Ivanovo State Power Engineering University

# Vestnik of Ivanovo State Power Engineering University (Vestnik ISPEU)

The Journal has been published since 2001 ISSN 2072-2672 Issue 6 /2012



**The issue is prepared by:**

Responsible people for the issue: B.M. Larin, Yu.A. Mit'kin, V.A. Poletaev, A.R. Kolganov, A.N. Golubev, S.V. Kosyakov, A.M. Karyakin

Chief of Educational and Scientific Literature Publishing Office **S.V. Klyunina**
Technical Editor **N.V. Koroleva**
Editor **S.M. Kotкova**

**CONTENT**

**HEAT AND POWER ENGINEERING**

**B.L. Shelygin, E.S. Malkov.** Efficiency Analysis of Heat Producing Unit at Variable Operating Modes While Burning Additional Fuel in Heat Recovery Boiler.....**5**

**E.V. Barochkin, V.P. Zhukov, A.Y. Nenaezdnikov, A.N. Belyakov, G.V. Ledukhovsky, A.P. Zimin.** Modeling of Deaeration Process in Bubble Stage with Liquid Flows Circulation.....**9**

**ELECTRICAL POWER ENGINEERING**

**O.S. Mel'nikova.** Influence of Power and Rated Voltage of Working Power Transformers on Oil Volume in Main Insulation.....**14**

**V.P. Golov, A.A. Martirosyan, I.A. Moskvin.** Characteristics Calculation of Steady-state Modes of Electrical Power Engineering System with the controlled device of series compensation.....**18**

**ELECTROMECHANICS**

**Yu.B. Kazakov, N.A. Morozov, S.A. Nesterov.** Magnetorheological Damper with Piston Magnetic System.....**23**

**V.V. Novikov, E.E. Nuzdina, S.A. Syrbu, M.S. Marshalov, R.U. Lisitsyn.** Improving Lubricating Ability of Lubricating and Cooling Technological Substances for Metal Treatment due to Mesogenic Compounds Additions.....**28**

**S.M. Perminov.** Research of Distribution of Magnetic Field Strength and Magnetic Flows in Classical Magneto-Liquid Sealer.....**32**

**A.P. Sizov, O.U. Balashov, E.V. Sergeev.** Viscometer Design for Magnetic Liquids Research.....**37**

**A.V. Stulov, A.I. Tikhonov.** Heat Calculation of Transformers Windings and Current-Limiting Reactors by Means of Electrical Equivalent Circuit.....**40**

**AUTOMATION CONTROL SYSTEMS**

**L.G. Kopylova, S.V. Tararykin.** Compensation of Load Torque Harmonic Disturbances in Following Electromechanical Systems and Elements of Control Structural Optimization.....**44**

**K.T. Tergemes.** Parametric Synthesis of Multimotor Asynchronous Drive with Thyristor Converter of Voltage .....**52**

**METHODS OF MATHEMATICAL SIMULATION**

**A.A. Mitushov, S.I. Shuvalov.** Mathematical Modeling of Thermal Power-plant Pipes State in Creeping Conditions...**55**

**A.L. Arkhipov, F.N. Yasinskiy.** Movement Simulation of Viscous Incompressible Fluid on the NVIDIA CUDA.....**60**

**COMPUTER SCIENCE AND INFORMATION TECHNOLOGIES**

**I.D.Ratmanova, E.R.Travnikov.** Automation of Power Consumption Rationing and Limits in Budgetary Sphere of the Region.....**64**

**N.N. Elizarova, A.A. Kuznetsova.** Application of Statistical Methods for Prior Information Processing.....**69**

**ECONOMICS**

**D.M. Maslov, Yu.V. Vilgina, Yu.V. Grubova.** Certification of ISPU Quality Management System in Accordance with the EFQM Model Criteria.....**74**

**V.I. Kolibaba, E.O. Kutumova, E.V. Kutumova.** Identification and Economic Assessment of Energy Saving Potential in Textile Industry.....**78**

**N.V. Savina, T.S.Kozlova.** Control of Electric Power Quality in Electric Power Supply Systems of Metallurgical Enterprises in Market Conditions.....**84**

**ARTICLES PARTICIPANTS AEP-2012**

**VII International** Conference on Automated electric: Scientific Results. Summary.....**93**

**N.V. Shvidchenko, S.I. Lukyanov, R.S. Pishnograev.** Control System of Electric Collecting Roller Table of Hot Rolling Broad-Strip Mill.....**95**

**V.R. Khramshin.** Development and Implementation of Automated Electric Drives and Control Systems of Technological Parameters of Hot Rolling Broad-strip Mill.....**100**

**S.I. Luk'yanov, N.V. Fomin, A.I. Khlystov, E.S. Luk'yanov.** Electric Drive Control System of Pulling Rollers of Blanks Continuous Casting Machine.....**104**

**V.N. Medvedev, A.S. Karandaev, O.I. Karandaeva, Y.I. Mamleeva, E.A. Khramshina.** Technological Demand and Efficiency Assessment of Implementation of Variable-Frequency Electric Drives on Thermal Power Plants.....**109**

**R.G. Mugalimov, A.R. Mugalimova, M.R. Mugalimova.** Perspectives of Asynchronous Motors Application with Individual Compensation of Reactive Power in Industrial Electric Drives.....**114**

**E.Ya. Omelchenko, V.O. Moiseev, O.A.Telezhkin.** Automated Electric Drives of Drawing Mills According to the «Frequency Converter– Asynchronous Motor» System.....**119**

**V.N. Drozdov, V.A. Tolmachev, D.A. Subbotin.** Electromechanical Reverse Scanning Device Adjuster....**122**

**V.N. Drozdov, V.A. Tolmachev, D.A. Subbotin.** Reversible electromechanical scanner device control system.....**127**

**A.N. Gorunov, G.B.Onishchenko.** Regulated Electrodrive for Pump Set of the First Raise Water Supply Station.....**131**

*The Journal «Vestnik of Ivanovo State Power Engineering University» is included in the List of Leading Reviewed Scientific Journals and Publications, which are approved by the State Commission for Academic Degrees and Titles for publishing the main scientific results of the dissertations on the candidate and doctoral degrees.*

*The information on published articles is included into the Russian Science Citation Index system according to the Agreement №29-05/08 dated May 20, 2008 with JSC ltd. «Scientific Electronic Library».*

# HEAT AND POWER ENGINEERING

UDK 621.311.22

## EFFICIENCY ANALYSIS OF HEAT PRODUCING UNIT AT VARIABLE OPERATING MODES WHILE BURNING ADDITIONAL FUEL IN HEAT RECOVERY BOILER

B.L. SHELYGIN, E.S. MALKOV
Ivanovo State Power Engineering University, Ivanovo, Russian Federation
E-mail: admin@tes.ispu.ru

**Abstract**

**Background:** Currently the usage of the fuel combustion chamber and additional heat exchanger behind the heat recovery boiler for the heating network water is theoretically proved. It is necessary to evaluate the effectiveness of such power generating unit at variable operating modes of a gas turbine.
**Materials and methods:** Development of dependency is made on the basis of technical documentation for combined-cycle gas turbine and the calculation of boilers.
**Results:** Based on the established mathematical dependences for nominal operation mode of combined cycle plant, which includes a heat recovery boiler with an additional gas-water heat exchanger and combustion chamber additional fuel formulas for evaluating the performance of power unit at variable modes are obtained. Based on the obtained equations the analysis of efficiency combined cycle plant at variable modes operating was performed.
**Conclusions:** The author concludes that the efficiency increases in the power unit with the optional gas-water heat exchanger and the combustion of additional fuel behind heat recovery boiler at variable modes operating is from 1,5 to 5,1%. The considered mathematical equations allow not only to define the mode and technical and economical characteristics of the object but also to predict the changes with regards to the sourse data concerning to the similar units, which utilize the heat from gases of the gas-turbine units.

**Key words:** combustion chamber of additional fuel, variable mode, the relative consumption of additional fuel, heat power.

**References**

1. Ol'khovskiy, G.G. *Energeticheskie gazoturbinnye ustanovki* [Power Gas-turbine Units]. Moscow, Energoatomizdat, 1985.
2. Tsanev, S.V., Burov, V.D., Remezov, A.N. *Gazoturbinnye i parogazovye ustanovki teplovykh elektrostantsiy* [Gas-turbine and Combined-cycle Gas-turbine Units of Thermal Power Plants]. Moscow, Izdatel'stvo MEI, 2002.
3. Shelygin, B.L., Moshkarin, A.V., Malkov, E.S. *Vestnik ISPEU*, 2012, issue 2, pp. 4–7.
4. Moshkarin, A.V., Shelygin, B.L., Zhamlikhanov, T.A. *Vestnik ISPEU*, 2010, issue 2, pp. 7–10.
5. Shelygin, B.L., Moshkarin, A.V., Malkov, E.S. *Vestnik ISPEU*, 2012, issue 4, pp. 8–12.

UDK 621.926

## MODELING OF DEAERATION PROCESS IN BUBBLE STAGE WITH LIQUID FLOWS CIRCULATION

E.V. BAROCHKIN[1], V.P. ZHUKOV[1], A.Y. NENAEZDNIKOV[2], A.N. BELYAKOV[1], G.V. LEDUKHOVSKY[1], A.P. ZIMIN[1]
[1] Ivanovo State Power Engineering University, Ivanovo, Russian Federation
[2] OSC «Severstal», Cherepovets, Russian Federation
E-mail: zhukov-home@yandex.ru

**Abstract**

**Background:** Steam supply in bubbled liquid causes the appearance of circulating liquid flows, which at present are not considered in the description of deaeration process, but which can affect the size of steam bubbles, the area of interfacial surface and heat and mass transfer velocity. As a result, the circulation accounting of liquid flows is necessary for modeling of deaeration process.
**Materials and methods:** To consider the complicated movement of heat transfer agents in the layer and its influence on heat and mass transfer the authors use a new method, based on the Boltzmann kinetic equation.
**Results:** The mathematical model of water deaeration in bubbled liquid layer, based on the Boltzmann kinetic equation, is developed; parametric sensitivity of the model is investigated; the influence of circulating water flows on deaeration is shown.
**Conclusions:** The new approach to simulate the heat transfer agent movement and the heat-exchange process in bubbled liquid layer is proposed. The author prove that this method allows to increase the efficiency of deaeration process.

**Key words:** deaeration, bubble stage, heat and mass exchange, Boltzmann equation, interfacial surface.

**References**

1. Zhukov, V.P., Barochkin, E.V., Nenaezdnikov, A.Yu., Belyakov, A.N., Roslyakov, A.N. *Vestnik IGEU*, 2012, issue 3, pp. 12–16.

2. Kutateladze, S.S., Styrikovich, M.A. *Gidrodinamika gazo-zhidkostnykh sistem* [Hydrodynamics of gas-liquid systems]. Moscow, Energoizdat, 1958. 232 p.

3. Kutateladze, S.S. *Teploperedacha pri kondensatsii i kipenii* [Heat transfer in Condensation and Boiling Conditions]. Moscow, Gosudarstvennoe nauchno-tekhnicheskoe izdatel'stvo mashinostroitel'noy literatury, 1952. 231 p.

4. Leduhovsky, G.V. *Sovershenstvovanie tekhnologii desorbtsii kisloroda v struyno-barbotazhnykh deaeratorakh atmosfernogo davleniya.* Diss. kand. tekhn. nauk [Technological Development of Oxygen Desorption in Spray-buble Atmospheric Deaerator. Thesis of Candidate of Engineering]. Ivanovo, 2008. 226 p.

