INVESTIGATION OF THE HIGH ORDER MODE (HOM) FIELD DISTRIBUTION IN THE BEGINNING PART (30 CELLS) OF THE SBLC ACCELERATING STRUCTURE *

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Abstract

The field amplitude distribution for the trapped dipole modes in the initial part (30 cells) of the SBLC accelerating section has been studied experimentally. The decreasing of the trapped modes Q-factor in the initial part of the section has been realized by means of the coupler own frequency variation and subsequently measured. The input coupler own frequencies in the dipole modes' band were measured.

1. INTRODUCTION

Excitation of the trapped high order modes in travelling wave accelerating structures is a big problem to save the required beam parameters. It is particularly important for the case of the collider high power sections where requirements to the emittance are very strict [1].

There are various conceptions of diminishing the trapped modes influence on the beam dynamics in the disk loaded waveguide (DLW) accelerating structures. The geometry of accelerating structure could be chosen so that the hybrid mode frequencies in separate cells were detuning [2]. But this method doesn't always give the desired result so other techniques for the trapped modes damping are to be considered. Substantial efforts were spent at some laboratories on the development of the hybrid mode RF-power withdrawal device, the power from DLW cell being withdrawn into matched loads by means of cell narrow slot dimensions choice [3]. It should be noted that this method don't provide the required damping of the hybrid modes. Recently a preference is given to the single mode manifold design [4] and to the lossy-cells (the coating of the irises with an absorbing material) [5].

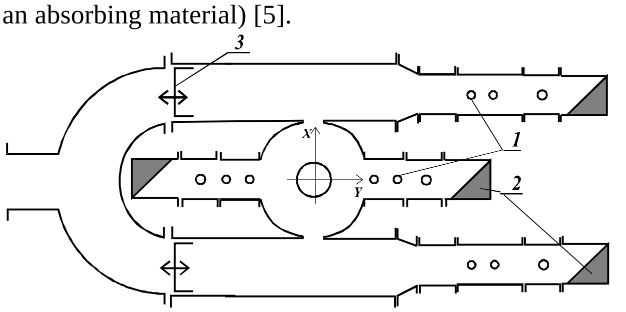

Fig.1 Plan of the investigated input coupler (1 - tuning pins; 2 - absorbing loads; 3 - short-circuiting plungers).

One more technique of the trapped modes damping is proposed to use the hybrid coupler [6]. It has been designed on the basis of the input coupler with addition the coupling holes for withdrawing the Y-polarized mode (see Fig.1). This technique is a rather complicated one because the input coupler serves mainly for the high level RF power feed into the accelerating section. Hence in addition to the high order modes damping it is necessary to secure the coupler matching at the operational frequency. Works in that direction were carried out on the SBLC accelerating section [7]. The dispersion relations of the first cells of that section as well as the field distributions in these cavities, calculated by MAFIA code, indicate that the structure is predisposed to the emergence of two types of HOM: TM_{11} near p-mode and TE_{11} near 0-mode. That also complicates the task of damping by means of the hybrid coupler in the passband of the dipole modes' dispersion relation curve.

Taking into account all possible complications it is expedient to study thoroughly the conception of trapped modes damping in the initial 1m length section of the SBLC by means of the input hybrid coupler.

2. HIGHER ORDER MODE FIELD AMPLITUDE DISTRIBUTION

At first, the trapped modes were studied in the existing real section with the symmetric coupler matched to the structure at the fundamental mode. The aim was to find out how the high order modes are positioned inside the section if nothing is done on their damping. Measurements were carried out by the small perturbation method by means of moving a thin cylindrical body (0.1 mm diameter and 8 mm length) along the accelerating structure at the distance 3 mm from the symmetry axis. The obtained field distributions are shown in Fig.2. It is seen how the HOM fields are being trapped in the constant gradient structure. The first trapped mode shows up at the frequency F=4130 MHz. It is positioned over five initial cells and has a p-like mode distribution. With this there is no a longitudinal field component in the coupler cavity. The last mode fully trapped in the structure under investigation has the frequency F=4161 MHz. In this case the p-like mode occupies from 24 to

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30 cells and is being transformed along the structure toward the input coupler where at this frequency the field is just beginning to show up.

At higher frequencies (F=4164÷4194MHz) the field penetrates into the coupler cavity and has the amplitude which is comparable with that in the neighbouring cells, but at that p-like mode should be in cells with number more than 30 (see Fig.2). At frequencies higher than 4194 MHz the field amplitudes are reduced in the first cells.

