INVESTIGATION OF INJECTION THROUGH BENDING MAGNET FRINGE FIELDS IN X-RAYS SOURCE BASED ON THE H-100M STORAGE RING

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In paper the injection in the X-ray source based on the H100-M storage ring, through fringe fields of a bending magnet is considered. The simulation of charged particle beam motion through 3-d fields of magnetic devices of the injection channel located on the ring, is performed. The focusing properties of the injection channel are determined.

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1. INTRODUCTION

The injection in the small storage rings is a problem due to impossibility of its realization by conventional methods, i.e. by means of septum magnets.

In the offered lattice of a X-ray source, based on the N-100m storage ring, it is possible to place only inflector, in which one beam is injected through the fringe fields of a bending magnet. The main task of this paper is description of optical properties of the beam channel up to the entry into the transport channel.

2. BEAM TRACING THROUGH DEVICES OF A RING

Integration of motion equations for the particle tracing through the ring devices in time with a constant magnetic field was made [2]:

$$\begin{cases} m\cdot x''(t) = \left(B_z \cdot y'(t) - B_y \cdot z'(t)\right), \\ m\cdot y''(t) = \left(-B_z \cdot x'(t) + B_x \cdot z'(t)\right), \\ m\cdot z''(t) = \left(B_y \cdot x'(t) - B_x \cdot y'(t)\right). \end{cases} \quad (1)$$

Here m is the relativistic mass; $B_{x,y,z}$ are the magnetic field components.

The use of set of equations (1) for trajectory calculation allows one to find the solution at any distance from the reference orbit where a field is described. The magnetic field of all devices were calculated by POISSSON [3] (2-D), MERMAID [4] (3-D) programs. For each device the magnetic field maps were obtained. For solution (1) the piecewise constant approximation of a magnetic field was used.

For definition of optical properties of the injection channel the tracing of a positron beam with an emittance of 10^{-7} m rad in an inverse direction to the direction of electrons injection (Fig.1) was used. The beam has started with 16mm x-deflection relatively to the reference orbit and was passed through the inflector fields, sextupole lens, quadrupole lens, fringe field of the magnet, and the high permeable pipe.

In Fig.1 the relative position of the bending magnet and of other devices of the ring is shown. The geometrical parameters of this location are obtained from the calculations of motion of the equilibrium circulating particle in 3D fields of the magnet. The interference of magnets was taken into account also.

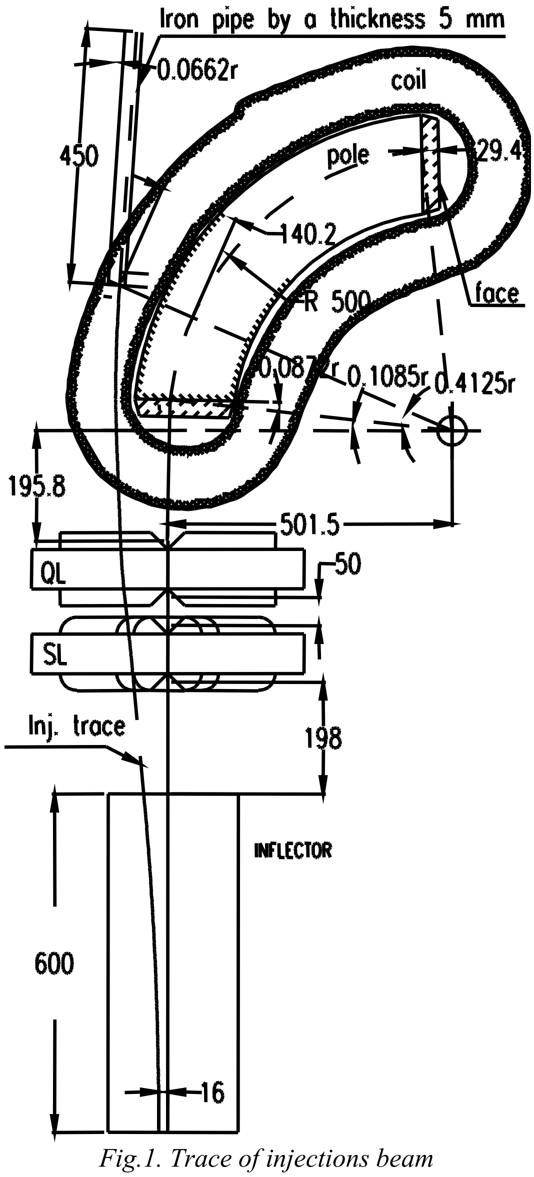

Fig.1. Trace of injections beam

2. INFLECTOR

For the inflector design the following requirements were taken into account:

Field in a point of injection ≥250 Gs
Field on a reference orbit ≤25 Gs

In Fig.2 the inflector cross-section, which allows one to implement this requirement, is shown.

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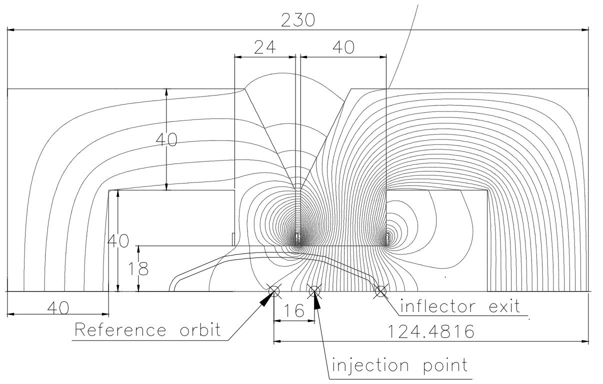

Fig.2. Cross-section of the inflector

In the calculation it was assumed, that the material permeability does not exceed 20. Current of the main winding is 700 A. Current of a compensating magnet winding is 50 A. The matched connection of windings allows one to obtain a field on a median plane of the inflector shown in Fig.3.

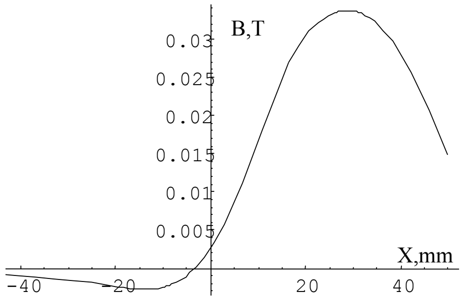

Fig.3. Magnetic field distribution in the median plane of the inflector

The inflector magnetic field configuration causes defocusing on x-axes (in the area of field increasing), as well as focusing on x-axes (in area of field decreasing).

The beam sizes at the inflector exit are ±0.7,±0.3 mm.

3. QUADRUPOLE LENS

The strength of the quadrupole lens is 9.T. The gradient is 1.8 T/m. In the field of this lens the beam, being under X-focusing acquires the sizes of ±1.85,±0.5 мм. Center of a beam is declined up to 83 mm from the reference orbit (Fig.4).

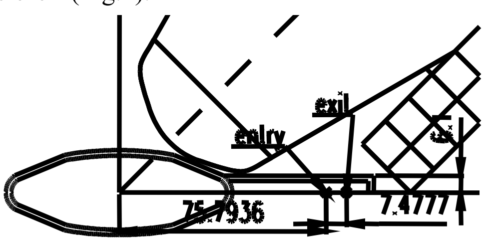

Fig.4. Cross-section of the aperture in the quadrupole lens

4. SEXTUPOLE LENS

The strength of the sextupole is K2L=–9.244 T/m. In the field of this lens the beam, being under X-defocusing, acquires the sizes of ±0.95, ±0.4 mm. The center of the beam is declined up to 70 mm from the reference orbit (Fig.5). Therefore the vacuum chamber for injection beam passing in this place can be separated from the vacuum chamber of a circulating beam (see Fig.5).