5. Sharapov, V.I., Tsyura, D.V. *Termicheskie deaeratory* [Thermal Deaerators]. Ul'yanovsk, UGTU, 2003. 560 p.

6. Vulis, L.A. *Teoriya i raschet magnitogazodinamicheskikh techeniy v kanalakh* [Theory and Designing the Magnetic Gas Dynamic Flows in Channels]. Moscow, Atomizdat, 1971. 384 p.

7. Barochkin, E.V., Zhukov, V.P., Nenaezdnikov, A.Yu., Belyakov, A.N., Roslyakov, A.N. *Vestnik IGEU*, 2012, issue 3, pp. 58–61.

8. Belyakov, A.N., Zhukov, V.P., Vlasyuk, A.A., Barochkin, A.E. *Svidetel'stvo o gosudarstvennoy registratsii programmy dlya EVM «Raschet mnogomernykh sovmeshchennykh protsessov izmel'cheniya, klassifikatsii v sypuchikh sredakh»* [Certificate of State Registration of Computer Program «Calculation of Multidimensional Combined Process of Grinding, Classification in Granulated Solids»], no. 2010612671, 2010.

9. Royak, M.E., Soloveychik, Yu.G., Shurina, E.P. *Setochnye metody resheniya kraevykh zadach matematicheskoy fiziki* [GridSolution Method of Boundary Problems in Mathematical Physics]. Novosibirsk, Izdatel'stvo NGTU, 1998. 120 p.

# ELECTRICAL POWER ENGINEERING

UDK 621.321

## INFLUENCE OF POWER AND RATED VOLTAGE OF WORKING POWER TRANSFORMERS ON OIL VOLUME IN MAIN INSULATION

O.S. MEL'NIKOVA
Ivanovo State Power Engineering University, Ivanovo, Russian Federation
E-mail: o.c.melnikova@mail.ru

**Abstract**

**Background:** Nowadays there are no data in literature regarding the oil volume changes in basic insulation and its electrical strength statistical characteristics depending on nominal technical parameters of working power transformers. As a result, the research of the influence of power and rated voltage of working power transformers on oil volume in main isolation is very important.
**Materials and methods:** Using the data base of working power transformers technical parameters in a wide range of meanings the author analyzes the oil volume change in basic insulation depending on transformers capacity and nominal voltage, and also their damage rate while exploiting. To evaluate the change of electrical strength statistical characteristics of oil volume in basic insulation depending on its volume the author uses Gnedenko-Weilbull"s three-parameter distribution, which shows physical processes during oil testing.
**Results:** The author describes the correlation relationship between the oil volume in working power transformers in their basic insulation and their nominal capacities and voltages in a range of 25–1000000 кVA and 6–1150 кV. It is proved that when the transformers capacity rises in certain limits and voltage is fixed, the oil volume in main insulation is reaching 10–12, and if the transformer capacity is fixed, the oil volume with increasing of voltage class is reaching 3,5.
**Conclusions:** The received results are very important for the development of the specific exploitation limits to the basic insulation of the working power transformers.

**Key words:** Transformer, power, voltage, transformer oil, oil volume, electrical strength statistical characteristics.

**References**

1. Sokolov, V.V. Aktual'nye zadachi razvitiya metodov i sredstv diagnostiki transformatornogo oborudovaniya pod napryazheniem [Actual tasks of developingthe methods and means of transformer equipment diagnostics under high voltage]. *Izvestiya RAN. Energetika*, 1997, no. 1, pp. 155–168.

2. Vanin, B.V., Lvov, Y.N. O povrezhdeniyakh silovykh transformatorov napryazheniem 110–500 kV v ekspluatatsii [On Power Transformers Damages with 110–500 kV voltage in operation process]. *Elektricheskie stantsii*, 2001, no. 9, pp. 53–58.

3. Gurin, V.V., Sokolov, V.V. Obsledovanie silovykh transformatorov v ekspluatatsii [Power Transformers Inspection during Operation]. *Elektrotekhnika*, 1994, no. 9, pp. 43–45.

4. Tikhomirov, P.M. *Raschet transformatorov: uchebnoe posobie dlya vuzov* [Transformers Calculation: Guide book for universities]. Moscow, Energoatomizdat, 1986. 528 p.

5. Vidmar, M. *Transformator v ekspluatatsii* [Transformer in Operation]. Moscow-Leningrad, GNTI, 1931. 292 p.

6. Kuchinskiy, G.S. *Izolyatsiya ustanovok vysokogo napryazheniya: uchebnik dlya vuzov* [Insulation of High-Voltage Installations: Guide book for Universities]. Saint-Petersburg, Energoatomizdat, St. Petersburg dep-t, 2003. 608 p.

7. Vereschagin, I.P., Larionova, V.P. *Elektrofizicheskie osnovy tekhniki vysokikh napryazheniy: uchebnik dlya vuzov* [Electrophysical basis of high voltage engineering: Guide book for Universities]. Moscow, Energoatomizdat, 1993. 543 p.

8. Mit'kin, Yu.A., Mel'nikova, O.S. *Vestnik IGEU*, 2012, issue 4, pp. 17–21.

UDK621.311

# CHARACTERISTICS CALCULATION OF STEADY-STATE MODES OF ELECTRICAL POWER ENGINEERING SYSTEM WITH THE CONTROLLED DEVICE OF SERIES COMPENSATION

V.P. GOLOV, A.A. MARTIROSYAN, I.A. MOSKVIN
Ivanovo State Power Engineering University, Ivanovo, Russian Federation
E-mail: golov@ispu.ru

**Abstract**

**Background:** The existing method of calculating the steady-state modes of the electrical power engineering system with the controlled device of series compensation should be constantly bound to the specific steady-state mode that is very inconvenient for researches and applying the controlled series compensation device with specific characteristics. It is important to carry out the characteristics calculation of the steady-state modes of the electrical power engineering system with the controlled device of series compensation without any links with the specific mode.
**Materials and methods:** The calculation of the steady-state modes of the electrical power engineering system with the controlled device of series compensation is carried out on the basis of the formed algebraic equations with using the Newton method. The verification of given results is controlled in "Energy" software package.
**Results:** The mathematical model is created and calculations of steady-state modes characteristics of the electrical power engineering system with the controlled device of series compensation are made without without any links with the specific mode, the initial data include characteristics of the controlled device of series compensation.
**Conclusions:** The developed software means allow to define changes of mode parameters at the set regulating device characteristic, to obtain controlled device characteristics for the solution to the problem of stability improvement, and to make steady-state modes calculations of electrical power engineering system with the controlled device of series compensation, altering the way of mode weighting at various calculation stages.

**Key words:** controlled device of series compensation, steady-state mode, mathematical model.

**References**

1. D'yakova, A.F. *lektricheskie seti sverkh- i ul'travysokogo napryazheniya EES Rossii. Teoreticheskie i prakticheskie osnovy* [Electrical networks of super and ultra-high voltage of Russia. Theoretical and practical Bases]. Moscow, NTF «Energoprogress» Korporatsii «EEEK», 2012.

2. Martirosyan, A.A. *Povyshenie ustoychivosti elektroenergeticheskikh sistem s primeneniem reguliruemoy prodol'noy kompensatsii.* Diss. kand. tehn. nauk [Stability Growth of Power Engineering Systems with Controlled Device of Series Compensation. Cand. tech. sci. diss.]. Ivanovo, 2009. 146 p.

3. Golov, V.P. *Izvestiya vuzov. Energetika*, 1978, no. 6, pp. 3–8.

4. *Elektricheskie sistemy i seti: Uchebnik dlya vuzov* [Electric systems and networks: Guide book for universities]. Moscow, Energoatomizdat, 1989. 592 p.

5. Golov, V.P., Martirosyan, A.A., Moskvin, I.A., Vinogradova, A.A. *Vestnik IGEU*, 2012, issue 5, pp. 26–31.

6. Kuleshov, A.I., Il'ichev, N.B., Serov, V.A. *Svidetel'stvo ob ofitsial'noy registratsii programmy dlya EVM №2004611423. Raschet i analiz ustanovivshikhsya rezhimov elektroenergeticheskikh sistem («Energiya UR»)* [Certificate of Software Registration № 2004611423. Calculation and Analysis of Steady-state Modes of Electrical Engineering Systems].

7. Venikov, V.A. *Perekhodnye elektromekhanicheskie protsessy v elektricheskikh sistemakh* [Transitional Electromechanical Processes in Electric Systems]. Moscow, Vysshaya shkola, 1985.

8. Fajbisovicha, D.L. *Spravochnik po proektirovaniyu elektricheskikh setey* [Reference Book for Designing Electric Networks]. Moscow, ENAS, 2012. 376 p.

# ELECTROMECHANICS

UDK 621.321

## MAGNETORHEOLOGICAL DAMPER WITH PISTON MAGNETIC SYSTEM

Yu.B. KAZAKOV, N.A. MOROZOV, S.A. NESTEROV
Ivanovo State Power Engineering University, Ivanovo, Russian Federation
E-mail: elmash@em.ispu.ru

**Abstract**

**Background:** Magnetic liquid dampers have already been used in practice, but there is no fairly complete theory of the influence of magnetic fields and hydrodynamic processes on their power and dissipation parameters.
**Materials and Methods:** Simulation results of the electromagnetic field of the magnetic liquid damper in the ANSYS system and S.M. Targa's hydrodynamic solutions are applied in the article.
**Results:** The authors consider the damper simulation with nanodispersed magnetic rheological liquids and piston magnetic system with the alternating poles and the magnetization reels. The authors find out that the damper properties and power characteristics of the device are defined by characteristics of the magnetic rheological liquids, intensity of the piston magnetic field, and the shift speed.
**Conclusions:** The proposed formulas can be used to estimate hydraulic parameters of dampers with magnetorheological liquid and the piston magnet system.

**Key words:** nanodispersed magnetorheological liquids, magnetic field, simulation, damper, magnetic liquid, piston magnetic system, shift speed, viscosity.

**References**

1. Radchuk, A.V., Sabaneev, N.A., Morozov, N.A. Primenenie nanodispersnoy magnitnoy zhidkosti v pryamokhodovykh dempfiruyushchikh ustroystvakh [Application of nanodispersed magnetic liquids in forward dampers]. *Izbrannye trudy XXI Mezhdunarodnoy innovatsionno-orientirovannoy konferentsii molodykh uchenykh i studentov po sovremennym problemam mashinovedeniya «MIKMUS-2009»* [The XXIst Innovation-oriented Young Scientists and Students Conference devoted to the modern problems of machine science «MIKMUS-2009», November 16–18, 2009, Selected Works]. Moscow, Institut mashinovedeniya im. A.A. Blagonravova (IMASh) RAN, 2010, pp. 111–118.

2. Kazakov, Yu.B., Morozov, N.A., Radchuk, A.V. Dempfiruyushchie ustroystva na osnove nanodispersnykh magnitoreologicheskikh zhidkostey [Damper Devices based on Nanodispersed Magnetorheological Liquids]. *Sbornik nauchnykh trudov XIV Mezhdunarodnoy Plesskoy konferentsii po nanodispersnym magnitnym zhidkostyam* [The XIVth International Plyos Conference of Nanodispersed Magnetic Liquids, September 7–10, Plyos, Russia: Collected Scientific Works]. Ivanovo, 2010, pp. 328–336.

3. Kazakov, Yu.B., Morozov, N.A., Nesterov, S.A. Upravlyaemye dempfiruyushchie ustroystva na osnove nanodispersnykh magnitnykh zhidkostey [Controlled Damper Devices based on Nanodispersed Magnetic Liquids]. *Trudy XIV Mezhdunarodnoy konferentsii «Elektromekhanika, Elektrotekhnologii, Elektrotekhnicheskie materialy i Komponenty»* [Works of the XIVth International Conference «Electromechanics, Electrical Technologies, Electrical and Technical Materials and Cmponents», September 23–29, 2012, Krym]. Alushta, 2012, pp. 54–55.

