



Russian Academy of Sciences Program Systems Institute



System Analysis Research Center

Director: Doctor of Sciences, Professor A.M.Tsirlin

Fields of research work:

- Optimal Control Methods for Irreversible Thermodynamic Systems and Estimations of Extreme Performance of these Systems
- Mathematical Models and Optimal Processes in Irreversible Microeconomics
- Optimal Control of Temperature Fields and Energy Saving Problems (Cooling in Supercomputers, Energy Saving in House-Building)
- Problem on Equivalence of Differential Equations
- Geometrical Conditions of Solvability of Convolution Equations

Optimal Control Methods for Irreversible Thermodynamic Systems and Estimations of Extreme Performance of these Systems

Scientific supervisor Prof. A.M.Tsirlin

Main results:

- Extreme performance of heat engines and refrigerators with pre-given power input/output.
- Optimal direct and reverse transformation of heat to work in a thermodynamic system of general form.
- Extreme performance of separation processes using either mechanical or heat energy with pre-given productivity of these processes. Particularly, processes of rectification, absorption are considered.
- Maintaining of the pre-given field of potentials (e.g. temperatures, concentrations, pressures) with the minimal energy expenditures.

The work was supported by INTAS (1990-1995), ISF (1993-1995), Russian Foundation for Basic Research (1999-2003).

More than 75 books and articles were published in the frame of this work. Major publications:

- Berry R.S., Kazakov V., Sieniutycz S., Szwasz Z., Tsirlin A.M. Thermodynamic Optimization of Finite-Time Processes. John Wiley & Sons, LTD, 1999
- Tsirlin A.M., Mironova W.A., Amelkin S.A., Kazakov V.A. Finite-Time Thermodynamics: Conditions of Min. Dissipation for Thermodynamic Processes with Given Rate, Phys.Rev.E, 58, (1998)
- Tsirlin A.M. Optimal Processes in Irreversible Thermodynamics and Microeconomics. Moscow, Fizmatlit, 2002.
- Tsirlin A. M., Kazakov V. Realizability Areas for Thermodynamic Systems with Given Productivity, Journal of Nonequilibrium Thermodynamics, 1, (2002).
- Tsirlin A.M. Irreversible Estimation of Extreme Performance of Thermodynamic and Microeconomic Systems. Moscow, Nauka, 2003.
- Mironowa V.A., Tsirlin A.M., Kazakov V.A., Berry R.S. Finite-Time Thermodynamics: Exergy and Optimization of Finite-Constrained Processes J.Appl.Phys. 76, (1994).
- Tsirlin A.M., Kazakov V.A. Irreversible Work of Separation and Heat-Driven Separation. J.Phys. Chem. B 108, (2004).

Perspectives of further investigations:

To obtain conditions of minimal dissipation for vector processes of transfer. To apply theoretical results to energy saving problems. To develop algorithms of optimization of complex systems, online optimal control of minimal dissipation processes.

Mathematical Models and Optimal Processes in Irreversible Microeconomics

Scientific supervisor Prof. A.M.Tsirlin

Main results:

- Accounting of irreversibility factor during investigation of economic processes; existence of wealth function and its characteristics.
- Extreme performance of firms in time constrained economic processes.
- Extremal principle determining a stationary condition of an open economic system.

The work was supported by RFBR (2000-2004).

There are more than 30 publications in the frame of this work. Major publications:

- Tsirlin A.M., Kazakov V.A. Optimal Processes in Irreversible Thermodynamics and Microeconomics. INDECS, 2 (2004).
- Tsirlin A.M., Kazakov V.A. Average Relaxations of Extremal Problems and Generalized Maximum Principle. Advances in Mathematics v.6, Nova Science publishers, 2004.
- Amelkin S.A. Limiting Possibilities of Resource Exchange Process in a Complex Open Microeconomic System. INDECS, 2 (2004).
- Tsirlin A.M., Kazakov V.A. Extremal Principles and Limiting Possibilities of Open Thermodynamic and Economic Systems. In Variational and extremum principles in macroscopic systems, S. Sieniutycz & H. Farkas (eds.), Kluwer Academic Publishers. 2004.
- Tsirlin A., Amelkin S. Dissipation and Conditions of Equilibrium for Open Microeconomic System. Open Sys. & Information Dyn. 8: (2001).
- Amelkin S., Tsirlin A. Optimal Choice of Prices and Flows in a Complex Open Industrial System. Open Sys. & Information Dyn. 8: (2001)

Perspectives of further investigations: Investigation of stationary regimes of open microeconomic systems. Accounting of consumption, production and changing of resources characteristics (e.g. deterioration, spoiling, wear and tear).





