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Unser Zeichen:
Datum: April 26th, 2020

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REVIEW
of the dissertation by Maria A. Mizintseva
"Joint optimization of smooth and non-smooth functionals in the problems of beam control"
for the Ph. D. degree in physical and mathematical sciences,
Speciality 05.13.18 - «Mathematical modeling, numerical methods and program complexes»

The problem of optimal control of a beam (or ensemble) of trajectories arises in various applications dealing with dynamic systems with uncertainty or partial information about the initial data, in case of external perturbations. Supposing that each beam trajectory corresponds to some particle, the dynamics of a beam of trajectories can be described by a system of equations for the so-called program particle and equations in deviations from this particle for all other particles of the beam. This approach is known as joint optimization of a program and disturbed motions, and it has proven to be particularly useful in the field of modeling and optimization of charged particle beam dynamics in accelerators. The dissertation of Maria A. Mizintseva considers this well-studied problem of joint optimization of a program and disturbed motions, but she introduces a novel approach to the description. The author introduces quality functionals, namely a combination of smooth and non-smooth functionals, which constitutes the scientific novelty of the dissertation. The optimization approach based on combined quality functionals is applied to the problem of optimization of the longitudinal dynamics of charged particles in a radio-frequency quadrupole (RFQ) accelerator.
The results obtained in the thesis are of theoretical and practical value and seem to be promising in applications in complex dynamic systems that require the control of various parameters, considering both the average characteristics of the beam and the most deviating trajectories.

The dissertation consists of an introduction, four chapters, conclusion and list of references.
The introduction brings forward the following thesis statements:
1. New mathematical models of joint optimization of a program motion and a beam of disturbed motions using a combination of smooth and non-smooth functionals.
2. Optimality conditions and analytical expressions for variations of the introduced combined quality functionals in the proposed new mathematical optimization models.
3. A new mathematical model of optimization of the longitudinal motion of particles in a radio-frequency quadrupole (RFQ) accelerator based on the combined quality functionals.

09/2-02-220 от 26.04.2020

4. Software implementation of the developed model of optimization of the longitudinal motion of particles in an RFQ accelerator.

Chapters 1 and 2 correspond to the first two defense statements. There, the author states various new optimization problems. Different quality functionals of combined a type are introduced to the problem of joint optimization of a program motion and beam of trajectories. Analytical expressions for the variations of the quality functionals are obtained, and the necessary optimality conditions are formulated in the form of five new theorems.

Chapter 3 focuses on the application of the proposed approach to the problem of charged particle beam dynamics optimization in an RFQ accelerator. A new optimization problem is stated. Here, one finds another theorem and the analytical expression for the sub-gradient of the quality functional.

The fourth chapter is devoted to the results of optimization of the longitudinal dynamics of the charged particles in an RFQ channel using the optimization module developed for the BDO RFQ software package. The results presented in the chapter seem adequate and successfully passed validation using the software complex LIDOS RFQ Designer, which works with more sophisticated models of the particle dynamics.

It can be clearly stated that all initial thesis statements are adequately presented in the dissertation and that the obtained results are justified and reliable.

Some additional remarks:

1. Even though the literature survey seems extensive, it mainly includes Russian/Soviet references. It would be fair to give an overview of the international efforts on the research topic.
2. "Aprobation" in the introduction is missing the second "p". Moreover, using the term "validation" would be more correct here.
3. Although the text of the dissertation is overall well written and grammatically correct, the author definitely struggled with punctuation. In particular, commas are missing in some places and misused in others.
4. The author explores the proposed optimization approach in application to the problem of charged particle beam dynamics in a particular linear accelerator and arrives to a conclusion that the approach proves to be viable and practical. The dissertation could benefit from an extended discussion on perspective applications of her novel approach to other fields.

The mentioned remarks do not detract from the general positive evaluation of the work.

The thesis completely satisfies the three components of the speciality: mathematical modeling, numerical methods and program complexes, and contains interesting and valuable new results. **The author Maria A. Mizintseva by all means deserves to be awarded the Ph. D. degree in physical and mathematical sciences.**

With best regards,

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