Calculation of Field Configurations of the Electrostatic Septum and Massless Septum Magnet for the Slow Extraction System of the JHF Main Ring

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Abstract

Since accelerating beam intensity is enormous in the JHF synchrotron, even small beam losses during the slow extraction leads to unacceptable level of radiation. We set a criterion such that tolerable beam loss in the slow extraction process should be less than 1% of the averaged beam current of 10 μA. We have examined the field configurations of the electrostatic septum and the massless septum magnet, respectively. The calculations of electrostatic and magnetic fields were carried out by the computer code POISSON.

1. Introduction

A low beam loss extraction is necessary for the high intensity proton synchrotron. In slow extraction, the system is composed of the electrostatic septums and magnetic septum magnets. The electrostatic septum has advantage because the configuration of the electrostatic field edge at the wires can be made sharply. But it may have the radiation problem because the beam hits the wires.

On the other hand, the massless-septum magnet for slow extraction is very attractive because it does not need the wires or septum coils. This new type of massless septum magnet has been proposed by LANL group.[1][2] The massless septum magnet has a configuration that is consisting of two pairs of magnetic poles and the magnetic field produced by each poles is opposite. Therefore the extracted beam and the circulating one are separated each other.

2. Computer Calculation of the Electrostatic Field around the Wires for the Electrostatic Septum

The electrostatic fields in the septum are calculated for an electrostatic problem consisting of two wires between two plates at fixed potentials. In order to examine the field distortions for different wire thickness, the electrostatic fields have been calculated by changing the diameters but keeping the wire-wire distance constant. The geometrical configuration and the dimension of this

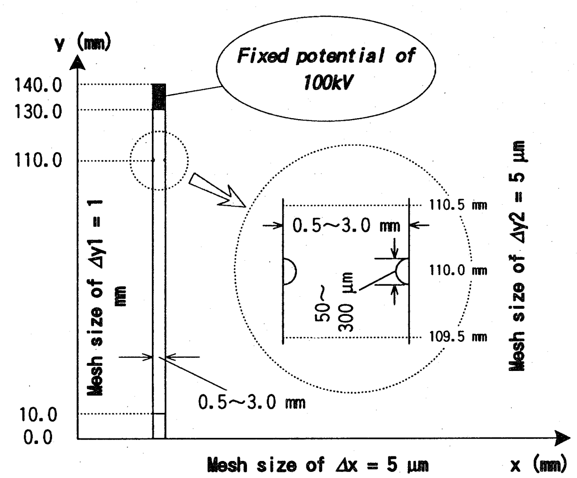

Fig.1 The geometrical configuration and the dimension of this model.

model are shown in Fig. 1. The mesh size of Δx is 5 μm and Δy_1 is 1 mm except for the region around the wires (109.5 mm $\leqq y_2 \leqq$ 110.5 mm); the mesh size of Δy_2 is 5 μm in this region. The distance between two wires is 1 mm and the wire diameter is changed from 50 μm to 300 μm. A fixed potential of 100 kV is applied to the 10 mm thickness plate (y = 130 – 140 mm). The electrostatic field between the plate and wires (110 mm $\leqq y \leqq$130 mm) is 50 kV/cm. Those calculated equipotential lines are shown in Fig. 2 and three-dimensional plots are also shown in Fig. 3. Fig. 4 shows the field strengths averaged over the x-distance for the following condition: (a) changing the diameter of the wire D and keeping the wire spacing S constant; (b) changing S and D constant.

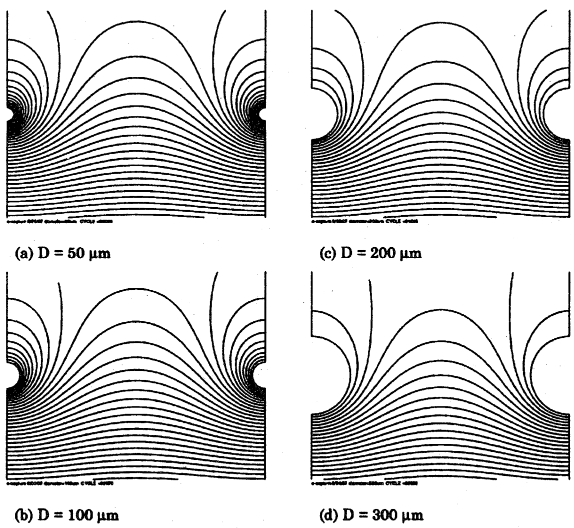

Fig. 2 The calculated equipotential lines. The distance between two wires is 1 mm and the wire diameters are changed from 50 µm to 300 µm.

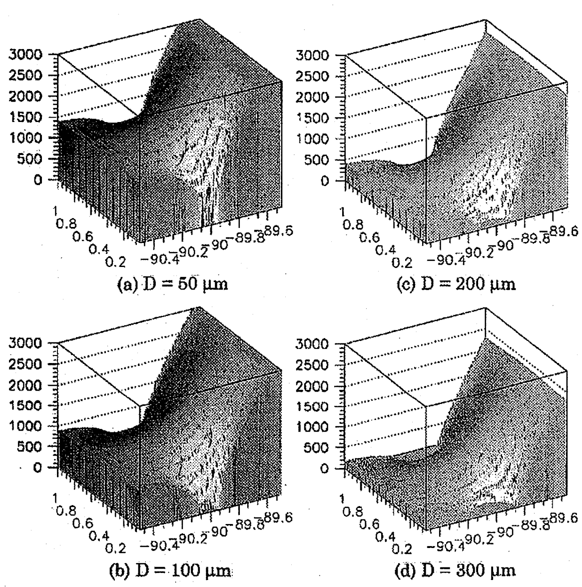

Fig. 3 The three-dimensional plots of the calculated potential. The wire parameters are same as in Fig. 2. The axis are x (0 – 1 mm), y (-90.4 – -89.6 mm) and z (0 – 3000 V).