4. Morozov, N.A., Nesterov, S.A. Tipovye konstruktsii dempferov na osnove nanodispersnykh magnitnykh zhidkostey [Typical Damper Constructions based on Nanodispersed Magnetic Liquids]. *Sbornik nauchnykh trudov XV Mezhdunarodnoy Plesskoy konferentsii po nanodispersnym magnitnym zhidkostyam* [Collected Scientific Works of the XVth International Plyos Conference of Nanodispersed Magnetic Liquids, September 4–7, Plyos, Russia]. Ivanovo, 2012, pp. 307–314.

5. Morozov, N.A., Nesterov, S.A. Ekstsentrisitet magnitoprovodyashchego kol'tsa v kol'tsevom zazore [Eccentricity of magnetically conductive ring in the annular clearance]. *Materialy VI Mezhdunarodnoy nauchno-prakticheskoy konferentsii «Povyshenie effektivnosti energeticheskogo oborudovaniya»* [Works of VI International Scientific and Practical Conference «Increasing Efficiency of Power Engineering Equipment», December 6–8, 2011]. Ivanovo, 2011, pp. 479–484.

6. Morozov, N.A., Radchuk, A.V. Otsenka ispol'zovaniya v dempfiruyushchikh sistemakh s nanodispersnoy magnitnoy zhidkost'yu nemagnitnykh podvizhnykh elementov [Estimation of Nonmagnetic Movable Elements Usage in Damper Systems with Nanodispersed Magnetic Liquids]. *Sbornik nauchnykh trudov II Vserossiyskoy nauchnoy konferentsii «Fiziko-khimicheskie i prikladnye problemy magnitnykh dispersnykh nanosistem»* [Collected Scientific Works of the IInd All-Russian Scientific Conference «Physical and Chemical and Applied Issues of Magnetic Dispersed», September 14–17, 2009]. Stavropol', 2009, pp. 253–255.

7. Morozov, N.A., Kazakov, Yu.B. *Nanodispersnye magnitnye zhidkosti v tekhnike i tekhnologiyakh* [Nanodispersed Magnetic Liquids in Techniques and Technologies]. Ivanovo, 2011. 264 p.

8. Targ, S.M. *Osnovnye zadachi teorii laminarnykh techeniy* [Main Tasks of the Laminar Flows Theory]. Moscow-Leningrad, Gosudarstvennoe izdatel'stvo tekhniko-teoreticheskoy literatury, 1951. 420 p.

9. Rozentsveyg, R. *Ferrogidrodinamika* [Ferrohydrodynamics]. Moscow, Mir, 1989. 356 p.

10. Morozov, N.A., Nesterov, S.A. O techenii magnitnoy zhidkosti v kol'tsevom zazore magnitnoy sistem [About Magnetic Liquids Flow in Annular Clearance of Magnetic Systems]. *Sbornik nauchnykh trudov III Vserossiyskoy nauchnoy konferentsii «Fiziko-khimicheskie i prikladnye problemy magnitnykh dispersnykh nanosistem»* [Collected Scientific Works of the IIIrd All-Russian Scientific Conference «Physical and Chemical and Applied Issues of Magnetic Dispersed», September 15–18, 2011]. Stavropol', 2011, pp. 129–135.

11. Kazakov, Yu.B. *Germetizatory na osnove nanodispersnykh magnitnykh zhidkostey i ikh modelirovanie* [Sealers based on Nanodispersed Magnetic Liquids and their Designing]. Ivanovo, 2010. 184 p.

12. Kazakov, Yu.B., Morozov, N.A., Nesterov, S.A. Modelirovanie dempfera s nanodispersnoy magnitoreologicheskoy zhidkost'yu i porshnevoy magnitnoy sistemoy [Damper Designing with Nanodispersed Magnetorheological Liquids and Piston Magnetic System]. *Sbornik materialov IV Mezhdunarodnoy konferentsii s elementami nauchnoy shkoly dlya molodezhi «Funktsional'nye nanomaterialy i vysokochistye veshchestva»* [Collected Works of the IVth International Conference with Elements of Scientific School for the Youth «Functional Nanomaterials and High-Clean Substances». Suzdal. October 1–5, 2012]. Moscow: IMET RAN, 2012, pp. 109–110. Available at: http://www.fnm.imetran.ru

UDK 621.9, 665.765

# IMPROVING LUBRICATING ABILITY OF LUBRICATING AND COOLING TECHNOLOGICAL SUBSTANCES FOR METAL TREATMENT DUE TO MESOGENIC COMPOUNDS ADDITIONS

V.V. NOVIKOV[1], E.E. NUZDINA[1], S.A. SYRBU[1], M.S. MARSHALOV[2], R.U. LISITSYN[2]
[1] Ivanovo State University, Ivanovo, Russian Federation
[2] Ivanovo Institute of State Firefighting Service of EMERCOM of Russia, Ivanovo, Russian Federation
E-mail: novikov-ww@mail.ru

**Abstract**

**Background:** The actuality of the article is connected with the replacement problem of the toxic additions in the lubricating and cooling technological substances on less toxical and biodecomposable additions without losses of functional properties of these substances. At present time in scientifical literature there is information about the possibility to appy the mesogenic cholesterol compounds as good additions. But the problem still requires the further research.
**Materials and methods:** The authors tested a large number of the lubricating and cooling technological substances structures with additions of cholesterol mesogenic compounds (MCC) while holes drilling.
**Results:** The authors carried out the experimental researches. The efficiency criterion of lubricity of the lubricating and cooling technological substances was suggested. The authors defined the most effective structures of the lubricating and cooling technological substances.
**Conclusions:** Implementation of the additions of cholesterol mesogenic compounds for the lubricating and cooling technological substances allows improving the lubricating ability of the structures and the quality of metal treatment.

**Key words:** metal treatment, drilling, surface quality, lubricant, cutting oil, lubricating fluid, additions, cholesterol compound, mesomorphism, tribology.

**References**

1. Hebdy, M., Chichinadze, A.V. *Spravochnik po tribotekhnike* [Reference book of Tribological Engineering]. Moscow, Mashinostroenie, 1990, vol. 2. 420 p.

2. Ermakov, S.F., Rodnenkov, V.G., Beloenko, E.D., Kupchinov, B.I. *Zhidkie kristally v tekhnike i meditsine* [Liquid Crystals in Engineering and Medicine]. Minsk, «Asar»; Moscow, «CheRo», 2002. 412 p.

3. Karabanov, R.I., Latyshev, V.N., Chistyakova, I.G., Chaykovskiy, V.M. *Smazochno-okhlazhdayushchaya zhidkost' dlya mekhanicheskoy obrabotki metallov* [Lubricating Fluid for Mechanical Treatment of Metals]. Avtorskoe svidetel'stvo, no. 601304 (USSR), 1978.

4. Shkolnikova, V.M. *Topliva, smazochnye materialy i tekhnicheskie zhidkosti. Assortiment i primenenie. Spravochnik* [Fuels, Lubricating Fluids, and Technical Liquids. Types and Application. Reference book. Editor V. M. Shkolnikov]. Moscow, Izdatel'skiy tsentr «Tekhinform», 1999. 596 p.

5. Kolbashov, M.A., Latyshev, V.N., Novikov, V.V., Syrbu, S.A. *Trenie i iznos*, 2009, vol. 20, no. 6, pp. 564–567.

6. Novikov, V.V., Latyshev, V.N., Syrbu, S.A., Kolbashov, M.A. O mekhanizme smazochnogo deystviya soedineniy kholesterina s khimicheski aktivnymi lateral'nymi zamestitelyami [About Lubricating Mechanism of Cholesterol Compounds with Chemically Active Lateral Substitute]. *Tezisy dokladov na konferentsii Polikomtrib-2011* [Reports' Points at the «Polikomtrib-2011» Conference]. Gomel', Belarus', 2011, pp. 162–163.

7. Latyshev, V.N. *Povyshenie effektivnosti SOZh* [Increasing the Efficiency of Lubricating Fluids]. Moscow, Mashinostroenie, 1985. 65 p.

8. Latyshev, V.N. *Tribologiya rezaniya. Kniga 1: Friktsionnye protsessy pri rezanii metallov* [Cutting Tribology: Book 1, Frictional Processes for Metal Cutting]. Ivanovo, Ivanovskiy gosudarstvennyy universitet, 2009. 108 p.

9. Kolbashov, M.A. *Povyshenie stoykosti bystrorezhushchego instrumenta i uluchshenie kachestva obrabotannoy poverkhnosti pri rezanii za schet primeneniya sots s prisadkami zhidkokristallicheskikh soedineniy*. Diss. kand. tekhn. nauk [Increasing the Stability of Quick-Cutting Tools and Quality Improvement of Treated Surface while Cutting due to Application of the lubricating and cooling technological substances with Liquid Crystals Additions. Cand. tech. sci. diss.]. Ivanovo, 2010.

10. Novikov, V.V., Latyshev, V.N., Marshalov, M.S., Nuzhdina, E.E., Kolbashov, M.A. Properties of Cutting Oils with Additives of Liquid Crystals. Journal of Friction and Wear, 2011, vol. 32, no. 6, pp. 452–456.

11. Entelisa, S.G., Berlinera, E.M. *Smazochno-okhlazhdayushchie tekhnologicheskie sredstva dlya obrabotki metallov rezaniem. Spravochnik* [Lubricating and cooling technological substances for Metal Treatment by Cutting]. Moscow, Mashinostroenie, 1995. 496 p.

UDK 621.538

# RESEARCH OF DISTRIBUTION OF MAGNETIC FIELD STRENGTH AND MAGNETIC FLOWS IN CLASSICAL MAGNETO-LIQUID SEALER

S.M. PERMINOV
Ivanovo State Power Engineering University, Ivanovo, Russian Federation
E-mail: psm@upm.ispu.ru, elmash.ispu.ru

**Abstract**

**Background:** Nowadays there are no data about detailed distribution of magnetic field in magneto-liquid sealers. As a result, it is important to carry out the reseach devoted to the distribution of the magnetic field strength and magnetic flows in classical magneto-liquid sealers.
**Materials and methods:** The research is performed on the basis of modeling the magnetic field by means of the method of finite elements. The author uses the differentiated finite element scheme of 1080000 triangular elements.
**Results:** The author considers the main regularities of the distribution of magnetic field in magneto-liquid sealers: in the gap, on the magnetic system surface, in the cavity under the magnet. The author defines the distribution of the magnetic field strength in the gap, in the space near the magnetic system of the magneto-liquid sealer. The main magnetic flows of the magnetic system and their correlations are described. It is shown that the ends of the teeth of the pole attachments are able to perceive the pressure drop by 9.5% higher than the average. As a result of the simulation the author determines the detailed distribution of magnetic field strength of the magneto-liquid sealer.
**Conclusions:** The given results allow to design, test, operate, and fill the the magneto-liquid sealer.

**Key words:** magneto-liquid sealer, magnetic field, distribution of magnetic field strength, magnetic flows.

**References**

1. Bol'shakova, I.A., Perminov, S.M., Rusakova, N.N. Izmeritel'noe oborudovanie dlya magnitozhidkostnykh sistem germetizatsii na osnove miniatyurnykh datchikov Kholla [Measuring equipment for sealing magneto systems based on miniaturized Hall sensors]. *XIV Mezhdunarodnaya konferentsiya po magnitnoy gidrodinamike* [Measuring Equipment for Magneto-Liquid Sealing Systems based on Tiny Hall Sensors]. Latviya, Salaspils, 1995.