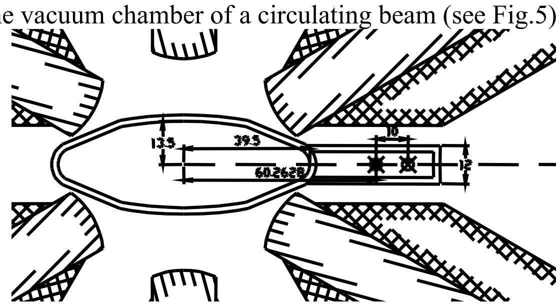

Fig.5. Cross-section of the aperture in the sextupole lens

5. BENDING MAGNET

Getting through a fringe field of a dipole magnet, the beam of particles is under strong X-defocusing. If one allows that the beam be moving in the decreased fringe field then at the entry into the channel of beam transporting will gain the impermissible sizes. Therefore it is necessary to shield the magnetic field of the dipole magnet by means of the high permeable pipe (Fig. 6).

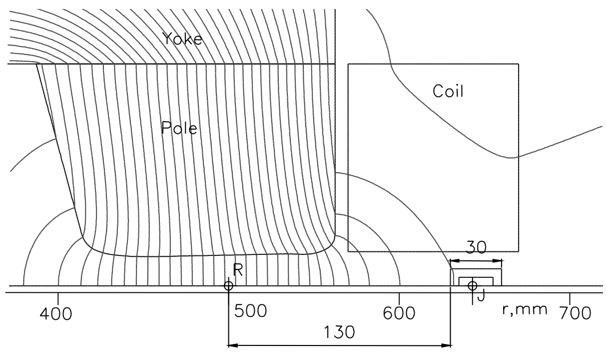

Fig.6. Shielding of the magnetic field by means of the high permeable pipe

However presence of magnetic material near to a reference orbit can give unallowable field distortions on the reference orbit. For an estimation of this perturbation a series of calculations of the field in the presence of the high-permeable pipe near the reference orbit were performed.

The results of these calculations are shown in Fig.7.

Fig.8 shows a shielding characteristic of the iron pipe.

The simulation of a motion in a fringe field of the magnet has shown, that there is an optimum, at which the beam reaches a sufficient not large distance from the reference orbit for setting a iron pipe. The location of the magnetic screen is shown in Fig.1.

In Fig.9 the sizes of the beam in a reference to the injection synchronous particle coordinate system are shown.

During deriving of the optimum envelopes the different variants of relations of the size and angular beam divergence at the inflector entry were calculated. The results are given in a Fig.10,11.

From obtained results it follows, that the optimum relation of a size-divergence is equal to 0.22mm×0.45mrad.

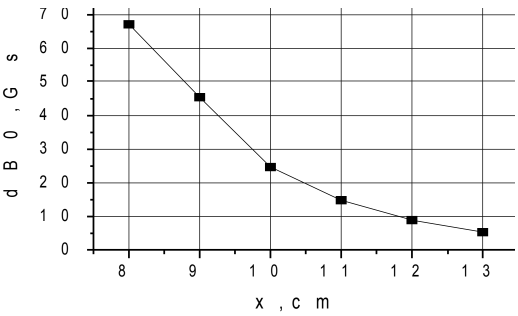

Fig.7. The value of dipole perturbation disordered by the high-permeable pipe on a reference orbit versus the distance between the reference orbit and the iron pipe edge

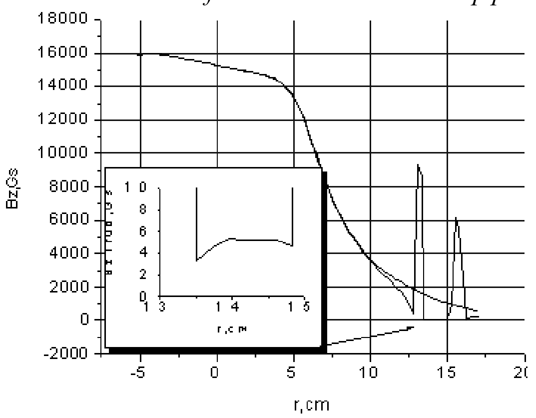

Fig.8. Magnetic field of the dipole magnet in the regular part with the presence of the iron pipe and without one