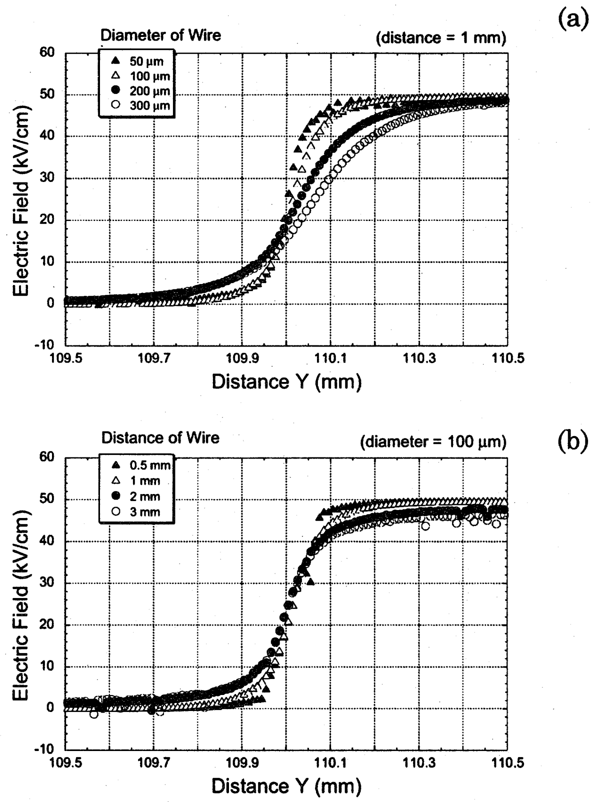

Fig. 4 The electrostatic field strength average over the x-distance for the following condition:
(a) $D = 50 - 300$ µm, $S = 1$ mm;
(b) $D = 100$ µm, $S = 0.5 - 3.0$ mm

3. Computer Calculation of the Massless Septum Magnet

We are examining a possibility to use the massless septum magnet. The upper half of the designed magnet is shown in Fig. 5. The calculated field lines are also presented in this figure. The gap height from the median plane is 40 mm in the circulating-beam region (left region) and 20 mm in the extracted beam region (right region). The magnetic flux density at the median plane is plotted as a function of the horizontal distance in Fig. 6. When the coil currents are 1300 A for the left coil and 2800 A for the right coil, the magnetic flux density (B_y) in the extracted region is 0.175 T. The tables presented in Fig. 6 summarize the coefficients in a series of multiples in the region from x = -40 mm to +25mm. The kick angle Δx' given by the magnetic flux density is

$$\Delta x' = -\frac{B'l}{B\rho}x - \frac{l}{B\rho}\sum_{k=3}^{\infty} B^{(k-1)} \frac{x^{k-1}}{(k-1)!} \quad ,$$

where $B\rho$ is the magnetic rigidity, l the effective length of the magnet and $B^{(k)}$ the coefficients in a series of multiples of the magnetic field, respectively. The problem is that the gradient of B_y is not so sharp. The effects of such a field on circulating and extracted beam is now being investigated.

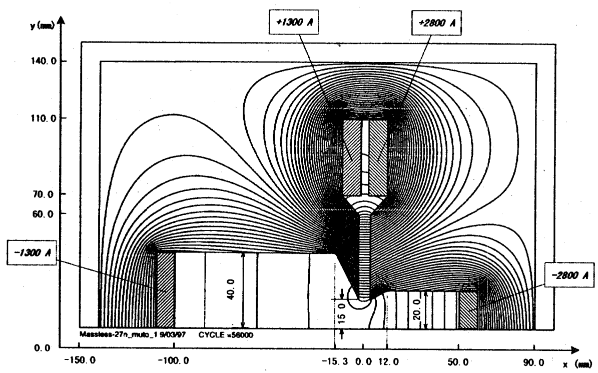

Fig. 5 The upper half of the designed magnet. The calculated field lines are also presented in this figure.

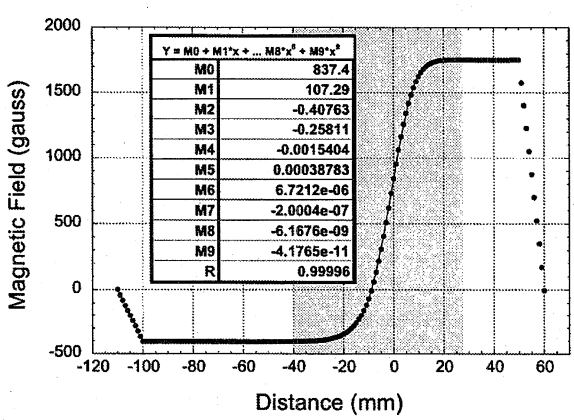

Fig. 6 The magnetic flux density at the median plane plotted as a function of the horizontal distance. The presented tables summarize the coefficients in a series of multiples in the region from x = -40 mm to +25mm.

5. Concluding Remarks

The electrostatic field around the wires of electrostatic septum has been calculated by a computer code POISSON. We found that the field distortion due to the wire spacing is rather small. We also have examined the possibility of using the massless septum magnet. A simulation based on the calculated magnetic field distribution is in progress.

Acknowledgement

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References

[1] H. S. Butler *et al.*, Proc. of the Advanced Hadron Facility Accelerator Design Workshop, 1988.

[2] J. Liu *et al.*, Proc. of the Advanced Hadron Facility Accelerator Design Workshop, 1988.