2. Stradomskiy, Yu.I., Perminov, S.M., Borisov, S.S. Poverochnyy raschet magnitozhidkostnogo germetizatora [Checking Calculation of Magneto-Liquid Sealer]. *Materialy III Vsesoyuznoy shkoly-seminara po magnitnym zhidkostyam*. Moscow, IGU, 1983, pp. 241–242.

3. Stradomskiy, Yu.I., Perminov, S.M., Borisov, S.S., Rusakova, N.N. Konechno-raznostnoe modelirovanie magnitozhidkostnogo germetizotora [Finite-difference Simulation of Magneto-Liquid Sealer]. *Trudy IGEU. Magnitnye zhidkosti v IGEU* [Works of the IIIrd All-unity School – Seminar of Magnetic Liquids]. Ivanovo, 2004, pp. 149–169.

4. Perminov, S.M., Kazakov, Yu.B. Vliyanie nasyshcheniya stali polyusov i vala na magnitnoe pole i uderzhivayushchuyu sposobnost' rabochego zazora magnitozhidkostnogo germetizatora [Influence of Steel Saturation of poles and shaft on magnetic field and Retention of working gap of Magneto-Liquid Sealer]. *Tezisy dokladov na IV Vsesoyuznoy konferentsii po magnitnym zhidkostyam* [Reports' Points of the IVth All-Unity Conference of Magnetic Liquids]. Moscow, 1985, vol. 2, pp. 31–32.

5. *Sayt OOO «Tor»* [LLC «Tor» Website]. Available at: www//.elcut.ru.

6. *Magnitnye zhidkosti* [Magnetic Liquids]. Available at: www// ispu.ru

7. Perminov, S.M., Perminova, A.S. S*posob i ustroystvo dlya izmereniya namagnichennosti zhidkogo veshchestva, v chastno-sti, magnitnoy zhidkosti* [Ways and Tools for Measurement of Liquid Magnetization, for example, Magnetic Liquid]. Patent FR, no. 2402032, 2010.

8. Perminov, S.M. *Vestnik IGEU*, 2009, issue 3, pp. 33–36.

9. Perminov, S.M. *Vestnik IGEU*, 2011, issue 5, pp. 30–32.

UDK 538.4

# VISCOMETER DESIGN FOR MAGNETIC LIQUIDS RESEARCH

A.P. SIZOV[1], O.U. BALASHOV[1], E.V. SERGEEV[2]
[1] Ivanovo State Agricultural Academy, Ivanovo, Russian Federation
[2]Ivanovo Institute of State Firefighting Service of EMERCOM of Russia, Ivanovo, Russian Federation
E-mail:ivgsha@ tpi.ru.

**Abstract**

**Background:** Due to the development of techniques and devices working with magnetic liquids, the problem to research the flow characteristics of magnetic structured nanoliquid media is very urgent. The creation of new constructions of the viscometers as well as modernisations of the known ones can help to solve the problem.
**Materials and methods:** Calculations of magnetic characteristics of the offered мagnetic viscometer design are executed on the basis of the method of final elements.
**Results:** The author describes the specially developed design of мagnetic viscometer which helps to research flow characteristics of magneticnanodispersed environments named magnetic liquids (ML). The author considers the influence of external magnetic field strength on flow characteristics, magnetic properties of measuring surface of magnetic liquids parametres. The analysis of the received data is carried out.
**Conclusions:** The developed design of magnetic viscometer will allow to investigate properties of magnetic liquids environments in the magnetic field.

**Key words:** rheology, viscometer, magnetic structured media, magnetic liquid, magnetic field, ferromagnetic particles.

**References**

1. Orlov, D., Sizov, A.P. *Magnitnye zhidkosti v mashinostroenii* [Magnetic liquids in mechanical engineering]. Moscow, Mashinostroenie, 1993.
2. Sizov, A.P. *Povyshenie nadezhnosti mashin i mekhanizmov primeneniem magnitozhidkostnykh ustroystv.* Diss. dokt. tekhn. nauk [Increasing the Efficiency of Machines and Mechanisms with Application of Magneto-Liquid Devices. Dr. tech. sci. diss.]. Moscow, 1994.
3. Berkovskiy, V.M., Medvedev, V.F. *Magnitnye zhidkosti* [Magnetic Liquids]. Moscow, Khimiya, 1989.
4. Ginzburg, L.B., Fedotov, A.I. *Proektirovanie elektromagnitnykh i magnitnykh mekhanizmov* [Designing Electromagnetic and Magnetic Mechanisms]. Leningrad, Mashinostroenie, 1980.
5. Rozentsveyg, R.E. *Ferrogidrodinamika* [Ferrohydrodynamics]. Moscow, Mir, 1989.
6. Girkunov, V.M. *Tribotekhnika* [Tribological Engineering]. Moscow, Mashinostroenie, 1985.

UDK 621.321

# HEAT CALCULATION OF TRANSFORMERS WINDINGS AND CURRENT-LIMITING REACTORS BY MEANS OF ELECTRICAL EQUIVALENT CIRCUIT

A.V. STULOV, A.I. TIKHONOV
Ivanovo State Power Engineering University, Ivanovo, Russian Federation
E-mail: alxstl@mail.ru, ait@dsn.ru

**Abstract**

**Background:** At present time heat calculation of transformers windings and current-limiting reactors of aluminum or copper tape are carried out by methodologies without taking into account the current crowding-out effect. So, there is great difference between calculated and experimental values of middle and maximum temperatures. The development of the exact mathematical model of transformer windings with taking into account the irregular current distribution on tape height is necessary.
**Materials and methods:** The authors use the thermal tests results of windings of current-limiting reactor 1600 A, 0.35 Ohm, as well as the thermal tests results of low-tension windings of dry-type transformers. The authors apply the method of heat circuits and method of electrical equivalent circuits while developing the model.
**Results:** The heat model of windings is developed. It considers the irregular current distribution on tape height. The authors provide the comparative analysis of the measurement results of temperature distribution in tape windings with calculation values.
**Conclusions:** The offered mathematical model can be used for increasing the calculation accuracy and designing efficiency of tape windings. It is proved that the temperature distribution in the tape windings can be defined with the high accuracy by means of calculations of the offered model.

**Key words:** tape winding, current displacement, heat transfer, heat circuits, heat convection coefficient.

**References**

1. Tikhonov, A.I., Ivanov, A.V. *Proektirovanie i proizvodstvo tokoogranichivayushchikh reaktorov iz alyuminievoy lenty* [Construction and production of current-limiting reactors of alluminium tape]. Ivanovo, 2010. 116 p.
2. Sipaylov, G.A., Sannikov, D.I., Zhadan, V.F. T*eplovye, gidravlicheskie i aerodinamicheskie raschety v elektricheskikh mashinakh* [Heat, gidraulic and aerodynamic calculations in electrical machines]. Moscow, Vysshaya shkola, 1989. 239 p.
3. Isachenko, V.P., Osipova, V.A., Sukomel, V.A. *Teploperedacha* [Heat transfer]. Moscow, Energoatomizdat, 1981. 416 p.

# AUTOMATION CONTROL SYSTEMS

UDK 625.083

## COMPENSATION OF LOAD TORQUE HARMONIC DISTURBANCES IN FOLLOWING ELECTROMECHANICAL SYSTEMS AND ELEMENTS OF CONTROL STRUCTURAL OPTIMIZATION

L.G. KOPYLOVA, S.V. TARARYKIN
Ivanovo State Power Engineering University, Ivanovo, Russian Federation
E-mail: tsv@ispu.ru

**Abstract**

**Background:** Polyharmonical load torque is a main feature of electromechanical systems. Load torque fluctuations and, hence, executive device speed fluctuations cause significant changes of the finished product quality measures. In electromechanical systems, which have conventional structures, considerable decrease in speed pulsations level by increasing the loop gain of the follow-up system can cause significant deterioration of control response quality and reduction of linear range of system operation.
**Materials and methods:** Simultaneous requirements satisfaction of control response and harmonic disturbance compensation are implemented by combining the principle of disturbance internal model with other principles of automatic control system design. These principles are cascade control, subordinate control with series correction, state control, polynomial output control, motion rates separation.
**Results:** Comparative assessment of operating efficiency of control devices, synthesized by the combination of listed methods, is implemented. Assessment factors are response quality of load torque harmonic disturbances, acceptable variations range of inertia moment of system mechanical part, pulsations level of output speed signal when the noise is on its measuring channel, maximum value of signals time delay in power converter when the system is stable and the total degree of regulator dynamic blocks as well.
**Conclusions:** The obtained results enable to demonstrate the way the appointed quality factors are underlined when designer uses the combination of different principles of the system design. It allows to make the proper choice of the most efficient control structure.

**Key words:** electromechanical system, disturbance compensation, internal model principle, control structural optimization, selective invariance.

**References**

1. Shenfel'd, R., Khabiger, E. *Avtomatizirovannye elektroprivody* [Automatic electric drives]. Leningrad, Energoatomizdat. Leningradskoe otdelenie, 1985.

2. Selezneva, V.V. Vibrodiagnostika stankov po rezul'tatam obrabotki [Vibration-based diagnostics of machines according to processing results]. *Nadezhnost' i diagnostirovanie tekhnologicheskogo oborudovaniya: sbornik statey. INMASh ANSSSR* [Reliability and diagnostics of manufacturing equipment: Collected articles]. Moscow, Nauka, 1987.

3. Gudvin, G.K., Grebe, S.F., Sal'gado, M.E. *Proektirovanie sistem upravleniya* [Control system design]. Moscow, BINOM. Laboratoriya znaniy, 2004.

4. Tararykin, S.V. *Printsipy upravlyaemoy sinkhronizatsii mashin v tekhnologicheskikh agregatakh dlya proizvodstva lentochnykh i volokonnykh materialov.* Diss. dokt. tekhn. nauk [Principles of controlled machines synchronization in technological aggregates for tape and fiber materials production. Dr. tech. sci. diss.]. Ivanovo, 1992.

5. Chilikin, M.G., Klyuchev, V.I., Sandler, A.S. *Teoriya avtomatizirovannogo elektroprivoda: uchebnoe posobie dlya vuzov* [Theory of automatic electric drives: Tutorial for institute of higher education]. Moscow, Energiya, 1979.

6. Voronov, A.A. *Vvedenie v dinamiku slozhnykh upravlyaemykh system* [Introduction on dynamics of complex controlled systems]. Moscow, Nauka, 1985.

7. Tararykin, S.V., Tyutikov, V.V. *Sistemy koordiniruyushchego upravleniya vzaimosvyazannymi elektroprivodami* [Systems of coordinated control for interconnected electric drives]. Ivanovo, 2000.

8. Zaytseva, M.V., Parsheva, E.A. Robastnoe upravlenie lineynym ob»ektom pri nalichii vozmushcheniy i pomekh [Robust control of linear object under disturbances and noises]. *Mekhatronika, avtomatizatsiya, upravlenie*, 2011, no. 3.

9. Kulebakin, V.S. Ob osnovnykh zadachakh i metodakh povysheniya kachestva avtomaticheskogo regulirovaniya system [Main problems and methods of quality increasing automatic control systems]. *Trudy II Vsessiyskogo soveshchaniya po teorii avtomaticheskogo regulirovaniya* [Proceedings of II all-USSR meeting on automation control theory]. Moscow, Nauka, 1965, vol. II.

10. Gaiduk, A.R. *Osnovy teorii sistem avtomaticheskogo upravleniya: uchebnoe posobie* [Basics of automation control systems theory: tutorial]. Moscow: Uchebno-metodicheskiy i izdatel'skiy tsentr UCHEBNAYA LITERATURA, 2005.