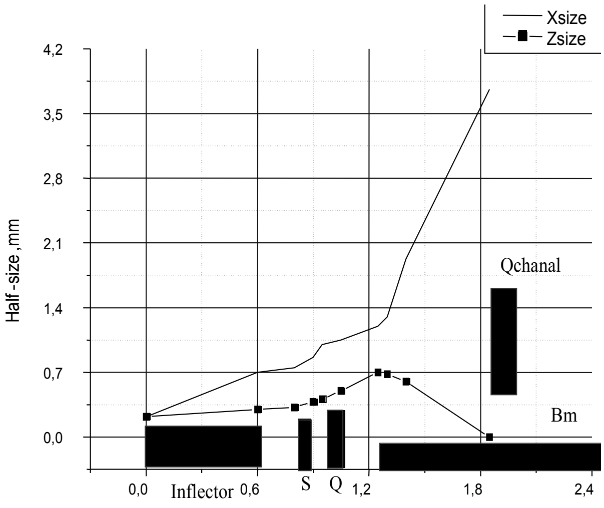

Fig.9. Sizes of the beam in the injection channel

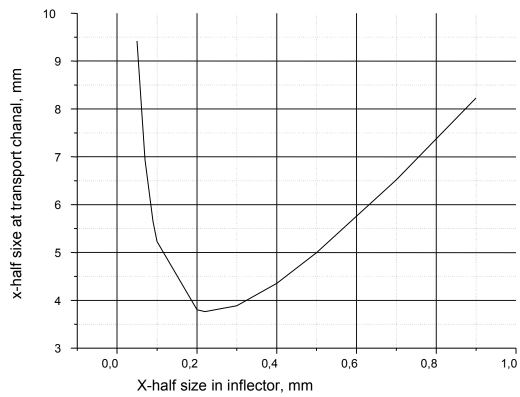

Fig.10. Dependence of X-size at exit of the iron pipe from the size on the entry into inflector

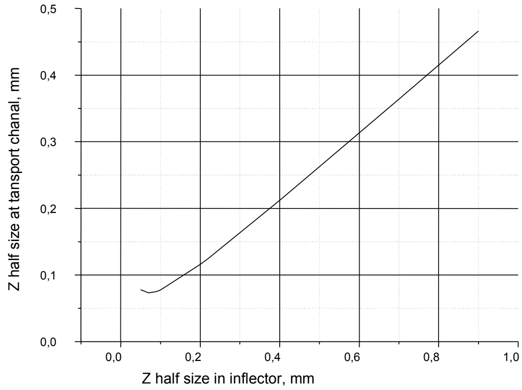

Fig.11. Dependence of Z-size at exit of the high permeable pipe from the size on the entry into inflector

6. CONCLUSION

The produced calculations show a possibility of realization of injection in the lattice of the N-100m storage ring through fringe fields of a dipole magnet by means of an inflector. Hereinafter the location of the magnetic channel will be improved according to the measuring data of magnetic devices, the manufacture of which one has started this year.

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ИССЛЕДОВАНИЕ ИНЖЕКЦИИ В ИСТОЧНИКЕ РЕНТГЕНОВСКОГО ИЗЛУЧЕНИЯ НА ОСНОВЕ НАКОПИТЕЛЯ Н-100М ЧЕРЕЗ РАССЕЯННЫЕ ПОЛЯ ПОВОРОТНОГО МАГНИТА

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Рассматривается инжекция в источник рентгеновского излучения на основе накопителя Н-100М через рассеянные поля поворотных магнитов. Проведено моделирование движения пучка заряженных частиц через трехмерные поля магнитных элементов канала инжекции. Определены фокусирующие свойства канала инжекции.

ДОСЛІДЖЕННЯ ІНЖЕКЦІЇ В ДЖЕРЕЛІ РЕНТГЕНІВСЬКОГО ВИПРОМІНЮВАННЯ НА ОСНОВІ НАКОПИЧУВАЧА Н-100М ЧЕРЕЗ РОЗСІЯНІ ПОЛЯ ПОВОРОТНОГО МАГНІТУ

Н. Ковальова, А.О. Мициков, В.Є. Іващенко, А.В. Резаєв, А.Ю. Зелінський

Розглядається інжекція в джерело рентгенівського випромінювання на основі нагромаджувача Н-100М через

розсіяні поля поворотних магнітів. Проведено моделювання руху пучка заряджених часток через трьохмірні поля магнітних елементів каналу інжекції. Визначені фокусуючи властивості каналу інжекції.