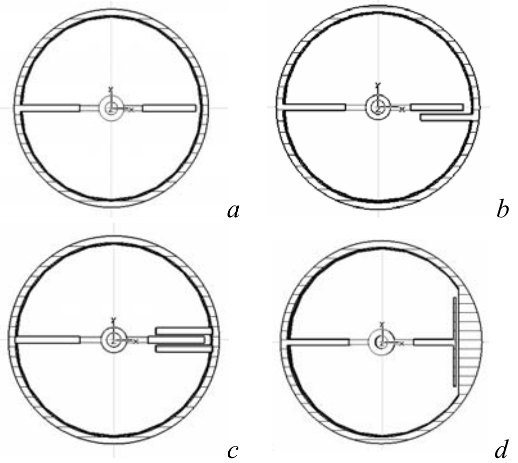


Fig.2. IH-resonator with separator capacity. Front view. a – vane-resonator; b – double-vanes; c – three wanes; d – plate capacity

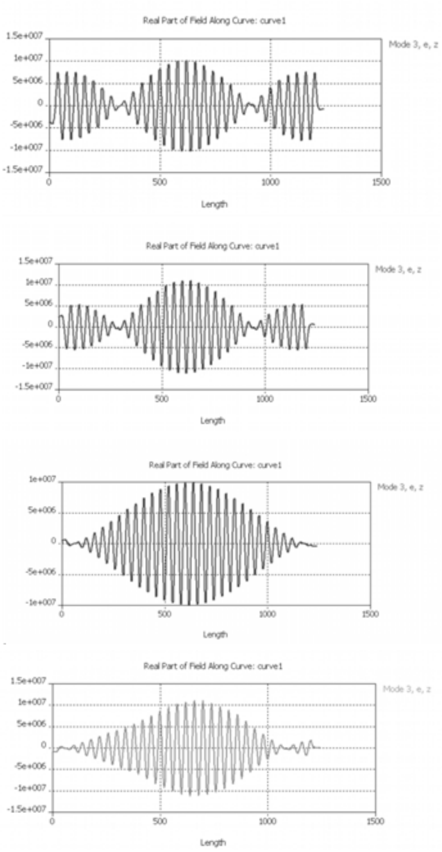
Computer simulation of RF field distribution in such constructions was done. The distribution of field on longitudinal axis of accelerating-focusing canal was

PROBLEMS OF ATOMIC SCIENCE AND TECHNOLOGY. 2010. № 3.
Series: Nuclear Physics Investigations (54), p.54-56.

derived and electrodynamics parameters structure were calculated. The designs of vane-resonator and double-vanes can not be used for acceleration because there are no π mode oscillations (see Fig.3,a,b). In constructions with three vanes and resonator with plate capacity π mode oscillation on actual mode is realized and acceleration in such structure is possible (Fig.3,c,d). However, after comparing Q-factors of this designs the resonator with plate capacity has the more efficiency with Q=7550 (Quality of construction with three vanes is Q=5000).

Therefore, to input of electrostatic potential in IH-resonators it is appropriate to use the design of resonator with plate capacity.

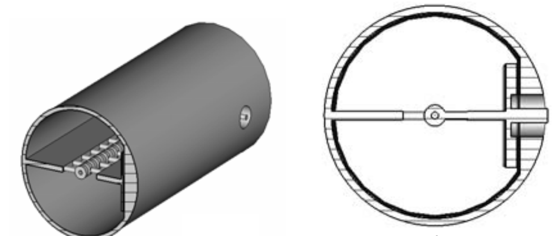
Two contacts in resonator side which are distant from each other on λ/2 are showed in Fig.4. They are used to supply the electrostatic potential into the resonator. The internal hole diameters for contacts are chosen basing on breakdown strength and exclusion radiation from them. The choke groove was used (see Fig.4) to decrease the radiation from supply hole. Computer simulation of RF fields in resonator with two contacts supply and choke groove was done and the fields distribution and electrodynamics characteristic were calculated. The radiation from supply hole was suppressed because of choke groove using in commeasure of contacts and T-shaped vane. It is clean by distribution of H-field showed in Fig.5.



a b c d

Fig.3. Distribution of E-field on longitudinal axis in double-chamber H-resonator with blocking capacity a – vane-resonator; b – double-vanes; c – three wanes; d – plate capacity

As result the quality of structure with supply has decreased slightly: Q=7350. The calculated shunt impedance is equal to R_{sh}=50 MOhm/m.



a b

Fig.4. IH-resonator with electrostatic input. a – general view; b – front view

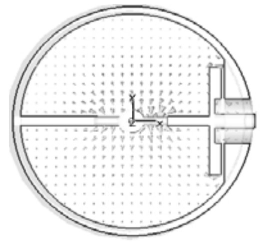


Fig.5. Distribution of H-field in IH-resonator with electrostatic input and the choke groove. Front view

3. H FUNNELING RESONATOR

H funneling resonator was studied also (see Fig.6). Computer simulation of RF field distribution without electrostatic potential supply was done initially, and electrodynamics characteristic were calculated.

Quality and shunt impedance of H-type resonator without supply are Q=9800, R_{sh}=80 MOhm/m.