11. Andrievskiy, B.R., Fradkov, A.L. *Izbrannye glavy teorii avto-maticheskogo upravleniya s primerami na yazyke MATLAB* [Selected chapters of automation control theory with examples on MATLAB language]. Saint-Petersburg, Nauka, 1999.

UDK 62-83(075.8)

# PARAMETRIC SYNTHESIS OF MULTIMOTOR ASYNCHRONOUS DRIVE WITH THYRISTOR CONVERTER OF VOLTAGE

K.T. TERGEMES
Caspian State University of Technologies and Engineering, Aktau, Kazakhstan
E-mail: tergemes@mail.ru

**Abstract**

**Background:** In existing systems of multimotor electric drive for synchronous rotation a considerable quantity of thyristor conventers of voltage and asynchronous motors are applied. It complicates the mathematical description of the given electric drives.
**Materials and methods:** For parametric synthesis of multimotor asynchronous electric drive with thyristor voltage converters the author uses the mathematical model of the asynchronous motor within the scope of performance characteristics as well as the application program package MATLAB. The flow diagram of parametric synthesis algorithm is developed on the basis of the theory of Lyapunov's direct method, scanning numerical method, and random numbers.
**Results:** The thyristor control systems of multimotor asynchronous electric drive which allow to support the rotation synchronism with great differences of loads of driving motors such as a card. The author draws up the flow diagram of parametric synthesis algorithm of multimotor asynchronous electric drive with thyristor voltage converters which helps to calculate the connection coefficients according to the differences of engines speed to provide synchronism of engine rotation at different loads on the shafts.
**Conclusions:** The calculated numerical values of the connection coefficients provide the synchronous rotation of all mechanisms and their multimotor asynchronous electric drives with thyristor voltage converters. It confirms with the given and completely matched curves of transitional processes of engine rotation speed.

**Key words:** multimotor electric drive, algorithm, parametric synthesis, connection coefficient, thyristor voltage converter.

**References**

1. Sadovskiy, I.M. *Soglasovannoe vrashchenie asinkhronnykh dvigateley* [Conformal rotation of asynchronous engines]. Moscow: Gosenergoizdat, 1948. 210 p.

2. Tergemes, K.T. *Mnogodvigatel'nye asinkhronnye elektroprivody chesal'nykh apparatov s tiristornymi preobrazovatelyami napryazheniya* [Multimotorial asynchronous electric drives of cards with thyristor voltage converters]. Almaty, Izdatel'stvo KBTU, 2006. 108 p.

3. Terekhov, V.N., Osipov, O.I. *Sistemy upravleniya elektroprivodov* [Control systems of Electric Drives]. Moscow, Akademy, 2006, pp.188–189.

4. Fel'dbaum, A.A., Butkovskiy, A.G. *Metody teorii avtomaticheskogo upravleniya* [Methods of Automatic Control Theory]. Moscow, Nauka, 1971, pp. 312–321.

5. Boyarinov, A.I., Kafarov, V.V. *Metody optimizatsii v khimicheskoy tekhnologii* [Optimisation methods in Chemical Technology]. Moscow, Khimiya, 1971, pp. 312–321.

# METHODS OF MATHEMATICAL SIMULATION

UDK 621.311.22

## MATHEMATICAL MODELING OF THERMAL POWER-PLANT PIPES STATE IN CREEPING CONDITIONS

A.A. MITUSHOV[1], S.I. SHUVALOV[2]
[1] Open joint-stock company «The Second Generating Company of the Wholesale Power Market» (JSC «OGK-2»), Moscow, Russian Federation
[2] Ivanovo State Power Engineering University, Ivanovo, Russian Federation
E-mail: ShuvalovS@rambler.ru, dmitriyikorovin@list.ru, tdmitrieva@ogk6.ru

**Abstract**

**Background:** Reliability of the pipelines operating under creeping conditions depends on the defects in metal in the form of pores and microcracks, the intensity of which is determined by the development and the ever-increasing plastic deformation. The existing forecasting models use the average performance, which can vary widely even in the same type of elements working in the same conditions. For sound prediction the model that adequately reflects the accumulation of defects, and takes into account the individual characteristics of the elements, is necessary.
**Materials and methods:** Evaluation of the connection between the damaged structure and residual strain is based on the statistical analysis of the pipelines diagnostics results of live steam and hot reheats Ryazan GRES, made of steel 15H1M1F. The appearance probability of individual classed of microdamages is determined by the Bayes method.
**Results:** The mathematical model that calculates the most likely and gamma percentages of permanent deformation and the likelihood of damage metal pores and microcracks is developed. The parameters values of the distributions for classes of structure microdamages are provided.
**Conclusions:** The proposed mathematical model is recommended for predicting the state of the metal bends and calculating the remaining resource.

**Key words:** pipeline bends, creepng, residual deformation, damageability, prediction of condition.

**References**

1. Mityushov, A.A. Vybor parametrov dlya prognozirovaniya ostatochnogo resursa oborudovaniya [Parameters Choice for Predicting Residual Life of Equipment]. *Sbornik dokladov V Yubileynoy vserossiyskoy nauchno-prakticheskoy konferentsii* [The Vth Anniversiry All-Russian Scientific and Practical Conference. Reports Book]. Ivanovo, 2010, pp. 59–62.
2. Chadek, Y. *Polzuchest' metallicheskikh materialov* [Creeping of Metal Materials]. Moscow, Mir, 1987. 304 p.
3. Petrenya, Yu.K. *Fiziko-mekhanicheskie osnovy kontinentual'noy mekhaniki povrezhdaemosti* [Physical and Mechanical Foundations of Continual Mechanics of Damageability]. Saint-Petersburg, AOOT «NPO TsKTI », 1997. 147 p.
4. Kachanov, L.M. *Teoriya polzuchesti* [Creep Theory]. Moscow, Fizmatgiz, 1960. 456 p.
5. Venttsel', E.S. *Teoriya veroyatnostey* [Probability Theory]. Moscow, Nauka, 1969. 576 p.
6. Mityushov, A.A., Korovin, D.I., Shuvalov, S.I. *Vestnik IGEU*, 2012, issue 2, pp. 12–15.

UDK 004.94

# MOVEMENT SIMULATION OF VISCOUS INCOMPRESSIBLE FLUID ON THE NVIDIA CUDA

A.L. ARKHIPOV, F.N. YASINSKIY
Ivanovo State Power Engineering University, Ivanovo, Russian Federation
E-mail: AlArMail999@mail.ru

**Abstract**

**Background:** The movement simulation of viscous incompressible fluid has a great number of different areas of practical application in engineering (for example, simulation of feed water flow in heat power plant loop). The similar tasks are resource-intensive in calculation. The expensive highly productive cluster multiprocessor systems are used to solve the task. So, the problem of the movement simulation of viscous incompressible fluid without expensive calculating clusters is urgent.
**Materials and methods:** The authors suggest solving the problem of the movement simulation of viscous incompressible fluid using the calculations on graphics processors (GPU). The NVIDIA CUDA platform is chosen as a means to carry out the calculations. It allows to make general parallel calculations on graphics processors. Besides, the authors use the adapted computing circuit of the problem solving algorithm of the movement simulation of viscous incompressible fluid.
**Results:** The article contains the way for simulating the movement of viscous incompressible fluid with using of calculations on graphics processors (GPU) that helps to reduce the computing system costs, save the high speed of calculations and their accuracy. The authors demonstrate the calculation acceleration in 85 times according to the operation in the central processor
**Conclusions:** The authors carry out thecalculations of the movement of viscous incompressible fluid on NVIDIA CUDA platform and it helps to accelerate the calculations in comparison with the program which can calculate only in central processor. The application of graphics processors allows to simulate the movement of viscous incompressible fluid without expensive calculating clusters. The costs of necessary equipment are less in 80–100 times.

**Key words:** numerical simulation, countercurrent derivative, parallel programming, NVIDIA CUDA.

**References**

1. Gushchin V.A., Matyushin P.V. Matematicheskoe modelirovanie techeniy neszhimaemoy zhidkosti [Mathematical Simulation of Viscous Incompressible Fluid]. *TRUDY MFTI*, 2009, vol. 1, no. 4, pp. 18–33.

2. *CUDA.* Available at: http://en.wikipedia.org/wiki/CUDA

3. Balaev, E.F., Nuzhdin, N.V., Pekunov, V.V., Sidorov, S.G., Chernysheva, L.P., Yasinskiy, I.F., Yasinskiy, F.N. *Chislennye metody i parallel'nye vychisleniya dlya zadach mekhaniki zhidkosti, gaza i plazmy* [Numerical Analysis and Parallel Computing for Fluid and Plasma Mechanical Problems]. Ivanovo, 2003, pp. 83–87.

4. *NVIDIA CUDA – negraficheskie vychisleniya na graficheskikh protsessorakh* [NVIDIA CUDA – Nongraphical Calculations on graphics Processors]. Available at: http://www.ixbt.com/video3/cuda-1.shtml

# COMPUTER SCIENCE AND INFORMATION TECHNOLOGIES

UDK 004.6

## AUTOMATION OF POWER CONSUMPTION RATIONING AND LIMITS IN BUDGETARY SPHERE OF THE REGION

I.D. RATMANOVA, E.R. TRAVNIKOV
[1]Ivanovo State Power Engineering University, Ivanovo, Russian Federation
[2]Power Economy and Tariff Management Department, Yaroslavl Region, Russian Federation
E-mail: idr@osi.ispu.ru

**Abstract**

**Background:** Fuel and power resources costs growth and, as a result, tariff rates growth make it necessary to assume measures aimed to increase energy consumption efficiency in all industry sectors. According to the law in the non-private sector considerable economy of fuel and power is to be achieved. Energy saving and energy efficiency enhancement co-ordination and their accomplishment by state-financed activities monitoring are up to relevant government authorities of the Russian Federation territorial units. In view of a large amount of information it's reasonable to apply informational decision support tools for power consumption limits.
**Matherials and methods:** Systems analysis of fuel and power resources consumption by non-private sector activities and power-consumption typology research aimed at reasonable average standards consideration became a basis for the developed methods for rating and limiting of non-private sector activities power consumption.
**Results:** An informational decision support technology which allows regional government authorities, public offices and public unitary enterprises to settle valid power resources consumption limits for achieving the savings rate ascertained by statute.
**Conclusions:** The implemented analytical service allows to determine power consumption limits taking into account an assessment of each activity FPR specific consumption deviation from the specified average standard for a relevant consuming cluster. Annual power consumption analysis allows to consider power resources expenditure reduction in the covered field.

**Key words:** Energy saving, budgetary sphere of region, power consumption rating and limiting, decision making support, informational analytic system.

**References**

1. Ratmanova, I.D. Organizatsiya monitoringa sostoyaniya TEK, toplivno-energeticheskiy balans regiona kak osnova sistemy upravleniya energosberezheniem [Heat and power network condition monitoring, region's fuel and power balance as the basis of energy saving control system]. *III mezhdunarodnaya nauchno-prakticheskaya konferentsiya «Energoobespechenie i energosberezhenie – regional'nyy aspekt»* (Pravitel'stvo Yaroslavskoy oblasti) [III international research and practice conference «Power supply and energy saving – regional aspect» (The Yaroslavl region administration)]. Yaroslavl', 2009, pp. 23–25.

2. Ratmanova, I.D. Informatsionno-analiticheskoe upravlenie energosberezheniem. Sistema vedeniya toplivno-energeticheskikh balansov [Energy saving informational analytic control. Heat and power balance system]. *Materialy Yaroslavskogo energeticheskogo foruma* [Yaroslavl power economy meeting report]. Yaroslavl', 2010, pp. 32–34.