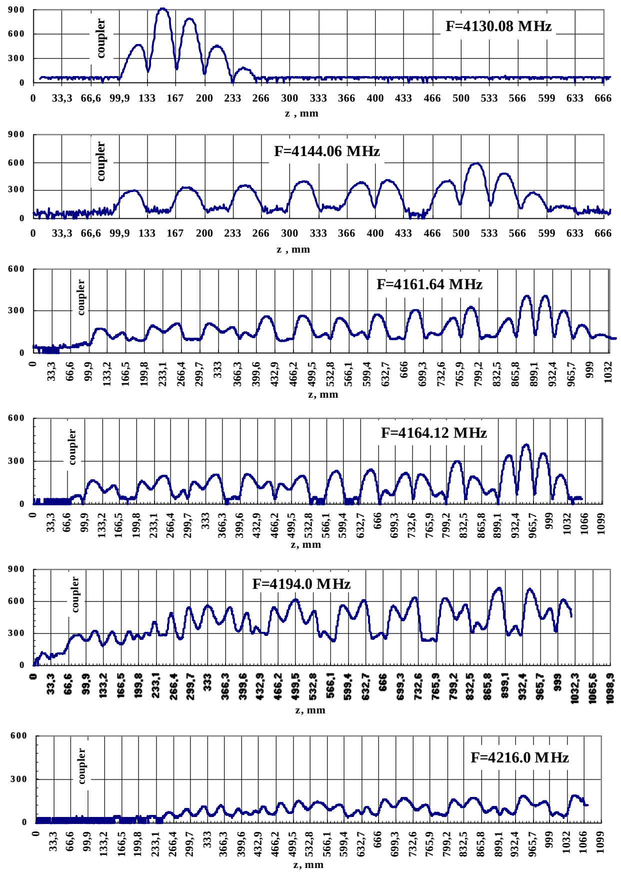

Fig. 2 The longitudinal electric field amplitude distribution (in units) in the 30 cells' SBLC structure for different frequencies of first dipole frequency band.

It means that at those frequencies the section initial part itself begins to trap the dipole modes. The results of the calculation of the trapped modes' field normalized amplitude for the accelerating structure under consideration and at various frequencies are presented in other article at this conference [8].

Hence, it is clear that the own frequencies of TM_{11}-type dipole modes of the coupler cavity differ from those of SBLC structure first cells and supposedly lie in the frequency band 4164÷4194 MHz and higher. So for providing the coupling of the first dipole modes with the input waveguides through the coupler cavity it is necessary to correlate the coupler cavity dipole modes frequencies with those of the section first cells.

3. INFLUENCE OF THE COUPLER CAVITY OWN FREQUENCY ON THE DIPOLE MODES FIELD DISTRIBUTION ALONG THE STRUCTURE.

The study of the influence of the coupler cavity own frequency on the dipole modes field distribution was carried out with the structure having the coupler, the frequency of which could be varied over the range 30-40 MHz are presented in Fig. 3. It can be seen that the field amplitude in the coupler increases with decreasing of its

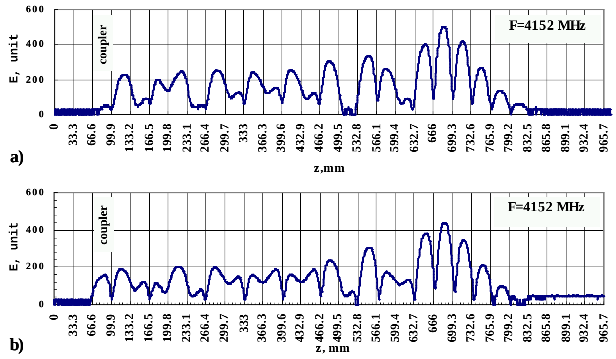

Fig. 3 The variation of the electric field amplitude in the coupler cavity in respect to the own frequency of input coupler: a). unchanged input coupler; b). the own frequency of the coupler was reduced on 30 MHz.

own frequency and that the standing wave pattern in the first cells changes a little. It confirms that the coupler cavity has its influence on the field distribution at this frequency. The Q-factor value lies in the range 7000-8000 when the short-circuiting plungers are used instead of the dissipating loads (Fig.1). With the loads it equals 5700. By means of changing the distance from the X-axis to the Y-junction (i.e. the short-circuiting plane position for the dipole modes) and using the tuning pins (Fig.1) the Q-factor value was reduced to the value Q=2080.