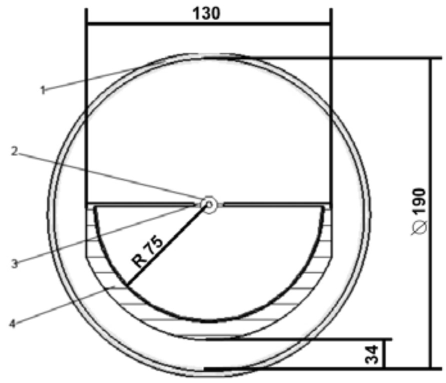


Fig.6. H funneling resonator without electrostatic input. Front view. 1 – resonator; 2 – drift tubes; 3 – vanes; 4 – inner resonator

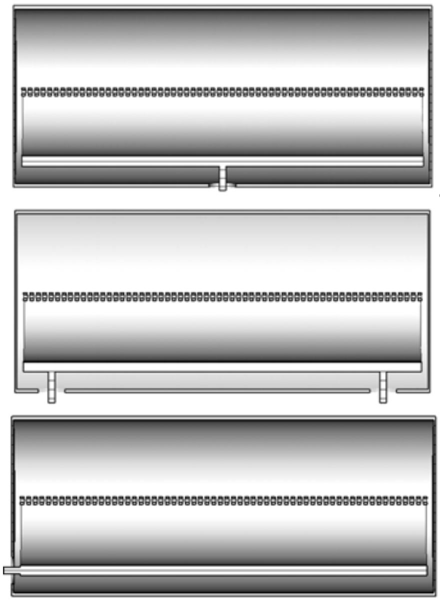
Three types of electrostatic potential supply in this H-resonator were considered. H-resonator with one supply in the center of resonator side is presented in Fig.7,a. Supply contact is placed vertically below of inner resonator. Two supplies at side which distant from each other on λ/2 are shown in Fig.7,b. Supply contact is placed vertically below of the inner resonator. The upply at the end surface is shown in Fig.7,c. The supply contact is placed horizontally on inner resonator level.

Computer simulation was done to define the optimal design of H funneling resonator with electrostatic potential supply. The computer simulation of RF field distribution and electrodynamics parameters were considered.

The RF field distributions are distort by contact supply and supply holes. But this distortions are more sufficiently in cases with one supply at the center of side (Fig.8,a) and one supply at the end surface (Fig.8,c) comparatively with two supply at sidewall which distant from each other on λ/2 Fig.8,b.

As a result of introduced distortions qualities of structures were fallen. The minimal decreasing is for design with two contacts supply (Q=8900, R_{sh}=80 MOhm/m).

In such way the construction with two contacts supply at resonator side which distant from each other on λ/2 is optimal for H funneling resonator.



a

b

c

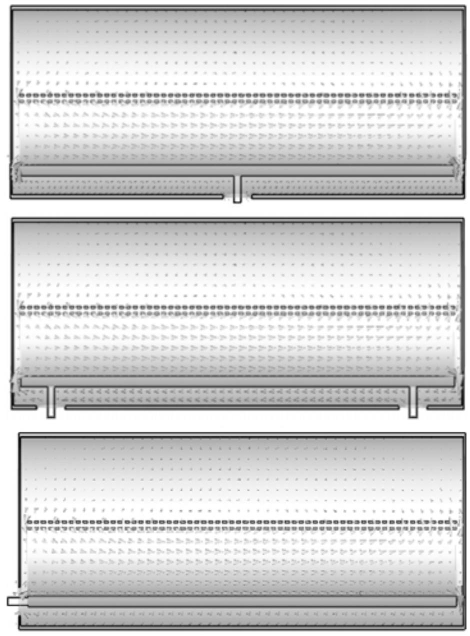
Fig.7. H-resonator, with:
a – one supply at center of side; b – two supply at side which distant from each other on λ/2;
c – supplies at end surface. Side-view

CONCLUSIONS

The several types of electrostatic potential input into H-type resonator were described. Most effective accelerating structure design is defined by electrodynamics efficiency and construction simplicity.

Optimal accelerating structure without electrostatic potential is IH-type resonator. It has high quality, low loss and simple to construct, as against H funneling resonator.

In structures with electrostatic input electrodynamics efficiency is higher in H funneling resonator. The quality and shunt impedance fall is not so like for IH-resonator.



a

b

c

Fig.8. Distribution of H-field in H funneling resonator with a – one supply at center of side; b – two supply at side which distant from each other on λ/2;
c – supply at end surface. Side-view

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Статья поступила в редакцию 09.09.2009 г.

КОНСТРУКЦИИ СИСТЕМЫ ВВОДА ЭЛЕКТРОСТАТИЧЕСКОГО ПОТЕНЦИАЛА В РЕЗОНАТОРЫ Н-ТИПА

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Использование электростатического потенциала является одним из возможных методов более эффективного ускорения ионов в линейном ускорителе на малую энергию. Например, дополнительную фокусировку пучка можно реализовать, если постоянный электростатический потенциал подавать на те же самые электроды, на которые подается ВЧ-потенциал. Но система ввода постоянного потенциала может существенно ухудшить электродинамические характеристики резонатора Н-типа. Предложена оптимальная конструкция системы ввода электростатического потенциала в такой резонатор.

КОНСТРУКЦІЇ СИСТЕМИ ВВЕДЕННЯ ЕЛЕКТРОСТАТИЧНОГО ПОТЕНЦІАЛУ В РЕЗОНАТОРИ Н-ТИПУ

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Використання електростатичного потенціалу є одним з можливих методів більш ефективного прискорення іонів у лінійному прискорювачі на малу енергію. Наприклад, додаткове фокусування пучка можна реалізувати, якщо постійний електростатичний потенціал подавати на ті ж самі електроди, на які подається ВЧ-потенціал. Але система введення постійного потенціалу може суттєво погіршити електродинамічні характеристики резонатора Н-типу. Запропоновано оптимальну конструкцію системи введення електростатичного потенціалу в такий резонатор.