UDK 65.012.12:331

# APPLICATION OF STATISTICAL METHODS FOR PRIOR INFORMATION PROCESSING

N.N. ELIZAROVA, A.A. KUZNETSOVA
Ivanovo State Power Engineering University, Ivanovo, Russian Federation
E-mail: elisarova@it.ispu.ru, anyagrunge@mail.ru

**Abstract**

**Background:** Statistical methods are widely used. The usage of a priori processing allows reducing a number of observations to design models.
**Materials and methods:** The author used the correlation analysis. The article also considers the informative determination method of independent features, based on the comparison of the probability characteristics.
**Results:** The author suggests the method of prior processing based on the correlation analysis. For the selection of input features the informative determination method of independent features is considered. As an example, the implementation of the methodology is discussed.
**Conclusions:** The method of prior processing is aimed not only at selecting the relevant variables, but also at testing the links between input variables. It allows to decrease a number of the required observations.

**Key words:** statistical methods, regression model, final figure, independent factor, mathematical expectation, variance, correlation, significance of coefficients, informational signs.

**References**

1. Elizarova, N.N. *Vesnik IGEU*, 2009, issue 3, pp. 76–80.
2. Belov, A.A., Ballod, B.A., Elizarova, N.N. *Teoriya veroyatnostey i matematicheskaya statistika: uchebnik* [Probability Theory and Mathematical Statistics]. Rostov n/D, Feniks, 2008. 318 p.
3. Gorelik, A.L., Skripkin, V.A. *Metody raspoznavaniya* [Recognition Methods]. Moscow, Vysshaya shkola, 1989. 231 p.
4. Ayvazyan, S.A. Mkhitaryan, V.S. *Prikladnaya statistika i osnovy ekonometriki: uchebnik dlya vuzov* [Applied Statistics and Econometrics Fundamentals]. Moscow, YuNITI, 1998. 1022 p.

# ECONOMICS

UDK 006.015.5

## CERTIFICATION OF ISPU QUALITY MANAGEMENT SYSTEM IN ACCORDANCE WITH THE EFQM MODEL CRITERIA

D.M. MASLOV, Yu.V. VILGINA, Yu.V. GRUBOVA
Ivanovo State Power Engineering University, Ivanovo, Russian Federation
E-mail: maslow@bk.ru, jvilgina@mail.ru, jgrubova@rambler.ru

**Abstract**

**Background:** In the conditions of educational system reformation and the tendency to higher educational institutions amount reduction the problems of quality management in higher professional education arise with growing urgency. A certified quality management system of a university is one of the factors ensuring its competitiveness.The assessment of organization activities in accordance with the EFQM model criteria is a convenient certification tool implying objective research of quality management system condition.
**Materials and methods:** During certification in accordance with the EFQM model criteria, a combination of the following methods is used: questionnaire polls, self-assessment, conference meetings, benchmarking, and validation procedure.
**Results:** EFQM model levels are considered, certificate reception procedure is characterised, ISPU experience in model application and certification in accordance with the «Recognised for Excellence» level is described.
**Conclusions:** ISPU quality management system certification in accordance with the EFQM model criteria gives the university a splendid opportunity to establish more fruitful contacts and develop cooperation with European partners, initiate and take part in joint European projects, and strengthen ISPU leading status in the sphere of ensuring quality management among Russian universities.

**Key words:** quality management system, certification, excellence model, benchmarking.

**References**

1. *European Foundation for Quality Management – EFQM*. Available at: http://www.efqm.org
2. Safonov, A.A., Bryukhanov, D.Yu. *Otchet po rezul'tatam otsenki Ivanovskogo gosudarstvennogo energeticheskogo universiteta imeni V.I. Lenina. Priznannoe sovershenstvo* [Report on Assessment Results of Ivanovo State Power Engineering University Named after V.I. Lenin. Recognised for Excellence]. Vserossiyskaya organizatsiya kachestva [All-Russian Quality Organization]. Moscow, 2012. 14 p.

UDK 338.28

## IDENTIFICATION AND ECONOMIC ASSESSMENT OF ENERGY SAVING POTENTIAL IN TEXTILE INDUSTRY

V.I. KOLIBABA, E.O. KUTUMOVA, E.V. KUTUMOVA
Ivanovo State Power Engineering University, Ivanovo, Russian Federation
E-mail: katherin1st@gmail.com

**Abstract**

**Background:** The textile industry is one of the energy-intensive sectors of Ivanovo Region with a considerable energy saving potential. Energy resources efficiency is the main task for the textile enterprises.
**Materials and Methods:** The development of the calculation method of energy saving potential in textile industry is based on the structure analysis and dynamics of energy resources consumption.
**Results:** The energy-effectiveness indicators and energy saving coefficients are calculated. The approbation results of methods on the finishing and spinning&weaving factories of medium capacity are given. The authors prove the necessity of using the innovative developing model by textile branch.
**Conclusions:** The developed algorithm allows to estimate the quantity of possible economy of heat energy and electricity.
**Key words:** textile industry, power efficiency, typical energy saving projects, structure and dynamics of energy consumption, energy-efficiency ratio, calculation method, energy saving potential.

**References**

1. Kutumova, E.O., Kutumova, E.V., Matvievskaya, N.Yu. Innovatsionnaya ekonomika tekstil'nykh predpriyatiy kak instrument snizheniya energoemkosti valovogo regional'nogo produkta [Innovative Economics of Textile Enterprises as a Tool for Decreasing the Duty of Gross Reginal Product]. *Sovremennye naukoemkie tekhnologii (regional'noe prilozhenie)*, 2012, no. 3 (29), pp. 33–40.

UDK 621.316.176

# CONTROL OF ELECTRIC POWER QUALITY IN ELECTRIC POWER SUPPLY SYSTEMS OF METALLURGICAL ENTERPRISES IN MARKET CONDITIONS

N.V. SAVINA[1], T.S. KOZLOVA[2]
[1] Amur State University, Blagoveshchensk, Russian Federation
[2] «Amurenergosbyt» Branch of «Far East Energy Company», Blagoveshchensk, Russian Federation
E-mail: Tan.ok@mail.ru

**Abstract**

**Background:** In market conditions the main factors which can define the production competitiveness remain quality and price. Hence, one of the most complex tasks during the production of the metallurgical enterprises is guaranteeing the quality.
**Materials and methods:** To research the control system of production of the metallurgical enterprise the method of the system analysis is applied.
**Results:** The control system of quality of the electric power in systems of power supply of the metallurgical enterprises in market conditions is given, as well as principles, technology and the main quality management processes of the electric power are developed.
**Conclusions:** The quality control system of the electric power at the metallurgical enterprises in the market conditions is developed. It allows to increase the competitiveness between enterprises as well as the quality of production.

**Key words:** Quality of the electric power, unsinusoidality, asymmetry, fluctuation, voltage, current, management technology, process approach, market, metallurgical enterprise.

**References**

1. Kartashev, I.I., Tul'skiy, V.N., Shamonov, R.G. *Upravlenie kachestvom elektroenergii* [Electric power quality management]. Moscow, Izdatel'skiy dom MEI, 2006.
2. Savina, N.V., Kozlova, T.S. Ekspluatatsionnyy kontrol' kachestva elektricheskoy energii v elektricheskikh setyakh [Operational quality control of electric energy in electric networks]. *Vestnik AmGU*, 2007, issue 37.
3. Rebrin, Yu.I. *Upravlenie kachestvom: uchebnoe posobie* [Quality management: Manual]. Taganrog, Izdatel'stvo TRTU, 2004.

# ARTICLES PARTICIPANTS AEP-2012

UDK 621.771.067

## CONTROL SYSTEM OF ELECTRIC COLLECTING ROLLER TABLE OF HOT ROLLING BROAD-STRIP MILL

N.V. SHVIDCHENKO, S.I. LUKYANOV, R.S. PISHNOGRAEV
Magnitogorsk State Technical University, Magnitogorsk, Russian Federation
E-mail: shvinikolaj@yandex.ru

**Abstract**

**Background:** The current control method of electric collecting roller table of hot rolling broad-strip mill provides the required voltage in the strip due to the difference between the strip speed and the roller speed. This leads to the increased wear of rollbarrels and great replacement costs. As a result, the problem of efficiency increasing of the electric collecting roller table of hot rolling broad-strip mill is highly important.
**Materials and methods:** The experimental assessment of the influence of the speed difference for rollers barrels wear of roller table is carried out on the example of 2000 hot rolling broad-strip mill.
**Results:** The authors suggest the calculation method for the required torque electric collecting roller table with the technological features of the rolling cycles of hot strips. The article contains the control method for electric collecting roller table, which provides the required torque within the specified speed range in order to reduce the wear of barrels rolls.The block diagram for controlling the electric collecting roller table, which implements the proposed control method, is also developed.
**Conclusions:** The offered control method of the electric collecting roller table allows to decrease the broad-strip mill intensivity. The obtained results can be applied to improve the efficiency of the collecting roller table of hot rolling broad-strip mill by increasing the equipment service life period.

**Key words:** electric collecting roller table, wear of roll barrels, calculating load torque of electric drive, control system, block diagram.

**References**

1. Luk'yanov, S.I., Shvidchenko, N.V. Razrabotka tekhnologicheskikh trebovaniy k elektroprivodu otvodyashchego rol'ganga s tsel'yu snizheniya iznosa bochek rolikov [Development of Technological Requirements for Electric Collecting Roller Table to Decrease Wear of Roll Barrels ]. *Trudy V Mezhdunarodnoy (XVI Vserossiyskoy) konferentsii po avtomatizirovannomu elektroprivodu* [Works of the Vth International (the XVIth All-Russian) Conference on Automated Electric Drive]. Saint-Petersburg, 2007, pp. 350–352.

2. Kragel'skiy, I.V., Vinogradova, I.E. *Koeffitsiyenty treniya. Spravochnoe posobie* [Friction Factors. Reference Book]. Moscow, Gosudarstvennoe nauchno-tekhnicheskoe izdatel'stvo mashinostroitel'noy literatury, 1962, p. 220.

3. Luk'yanov, S.I., Shvidchenko, N.V. Razrabotka sistemy upravleniya elektroprivodom otvodyashchego rol'ganga shirokopolosnogo stana goryachey prokatki 2000 OAO «MMK» [Development of Control Systen of Electric Collecting Roller Table of Hot Rolling Broad-strip 2000 ГП Mill]. *Izvestiya TulGu. Tekhnicheskie nauki,* 2010, issue 3, part 3, pp. 207–213.

4. Pishnograev, R.S. Issledovanie tokov kholostogo khoda elektrodvigateley rolikov otvodyashchego rol'ganga stana 2000 goryachey prokatki OAO «MMK» [Currents Research of No-load Current of Electric Collecting Roller Table of Hot Rolling Broad-strip 2000 ГП Mill] *Mezhvuzovskiy sbornik nauchnykh trudov «Elektrotekhnicheskie kompleksy i sistemy»* [The Universities' Collected Works]. Magnitogorsk, MGTU, 2005, issue 10, pp. 167–172.

5. Korolev, A.A. *Konstruktsiya i raschet mashin i mekhanizmov prokatnykh stanov: Uchebnoe posobie dlya vuzov* [Designing and Calculating the Machines and Mechanisms of Broad-strip Mills]. Moscow, Metallurgiya, 1985. 376 p.

6. Luk'yanov, S.I., Panov, A.N. *Obrabotka eksperimental'nykh dannykh: Uchebnoe posobie* [Processing of Experimental Data]. Magnitogorsk, MGMA, 1997. 75 p.