The obtained Q-factor dependence on the frequency F at minimal Q-value at certain frequencies is shown in Fig.4. It is clear that by decreasing the coupler cavity own frequency by about 25 MHz and using tuning elements in front of the matched loads it is possible to diminish the Q-factor of the trapped modes lower than 4000 over the frequency band about 20 Mhz.

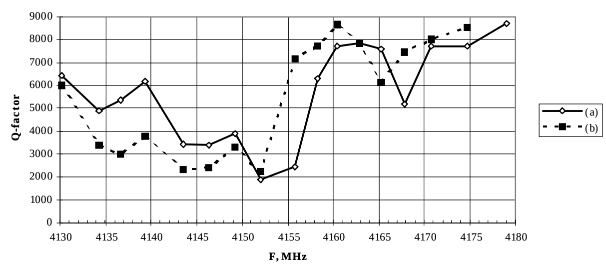

Fig.4 External Q-factor of the 30 cells' SBLC structure in the HOM frequency band for cases of the X-

polarization optimal tuning of input coupler at the frequencies 4152 MHz (a) and 4146 MHz (b).

In case of using so called “hybrid” coupler [6] which has forth coupling slots (two slots for the fundamental mode and dipole modes with X-polarization and two other slots for the dipole modes with Y-polarization) the additional coupling slots would lead to the coupler cavity own frequency decreasing by the value which is more than required one. At the same time the different width of coupling slots would result in the discrepancy of the coupler own frequencies for one dipole mode with different polarizations by about 50-70 MHz. It is demonstrated in Fig.5, where one can see that it is possible to reduce the external Q-factor value of the trapped modes with Y-polarization and at the same time to keep unchanged the modes with X-polarization.

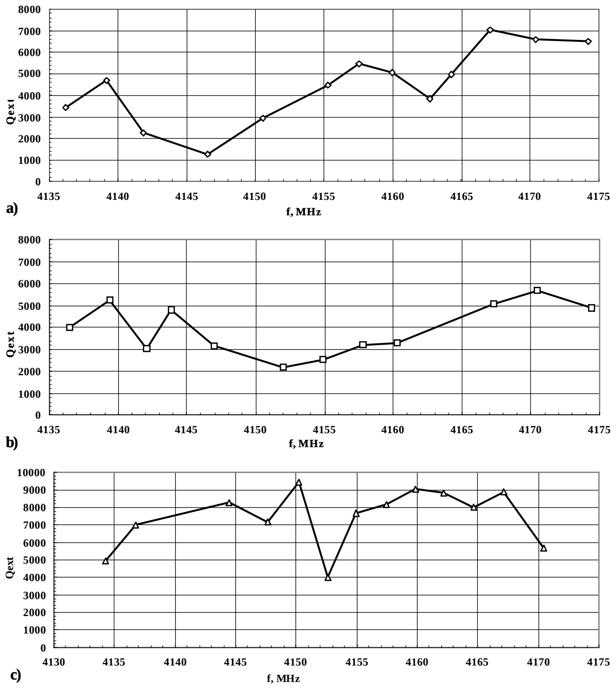

Fig.5 External Q-factor of the 30 cells’ SBLC structure at trappered HOM frequency band:
a). the HOM Y-polarization damping on the optimal frequency F=4145 MHz;
b) the HOM Y-polarization damping on the optimal frequency F=4152 MHz;
c) the HOM X-polarization damping in both cases.

The major problem consists in large difference between the coupler cavity own frequencies for the same mode with X and Y-polarizations. Such a problem can be solved if the dipole modes symmetry in the coupler cavity is rejected while keeping unchanged the field symmetry for the fundamental mode. It is realized by means of replacement the matched loads in one port for the X-polarization and in another port for the Y-polarization. In this case it is possible to control both polarizations and secure the required drop in the trapped modes Q-factors. Application of this technique resulted in obtaining the Q-factor value 4000 over the frequency range from 4130 MHz to 4160 MHz.

4. CONCLUSION

The obtained results have shown that it is possible to decrease the trapped modes loaded Q-factor over the frequency band 20 MHz by means of changing the coupler parameters. The problem of simultaneous damping of the dipole modes with different polarization could be solved if the coupler construction symmetry is not observed for those modes which is of no importance for the damping itself. The problem of keeping the coupler matching at the fundamental mode frequency is now under solution.

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