DEVELOPMENT OF A SOFTWARE COMPLEX FOR MODELING, ANALYZING AND OPTIMIZATION THE DYNAMICS OF CHARGED PARTICLE BEAMS IN SYNCHROTRONS AND TRANSPORT CHANNELS

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Abstract

The paper considers a new version of the software complex developed for modeling, analyzing and optimization the transverse dynamics of charged particle beams in synchrotrons and transport channels. Considered code provides the calculation of transverse dynamics of the charged particle beam in synchrotrons and transport channels based on the linear model, as well as the calculation of the structural functions of synchrotrons and transport channels, the beam acceptance and emittance, beam dynamics optimization. In the new version of the software complex, the ability to carry out calculations on a remote computing cluster, the web user interface. To store the results of calculating the beam dynamics, a database is used.

INTRODUCTION

At present, the Nuclotron – a synchrotron for the acceleration of beams of multiply charged ions, protons and deuterons is successfully functioning at the Joint Institute for Nuclear Research (Dubna, Russia) [1], as well as the project NICA is being implemented to create a collider of protons and heavy ions. The NICA accelerator complex is assumed to produce the beams of high quality with sufficiently rigid characteristics.

In contrast to analogous foreign software packages, such as MAD-X (CERN) and OptiMX (FNAL), the DAISI focuses on solving the problems of restoring the errors in magnetic fields and errors in alignment of magnetic elements, as well as also on the optimization of the beam dynamics in synchrotrons and transport channels.

At present, a software complex for modeling and optimizing dynamics in synchrotrons and transport channels is under development on the basis of the DAISI program complex [2], which provides high-performance computing using remote computing resources. The development of such a software package has been stipulated by the need of using high-performance computing tools for solving both the multi-parametric optimization problems of beam dynamics in synchrotrons and the problems of restoring the actual synchrotron parameters.

The program complex involves a friendly web graphical user interface and various sets of tools, methods and algorithms for calculating the beam dynamics, orbit correction, and restoring the parameters of the accelerator complexes. The software complex in point was used for solving the problem of placing the dipole magnets in the Nuclotron booster being under development and now it is being improved further to solve various problems within the framework of the NICA project..

DESCRIPTION OF THE PROGRAM COMPLEX

The software complex consists of a control program, a database and calculation modules, and a web user interface. The control program provides the start of calculations by user commands, data extraction from the database and saving of information about the performed calculations in the database.

Calculation modules provide executing the distributed calculations on remote computing nodes. At present, it has been implemented the module for calculating the linear transverse dynamics of the center of gravity of the beam, the module for calculating the beam transverse dynamics, the module for providing the arrangement of dipole magnets in synchrotrons, as well as the module of correcting the orbits under various restrictions imposed on the value of the maximum orbit deviation from the synchrotron axis in the different sections of the synchrotron

MODULES

The Module for Calculating the Lateral Dynamics of the Center of Gravity of the Beam in the Synchrotrons Based on a Linear Model

The module for calculating a transverse beam dynamics in the synchrotrons and transport channels provides computing the lateral dynamics of the center of gravity of the beam at the synchrotrons that is based on a linear model and uses the transport matrices of structural elements of the synchrotrons and transport channels (dipole bending magnets, focusing and defocusing quadrupole lenses, drift gaps, and multipole magnetic correctors). When calculating the dynamics, the structural elements intended for the slowed-down beam extraction

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from the synchrotrons and transport channels are not considered. One can add other structural elements of the synchrotrons and transport channels, as well as change the location of pick-up displays and multipole correctors. When calculating the dynamics, the own beam field is ignored. It is possible to take into account the errors of the magnetic field in the elements of the transport matrix. The module provides for the formation of the response matrix being made on the base of computing the transverse dynamics provided that a user specifies the locations of pick-up displays and multipole correctors in the drift gaps.

The Module for Providing the Arrangement of Dipole Magnets in Synchortons to Reduce the Maximum Deviation of the Orbit from the Axis of the Synchrotron

The module provides the order of arrangement of dipole magnets in synchrotrons, taking into account their effective lengths so as to ensure a decrease in the maximum deviation of the closed orbit from the axis of the synchrotron. The effective lengths of the dipole magnets are used as input parameters of the module. In the module, the developed algorithm for arranging the dipole magnets in synchrotrons is realized, and a call of the module for constructing a closed orbit is provided. The orbit deviations are calculated at the locations of the pickup monitors.

The Module of Correcting the Orbits under Various Restrictions on the Value of the Maximum Orbit Deviation from the Synchrotron Axis in Different Sections of the Synchrotron

The module provides correction of the orbit with the given restrictions on the maximum deviation of the closed orbit from the axis of the structure in individual sections of the synchrotron and the general bounds of the maximum deviation of the closed orbit from the synchrotron axis (for both transverse axes). Limits may also be imposed on the values of the maximum orbit deviation in individual sections, with the requirement that the orbit deviation from the synchrotron axis be reduced in other sections. The orbit deviations are calculated at the locations of the pickup monitors.

CONCLUSIONS

In the presented software complex for high-performance computing, there is implemented the model for calculating the transverse dynamics of the beam in synchrotrons and transport channels, as well as two auxiliary models. The given software complex is planned to be added with the models previously implemented in the DAISI package, together with new models for optimizing the dynamics of charged particle beams.

REFERENCES

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