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MAGNETIC FIELD MEASUREMENTS ON THE PERPENDICULAR BIASED RF BOOSTER CAVITY FOR THE PROPOSED TRIUMF KAON FACTORY

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Abstract

The successful operation of the full scale KAON Factory Ferrite tuned Booster Accelerating Cavity Prototype allowed us to do ac magnetic field measurements in the tuner. The field measured is close to that calculated. The measured data are discussed. They may be used for reliable computation of the perturbation of the beam dynamics due to the ferrite biasing magnetic field. Methods to compensate the disturbing magnetic fields are discussed.

1 Introduction

The design and the achievements on the prototype of the TRIUMF KAON RF Booster Cavity have been reported earlier[1,2] and at this Conference[3]. Some of its main parameters – resonance frequency, Q-factor, and thermal stability – are determined by the ferrite biasing field, applied orthogonally to the resonator rf magnetic field. Field measurements have been done on the prototype of a similar cavity[4], operated in dc mode. However measurement on such type cavity, operated in ac biasing mode, have never been done before. The knowledge of this field is important not only to check the design, but also to know the real ac field, strongly influenced by the eddy currents in the construction[5], as well as the field distribution in the space through which should pass the accelerated beam.

2 Test arrangement

A calibrated Hall probe, BHT 910, F.W. Bell production, was used to perform the magnetic induction field measurements. Due to the impossibility of measuring the field inside the ferrite or the rf cavity during the test operation, it was done at the outside surface of the cavity. The probe was brought to this surface through a hole drilled in the holding wall and the magnetic pole (Fig. 1). Sets of measurements were performed: 1. along the cavity axis; 2. along the radius in the cavity median plane; 3. along the radius of the holding flange. In all cases only the axial component of the magnetic induction field was measured. The probe sensitivity was 0.0486 T/mV. The output voltage of the Hall probe during the ac ferrite biasing was measured and recorded by a digital scope, synchronized by the induced voltage of a small coil probe, situated inside the tuner (Fig. 1).

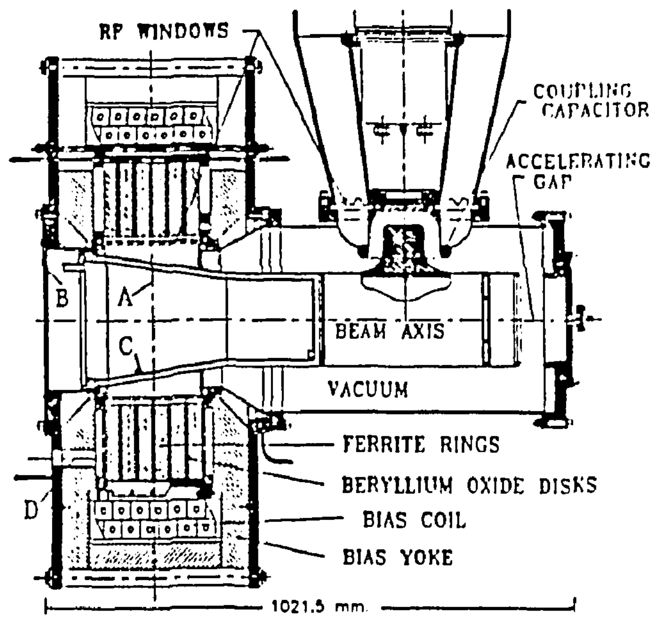

Figure 1: A - median plane, B - flange wall plane, C - synchro-coil position, D - hole for Hall probe insertion

3 Measurements on the surface of the ferrite filled resonator

The biasing field of the magnetic induction determines the cavity resonance frequency. The normal component of the magnetic induction field was measured at the outside wall of the resonator. Figure 2 shows the Hall probe voltage, measured at hole centre (curve 1) and under the pole surface on the resonator wall (curve 2), as well as the synchronizing pulse voltage (curve 3). As seen, the hole, drilled in the pole of the magnet, decreases the field. The biasing current and induction during the period for certain experimental conditions are presented on Fig. 3. By changing the current from 720 to 2520 A, the magnetic field on the resonator wall changes from 0.072 to 0.19 T. The induction field, as seen, is not only non-linear, but is also a double value function of the current – for example, at current of 1000 A during the accelerating cycle the induction field is 0.09 T, but during the reset time at the same current level the induction is 0.15 T. Besides this, at zero driving current the induction field is non-zero. Those results indicate some hysteresis proper-