Optimal Control of Temperature Fields and Energy Saving Problems (Cooling in Supercomputers, Energy Saving in House-Building)

Scientific supervisor Prof. A.M. Tsirlin

Main results:

- Conditions of optimal thermostating and optimal design of heat exchange systems.
- Software for multicoating walling calculation considering heat and moisture transfer between layers and existence of air spaces.
- Current systems of cooling for computers of high power shortcomings are analysed and the structure of proper system of cooling is outlined.

The work is supported by a grant of Presidium of Russian Academy of Sciences (since 2005).

Major publications:

- Tsirlin A.M., Kazakov V.A. Finite-time thermodynamics: active potentiostating, J.of Physics D, 31 (1998).
- Tsirlin A.M., Andreev D.A., Mogutov V.A., Kazakov V. Optimal Thermostating. Int.J. Thermodynamics, Vol.6 (2003).
- Andreev D.A. Optimization of Temperatures Field in Open Multichamber Systems. Prom. ASU i Kontrollery, 3 (2005).
- Tsirlin A.M., Andreev D.A., Mogutov V.A. Thermodynamic Analysis of a Problem of Thermostating. Reports of RAS, Energetika, 5 (2003).

Perspectives of further investigations: Substantiation of structure, calculation of estimations of minimal energy expenditures in cooling systems of high power computers. Software for designing of passive house building.

Problem on Equivalence of Differential Equations

Scientific supervisor Dr. V.A. Yumaguzhin

Main results:

- Local classification of linear ordinary differential equations is obtained up to replacement of variables.
- A differential invariant is found which is respondent for possibility to reduce a nonlinear ordinary differential equation of the second order to linear form by replacement of variables.

Major publications:

- Yumaguzhin V.A. Classification of Linear Ordinary Differential Equations I. Differential Equations, 38, No. 6 (2002).
- Yumaguzhin V.A. Classification of Linear Ordinary Differential Equations II. Differential Equations, 38, No. 7 (2002).
- Yumaguzhin V.A. Contact classification of linear ordinary differential equations. Acta Applicandae Mathematicae, vol.72, N1/2, (2002).

Perspectives of further investigations: Generalization of developed approach to nonlinear differential equations of high order.

Geometrical Conditions of Solvability of Convolution Equations

Scientific supervisor Dr. S.V. Znamenskij

Main results:

- A criterion for solvability of convolution equations with an arbitrary second member.
- Interrelations between different definitions of complexity to given direction of a plane set.

The work was supported by RFBR (1998-2002).

Major publications:

- Znamenskij S.V., Znamenskaya E.A. Convexity of a Plane Set in Given Direction. VINITI 'Scientific Resume'. Nauka, 2002.
- Znamenskij S.V., Kozlovskaya E.A. A Criterion of Epimorphism of Convolution Operator with a Point Bearer in a Set of Functions which are Holomorphic on a Coherent Set in C . Reports of RAS. Mathematics, 368, No. 6 (1999).
- Znamenskij S.V., Znamenskaya E.A. Existing of Analytical Antiderivatives on an Arbitrary Set of Complex Space. Uspehi Mat. Nauk, 55, No.1 (2000).
- Znamenskij S.V., Znamenskaya E.A. Surjectivity of Convolution Operator with a Point Bearer in a Set of Functions which are Holomorphic on a Coherent Set in C . Reports of RAS. Mathematics, 376, No. 5 (2001).

Perspectives of further investigations: To continue a preparation of a review and a monography containing comparative analysis of generalizations of complexity. These generalizations are natural answers to laconic questions of complex analysis. To carry out the investigation of Kiselman problem on uniqueness of bearer of an analytical functional.

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