7. Polyakov, B.A., Varshavskiy, E.A., Karetnyy, Z.P. *Stal'*, 1987, no. 9, pp. 64–67.

8. Luk'yanov, S.I., Shvidchenko, N.V. Razrabotka matematicheskoy modeli elektroprivoda otvodyashchego rol'ganga shirokopolosnogo stana goryachey prokatki [Development of Mathematical Model of Electric Collecting Roller Table of Hot Rolling Broad-strip Mill]. *Mezhvuzovskiy sbornik nauchnykh trudov «Matematicheskoe i programmnoe obespechenie sistem v promyshlennoy i sotsial'noy sferakh»* [International Collected Works on «Mathematical Support and Computer Software of Systems in Industrial and Social Areas of Life»]. Magnitogorsk, Izdatel'stvo Magnitogorskogo gosudarstvennogo tekhnicheskogo universiteta imeni G.I. Nosova, 2011, part 2, pp. 71–76.

UDK 62-83:004

# DEVELOPMENT AND IMPLEMENTATION OF AUTOMATED ELECTRIC DRIVES AND CONTROL SYSTEMS OF TECHNOLOGICAL PARAMETERS OF HOT ROLLING BROAD-STRIP MILL

V.R. KHRAMSHIN
Magnitogorsk State Technical University, Magnitogorsk, Russian Federation
E-mail: hvr_mgn@mail.ru

**Abstract**

**Background:** The author pays special attention to the problems of control systems improvement of technological parameters of broad-strip mill, as well as automated control systems of speed, tension and thickness. However, because of the implementation of foreign – made equipment at iron and steel plants, the products to improve the automated electric drives and control systems at the Russian enterprises are developed limitedly. Another factor is the implementation of industrial controllers. The mentioned factors cause the importance of studying speed modes of electric drives.
**Materials and methods:** Methods of mathematical modeling of the interconnected electromechanical systems and experience trial on an acting mill are used.
**Results:** The complex of the developed and introduced scientific and technical solutions to the problem of perfection of automatic electric drives and regulating systems of technological parameters of broad-strip mills of a hot rolling is observed at gauge spreading rolling strips. Scientifically well-founded power saving up automatic electric drives, algorithms and management systems of the interconnected electromechanical systems of the broad-strip mill of hot rolling are developed.
**Conclusions:** The offered products provide accuracy raising of thickness regulation and strip tension, as well as stimulate the decrease of the losses of electric energy without application of any compensating arrangements. The flat rolled products manufacturing extends the opportunities of the present and new-build flat rolled devices, increases the economic production efficiency, its resources and energy savings, increase competitive ability.

**Key words:** rolling mill, electromechanical systems, technological parameters, control system, energy saving electric drive.

**References**

1. Karandaev, A.S., Khramshin, V.R., Andryushin, I.Yu. Tekhnologicheskie skhemy upravleniya elektroprivodami chistovoy gruppy shirokopo-losnogo stana goryachey prokatki [Technological Control Schemes of Electric Drives of Hot Rolling Broad-strip Mills]. *Trudy VII kongressa prokatchikov* [Works of the VIIth Rollers Congress]. Moscow, 2007, vol. 1, pp. 71–75.

2. Karandaev, A.S., Khramshin, V.R., Shilyaev, P.V. Sistema kosvennogo regulirovaniya natyazheniya v chistovoy gruppe shirokopolosnogo stana goryachey prokatki [System of Indirect Tension Control in Clean Group of Hot Rolling Broad-strip Mills]. *Sbornik dokladov I Mezhdunarodnoy nauchno-prakticheskoy konferentsii «INTEKhMET-2008»* [Reports' Book of the Ist International Scientific and Practical Conference «Intexmet-2008»]. Saint-Petersburg, 2008, pp. 122–125.

3. Karandaev, A.S., Khramshin, V.R., Lukin, A.A. Eksperimental'nye issledovaniya tiristornykh elektroprivodov s dvukhzonnym regulirovaniem skorosti s uluchshennymi energeticheskimi kharakteristikami [Experimental Researches of thyristor drives with two-area speed control and improved characterictics ]. *Vestnik Yuzhno-Ural'skogo gosudarstvennogo universiteta. Seriya «Energetika»*, 2010, no. 14(190), vol. 13, pp. 67–72.

UDK 621.771

# ELECTRIC DRIVE CONTROL SYSTEM OF PULLING ROLLERS OF BLANKS CONTINUOUS CASTING MACHINE

S.I. LUK'YANOV[1], N.V. FOMIN[1], A.I. KHLYSTOV[2], E.S. LUK'YANOV[2]
[1]Magnitogorsk State Technical University, Magnitogorsk, Russian Federation
[2]OJSC Magnitogorsk Iron and Steel Works, Magnitogorsk, Russian Federation
E-mail: ntc@magtu.ru

**Abstract**

**Background:** Nowadays, calculation and moment distribution of an ingot pulling for electric drives of pulling rollers are a paramount task for ensuring quality of the ingots.
**Materials and methods:** The authors use the developed mathematical model of resistance efforts calculation to the ingot pulling.
**Results:** The control system of the electric drive of the pulling rollers with implementation of the pulling moments distribution demanded on technological conditions is offered.
**Conclusions:** It is established that the offered model of efforts calculation can be used for the usage of the regulation system of pulling rollers.

**Key words:** automatic control system, electric drive, continuous casting machine

**References**

1. Devyatov, D.Kh., Luk'yanov, S.I., Logunova, O.S., Suspitsyn, E.S., Tutarova, V.D., Shvidchenko, D.V. *Avtomatizirovannaya sistema kontrolya i upravleniya MNLZ* [Automated Control System of Blanks Continuous Casting Machine]. Magnitogorsk, MGTU, 2009. 640 p.

2. Luk'yanov, S.I., Fomin, N.V., Khlystov, A.I. Mnogodvigatel'nyy elektroprivod tyanushchikh rolikov mashiny nepreryvnogo lit'ya zagotovok. Elektroprivody peremennogo toka [Multimotor Drive of Pulling Rollers of Blanks Continuous Casting Machine]. *Trudy XV mezhdunarodnoy nauchno-tekhnicheskoy konferentsii* [Works of the XVth International Scientific and Technical Conference]. Ekaterinburg, Izdatel'stvo UMTs UPI, 2012. 323 p.

3. Luk'yanov, S.I. Fomin, N.V., Demkin, D.M., Khlystov, A.I., Luk'yanov, E.S. Razrabotka sistemy upravleniya elektroprivodom tyanushchikh rolikov krivolineynoy MNLZ s vertikal'nym uchastkom [Development of Control System of Pulling Rollers of Blanks Continuous Casting Curving Machine with vertical Sector]. *Izvestiya TulGU. Tekhnicheskie nauki*, 2010, issue 3, part 3. 244 p.

4. Luk'yanov, S.I., Fomin, N.V., Khlysto, A.I. Raschet prodol'nykh usiliy v slitke MNLZ [Calculation of Longitudinal Stresses in Ingots of Blanks Continuous Casting Machine]. *Mezhvuzovskiy sbornik nauchnykh trudov «Matematicheskoe i programmnoe obespechenie sistem v promyshlennoy i sotsial'noy sferakh»* [International Collected Scientific Works on Mathematical and Computer Software of Systems in Industrial and Social Fields]. Magnitogorsk, Izdatel'stvo Magnitogorskogo gosudarstvennogo tekhnicheskogo universiteta imeni G.I. Nosova, 2011, part 2. 245 p.

UDK 621.313.333

# TECHNOLOGICAL DEMAND AND EFFICIENCY ASSESSMENT OF IMPLEMENTATION OF VARIABLE-FREQUENCY ELECTRIC DRIVES ON THERMAL POWER PLANTS

V.N. MEDVEDEV[1], A.S. KARANDAEV[2], O.I. KARANDAEVA[2], Y.I. MAMLEEVA[2], E.A. KHRAMSHINA[2]
[1]JSC «EnergoSet'», Moscow, Russian Federation
[2]Magnitogorsk State Technical University, Magnitogorsk, Russian Federation
E-mail: askaran@mail.ru, hvr_mgn@mail.ru

**Abstract**

**Background:** The industrial implementation of variable-frequency electric drives on additional mechanisms of any thermal power station requires the technical and economic analysis. Thus, the features of the technological process and the equipment configuration should be considered attentively.
**Materials and methods:** The authors carry out the analysis of the technological demand of the controlled electric drive on the Heat Power Station of open joint-stock company «Magnitogorsk iron-and-steel works» in accordance with the basic criteria of the estimation of implementation technical efficiency.
**Results:** It is shown that with economy of electric energy the basic stimulating motives are the technological demand and automation possibility. The feasibility report is given, the implementation sequence of variable-frequency electric drives is offered at stage-by-stage redesigning of the Heat Power Station equipment.
**Conclusions:** Apart from the energy savings the main stimulating motives of frequency regulation systems implementtation are the improvement of technological process and more accurate adherence to technical modes, as well as the improvement of working conditions and reliability improvement of heat-water supply of the population.

**Key words:** heat and power plant, variable-frequency electric drive, implementation, technological demand, efficiency, sequence of upgrading.

**References**

1. Krylov, Yu.A. *Razrabotka energo-resursosberegayushchikh tekhnologiy v toplivno-energeticheskom khozyaystve goroda na osnove sovremennogo elektroprivoda*. Diss. dokt. tekhn. nauk [Development of Energy and Resource Saving Technologies in Fuel and Energy City Area based on Modern Electric Drive]. Moscow, MEI, 2008. 40 p.

2. Remezov, A.N., Sorokin, A.V., Krylov, Yu.A. *Elektricheskie stantsii*, 2007, no. 10, pp. 43–47.

3. Lazarev, G.B. *Silovaya elektronika*, 2007, no. 3, pp. 41–48.

4. Lazarev, G.B. *Opyt i perspektivy primeneniya chastotno-reguliruemykh asinkhronnykh elektroprivodov v elektro-energetike Rossii* [Experience and Perspectives of Application of Variable-frequency Asynchronous Electric Drives in Power Engineering in Russia]. Available at: http://www.privod-news.ru/may_03/25-3.htm

5. Il'inskiy, N.F., Shakaryan, Yu.G. *Instruktsiya po raschetu ekonomicheskoy effektivnosti primeneniya chastotno-reguliruemogo elektroprivoda* [Calculation Instruction of Economical Efficiency of Variable-frequency Electric Drives Application]. Moscow, Mintopenergo RF, 1997.

UDK 621.313.333

# PERSPECTIVES OF ASYNCHRONOUS MOTORS APPLICATION WITH INDIVIDUAL COMPENSATION OF REACTIVE POWER IN INDUSTRIAL ELECTRIC DRIVES

R.G. MUGALIMOV, A.R. MUGALIMOVA, M.R. MUGALIMOVA
Magnitogorsk State Technical University, Magnitogorsk, Russian Federation
E-mail: energosberegenie@rambler.ru

**Abstract**

**Background:** Nowadays, the traditional asynchronous motors with non-high energy data are used in industrial electrical drives. Improving the energy efficiency of asynchronous electric drives is relevant technical and economic problem in all industries. To solve this problem the asynchronous motors with individual reactive power compensation are developed, researched, manufactured and tested in practice.
**Materials and methods:** The authors used the results of the practical tests and mathematical modeling. The results were processed using the probability theory and mathematical statistics according to correlation and regression analyses.
**Results:** The authors describe the comparative analysis of the specific differences between energy saving asynchronous motors and traditional asynchronous motors. The test results of the energy saving asynchronous motors with individual reactive power compensation are given.
**Conclusions:** Calculations and experiments conducted on real electric drives that are based on energy saving asynchronous motors allow to confirm that the transformer load factor decreases by 13%, the losses of electrical power supply systems and electric drives are reduced by 19%, the total capacity economy is 310-750 kW per year. Drives based on the proposed asynchronous motors with individual reactive power compensation are energy saving. Based on energy-saving asynchronous motors the controlled electric drives with thyristor converter can be developed.