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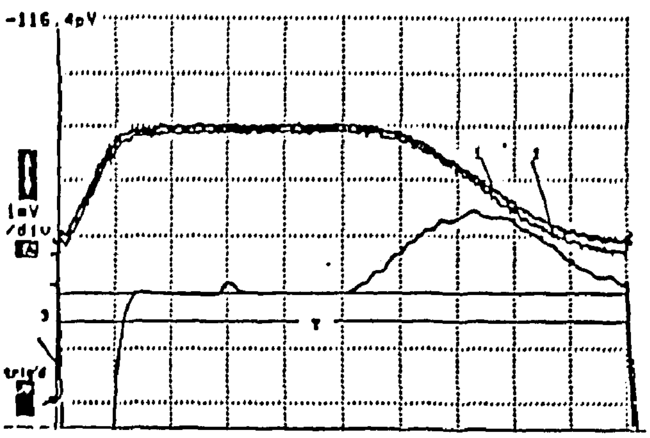

Figure 2: T = 20 ms

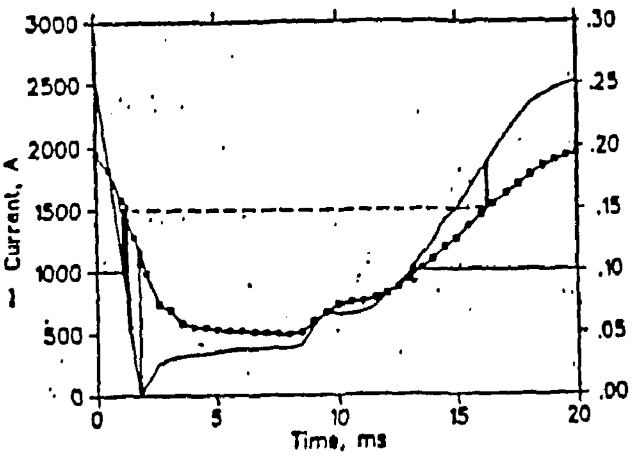

Figure 3:

ties of the biasing field. A knowledge of the real response function between the induction – at least, during the accelerating part of the cycle – and the biasing current is needed. Figure 4 shows the discrete frequency response between current and inductance field amplitudes and phases normalized towards the first harmonic of the bias current, received from the Fourier Analysis of the experimental curves.