**Key words:** asynchronous motor, reactive power, electric drive.

**References**

1. Il'inskiy, N.F. Rozhankovskiy, Yu.V., Gornov, A.O. Energosberezhenie v elektroprivode [Energy saving in electric drive]. *Energosberegayushchaya tekhnologiya elektrosnabzheniya narodnogo khozyaystva* [Energy saving technology of electric power supply in national economy]. Moscow, Vysshaya shkola, 1989. 129 p.

2. Mugalimov, R.G., Mugalimova, A.R. Energosberegayushchiy elektroprivod neftyanogo stanka-kachalki na osnove asinkhronnogo dvigatelya s individual'noy kompensatsiey reaktivnoy moshchnosti [Energy saving Electric Drive of Oil Conventional Pumping Unit based on Asynchronous Motors with Individual Reactive Power Compensation]. *Materialy Mezhdunarodnoy nauchno-tekhnicheskoy konferentsii «Elektromekhanicheskie preobrazovateli energii»* [Electromechanical Energy Converters: Materials of Scientific and Technical Conference]. Tomsk: TPU, 2005, pp. 196–199.

3. Mugalimov, R.G. *Privodnaya tekhnika*, 2011, no. 1, pp. 3–9.

4. Mugalimov, R.G., Mugalimova, A.R. *Vestnik MGTU*, 2011, no. 2, pp. 70–75.

5. Savitskiy, A.L., Mugalimov, R.G., Savitskaya, L.D. *Asinkhronnaya kompensirovannaya elektricheskaya mashina* [Asynchronous Compensate Electrical Machine]. Patent RF, no. 2112307, 1998.

6. Mugalimov, R.G., Mugalimova, A.R. K proektirovaniyu energosberegayushchego asinkhronnogo dvigatelya s individual'noy kompensatsiey reaktivnoy moshchnosti [On Designing the Asynchronous Motors with Individual Reactive Power Compensation]. *Trudy III Mezhdunarodnoy nauchno-tekhnicheskoy konferentsii «Elektromekhanicheskie i elektromagnitnye preobrazovateli energii i upravlyaemye energomekhanicheskie sistemy»* [Works of the IIIrd Scientific and Technical Conference of Electromechanical and Electromagnetic Energy Transducers and Controlled Electromechanical Systems]. Ekaterinburg, UGTU-UPI, 2007, pp. 77–80.

7. Mugalimov, R.G., Kosmatov, V.I., Mugalimova, A.R. Metod i algoritm proektirovaniya kompensirovannogo energosberegayushchego asinkhronnogo dvigatelya [Designing Method and Algorithm of Compensate Energy Saving Asynchronous Motor]. *Sbornik materialov V Mezhdunarodnoy (XVI Vserossiyskoy) nauchnoy konferentsii* [Collected Works of the Vth International (the XVI All-Russian) Scientific Coference, September 18-21, 2007]. Saint-Petersburg, 2007, pp. 281–284.

8. Gurin, Ya.S., Kuznetsov, B.I. *Proektirovanie seriy elektricheskikh mashin* [Design series of electrical machines]. Moscow, Energiya, 1978. 480 p.

9. Mugalimov, R.G. *Asinkhronnye dvigateli s individual'noy kompensatsiey reaktivnoy moshchnosti i elektroprivody na ikh osnove* [Induction motors with individual compensation of reactive power and electric based on them]. Magnitogorsk: FGBOU VPO «MGTU», 2011. 250 p.

UDK 621.778.06-83:621.313.333:004.421.2

# AUTOMATED ELECTRIC DRIVES OF DRAWING MILLS ACCORDING TO THE «FREQUENCY CONVERTER– ASYNCHRONOUS MOTOR» SYSTEM

E.Ya. OMELCHENKO, V.O. MOISEEV, O.A. TELEZHKIN
Magnitogorsk State Technical University, Magnitogorsk, Russian Federation
E-mail: momentum2@yandex.ru, ickar@mail.ru, gopko49@rambler.ru

**Abstract**

**Background:** The equipment analysis of metal industry demonstrated that the main electric drives systems has more than 80 % of wear, the low energy efficiency and reliability, high operational costs and the low power coefficient. Thus, the urgent scientific and technical tasks are increasing the labor productivity and decreasing the energy losses in metal industry, but their solution is connected with rebuilding or replacement of electrical drives systems.
**Materials and methods:** The structure scheme of the combined control system consisting of microprocessor-based systems of the field oriented control with rotor flux stabilization and continuous electromechanical unit is developed for the research of related electric drives system of drawing mills in MATLAB Simulink platform.
**Results:** The experiments results based on the mathematical model of the automated electric drive operation in starting-breaking modes are presented. The various alternatives of forming electric drive system in industrial application is offered.
**Conclusions:** The application of dynamic correction signal, flexible feedback of spring torque of coiling machine and controlled offset of main drive make it possible to considerably reduce elastic vibration of wire during its progress and stabilize wire tension.

**Key words:** drawing mill, frequency converter, asynchronous motor, field vector control, mathematical model.

**References**

1. Omel'chenko, E.Ya., Fadeev, A.V., Bakarzhi, V.V. Modernizatsiya elektroprivodov namotochnykh ustroystv volochil'nykh stanov [Modernization of electric drives of coiling machines of drawing mills]. *Trudy V mezhdunarodnoy (XVI Vserossiyskoy) konferentsii po avtomatizirovannomu elektroprivodu «AEP-2007» [Proceedings of V international* (XVI All Russians) conference on the Automatic Electric Drives]. Saint-Petersburg, 2007, pp. 341–344.

2. Omel'chenko, E.Ya., Moiseev, V.O. Metodika eksperimental'nogo opredeleniya momenta soprotivleniya i mo-menta inertsii mekhanizma [The methods of experimental identification of static and dynamic moment of inertia]. *Vestnik MGTU*, 2012, no. 2(38), pp. 74–76.

UDK 681.5.621.3.07

# ELECTROMECHANICAL REVERSE SCANNING DEVICE ADJUSTER

V.N. DROZDOV, V.A. TOLMACHEV, D.A. SUBBOTIN
Saint Petersburg National Research University of Information Technologies, Mechanics and Optics,
Saint Petersburg, Russian Federation
E-mail: Subb-Dm@yandex.ru

**Abstract**

**Background:** At present time in design of accurate reversible electromechanical scanner great attention is devoted to the characteristics of the control object and control system quality. At the same time, the quality of the operation of reversible scanner is determined, first of all, within the input assignment, which formation is often neglected. This leads us to the necessity of the input assignment ways forming search.
**Materials and methods:** During the research MatLab simulation package was used, where the corresponding mathematical models were designed and mathematical modeling was held.
**Results:** The paper presents a synthesis and a mathematical model for reverse scanning device adjuster in Simulink system of MatLab package. The obtained model takes into account the requirements set point to the acceleration, velocity and position of the work item.
**Conclusions:** Formed in the described manner input assignment can get the exact value of the speed and position of the scanning element in the work area.

**Key words:** input assignment, reverse scanning device, adjuster.

**References**

1. Samarin, Yu.N. *Nauchnye osnovy i metody proektirovaniya vyvodnykh ustroystv dopechatnykh sistem* [Scientific bases and methods for designing prepress output devices systems]. Moscow, MGUP, 2004. 514 p.

2. Available at: http://theoryandpractice.ru/posts/1754-napechatat-gorod-kak-3d-tekhnologii-privedut-k-kulturnoy-revolyutsii, 21.04.12.

3. Available at: http://www.nanonewsnet.ru/articles/2011/ pervoe-meropriyatie-po-3d-pechati-v-niderlandakh, 21.04.12.

4. D'yakonov, V.P. *Simulink 5/6/7.* Moscow, DMK-Press, 2008. 784 p.

UDK 681.5.621.3.07

# REVERSIBLE ELECTROMECHANICAL SCANNER DEVICE CONTROL SYSTEM

V.N. DROZDOV, V.A. TOLMACHEV, D.A. SUBBOTIN
Saint Petersburg National Research University of Information Technologies, Mechanics and Optics,
Saint Petersburg, Russian Federation
E-mail: Subb-Dm@yandex.ru

**Abstract**

**Background:** Currently in systems with small required operating element deflection angle from the zero position the reverse electromechanical scanning devices with a limited angle of rotation are used. These devices have high inertia and additional requirements for control systems quality.
**Materials and methods:** During the research MatLab simulation package was used, where the corresponding mathematical models were designed and mathematical modeling was held.
**Results:** The paper presents a synthesis and a mathematical model for reverse scanning device adjuster in Simulink system of MatLab package. The results of modal controller and combined management control system simulation are presented.
**Conclusions:** Modal regulator system has less sensitivity to changes in the parameters of the control object. The combined system, at the same time, has zero speed error and position in the work area.

**Key words:** Reversible electromechanical scanner device, control system, mathematical simulation.

**References**

1. Drozdov, V.N., Tolmachev, V.A., Subbotin, D.A. *Zadatchik reversivnogo elektromekhanicheskogo razvertyvayushchego ustroystva* [Electromechanical reverse scanning device adjuster].
2. Reshetnikov, E.M., Sablin, Yu.A., Grigor'ev, V.E. *Elektromekhanicheskie preobrazovateli gidravlicheskikh i gazovykh privodov* [Electromechanical converter of gas and hydraulic actuators]. Moscow, Mashinostroenie, 1982. 144 p.
3. Kuzovkov, N.T. *Modal'noe upravlenie i nablyudayushchie ustroystva* [Modal control and watching devices]. Moscow, Mashinostroenie, 1976. 184 p.
4. Drozdov, V.N., Miroshnik, I.V., Skorubskiy, V.I. *Sistemy avtomaticheskogo upravleniya s mikroEVM* [Automatic control systems with microcomputer]. Leningrad, Mashinostroenie. Leningradskoe otdelenie, 1989. 284 p.

UDK 62-83:621.69

# REGULATED ELECTRODRIVE FOR PUMP SET OF THE FIRST RAISE WATER SUPPLY STATION

A.N. GORUNOV, G.B.ONISHCHENKO
Moscow State Open University, Moscow, Russian Federation
E-mail: eapu@mail.ru

**Abstract**

**Backgraund:** Technical and economic efficiency of electric drive for pumps stations second lift was recognized. In the technical literature is almost not considered the feasibility of controlled electric pumps for the first lift. However, this issue is relevant, given the widespread use of the first lift station, equipped with high-power pumping units.
**Materials and methods:** Experimental studies were carried out on the existing pumping station first lift. To analyze the modes used computer simulation techniques.
**Results:** A comparison of three methods of capacity control pumping station first head: discrete control – switching-off pumps, throttle and speed changes through variable speed drive pumps.
**Conclusion:** It is demondtrated that regulated electrodrive supplies technical and economic advantager for pump sets of the first lifting.

**Key words:** pump set, regulated electrodrive, water treatment plant, the mathematical model.

**References**

1. Leznov, B.S. *Energosberezhenie i reguliruemyy privod v nasosnykh i vozdukhoduvnykh ustanovkakh* [Energosaving and regulated electrodrive for pump and airblow sets]. Moscow, Emergoatomizdat, 2006. 360 p.
2. Goryunov, A.N. Vzaimodeystvie nasosnykh ustanovok pervogo pod»ema i ochistnykh sooruzheniy vodopodgotovki [Intraction pump sets of the first lifting and cleaning structures of waterpreparation]. *Vodosnabzhenie i sanitarnaya tekhnika*, Moscow, 2010, no. 1.