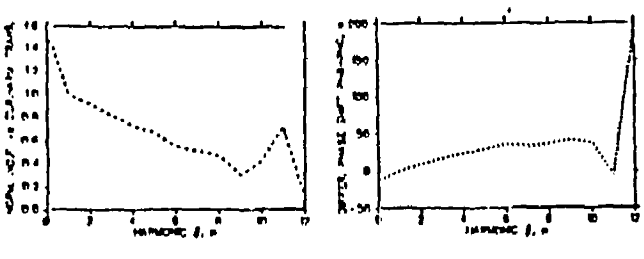

Figure 4: The lines connect the discrete harmonic values

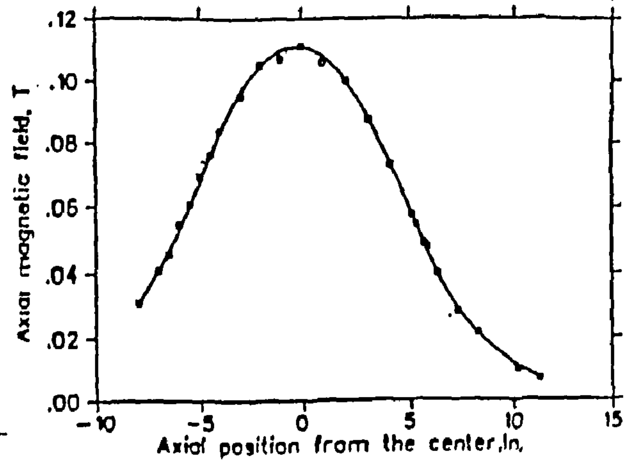

Figure 5: Axial distribution of the induction field

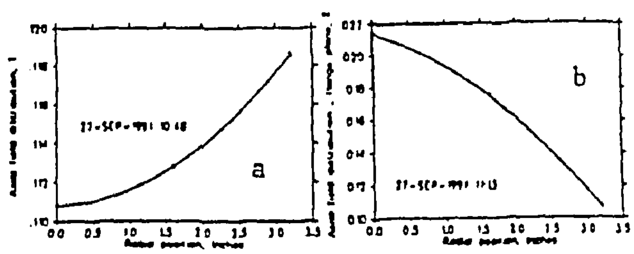

Figure 6: Induction field radial distribution: A - in the median plane, B - in the plane of the flange

4 Induction field measurements along the axis

The axial field distribution was measured in both direction – from the biasing center towards the resonance line root as well as towards the accelerating gap. Within the measuring accuracy the curve seems to have a symmetric bell form at the center with a tail around the noise level at a distance of 0.3 m (Fig. 5). The curve presents the maximum amplitude of the measured field during the cycle. The field amplitude at the center is 0.11 T – nearly half of the value at the resonator wall.

5 Induction field measurements in the radial direction

Induction field measurements in the radial direction were performed in two normal planes to the assembly axis – the central and the one, coinciding with the outside holding wall of the tuner. The results are shown on Fig. 6 a and b correspondingly.

6 Biasing system characteristics

Besides the field, the coil input current and voltage were measured. These measurements were used to determine the input characteristics of the biasing system in whole-spectral characteristics, as already mentioned, instantaneous and av-

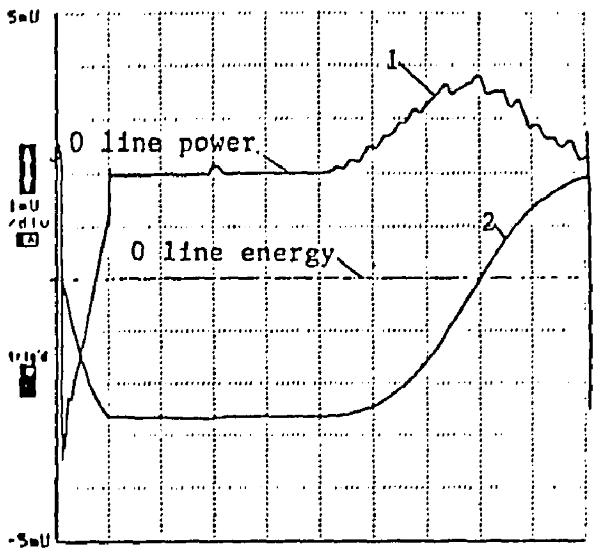

Figure 7: Instantaneous biasing power (1) and energy (2) distribution during the cycle; T = 20 ms. 1 div corresponds to 100 kW (1) and 200 J (2), respectively

erage power. By the maximal current of 2600 A the ampere-turns are 31,200. At the start of the modulation cycle reset time the coil is switched to return its stored energy to the power supply. The average power determined by these measurements is 19 kW (Fig. 7).

7 Disturbing fields compensation methods

Coaxial ferromagnetic shielding of the magnetic field in the central region of the tuner was discussed[2] and found to be not very practical. A central region induction free design[6] demands completely new prototype and development work. Early beam dynamics estimations show[7] that our measured level is acceptable from the beam dynamics point of view if a pair of cavities is assembled symmetrically together. A proposal to decrease the field at the axis based on the eddy current shaping of the tubes was checked and it may influence the field, but basically during the time, when dI/dt is maximum. The most practical option would be to decrease the "dummy" gap between the magnet poles or provide an additional coil in the central region with an independent synchronized programmed supply.

8 Conclusions

AC magnetic field measurements of a perpendicular biased ferrite tuned cavity in a large frequency range are reported. The biasing field of the magnetic induction shows hysteresis properties. Thanks to the measures taken to decrease the eddy current influence, the controlled biasing field approaches the static. The input power of the tuner is determined. Data concerning the frequency response between the driving current and the induction field may be derived from the measurements. Methods to decrease the field in the space passed by the beam are discussed. Additional measurements may give more information about the uniformity of the biasing field distribution.

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