ADVANCED TECHNOLOGIES IN AEROSPACE, MECHANICAL & AUTOMATION ENGINEERING: MIST: AEROSPACE - 2018

ABSTRACT BOOK

MODERN ISSUES IN SCIENCE AND TECHNOLOGY

INTERNATIONAL MULTIDISCIPLINARY SCIENTIFIC AND RESEARCH CONFERENCE: SOCHI-2018
International Workshop
«Advanced Technologies in Aerospace, Mechanical and Automation Engineering» - “MIST: Aerospace”
(Krasnoyarsk, Russia, October 20, 2018)
within the framework of
IX International Multidisciplinary Scientific and Research Conference
"Modern Issues in Science and Technology"
(Sochi, Russia, October, 2018)

International and Russian Union of Scientific and Engineering Associations, Krasnoyarsk Regional Union of Scientific and Engineering Associations, Krasnoyarsk Science and Technology City Hall are the main organizers of an International Scientific Workshop «Advanced Technologies in Aerospace, Mechanical and Automation Engineering» - “MIST: Aerospace”. The workshop took place in Krasnoyarsk in October 20, 2018 within the framework of IX International Multidisciplinary Scientific and Research Conference "Modern Issues in Science and Technology".

The purpose of the Workshop was to share the results and prospects of the achievements in using advanced scientific, innovative and information technologies in aerospace industry, mechanical engineering and automation.

The work of the Workshop was organised in the following directions:
- Aerospace Technologies;
- Mechanical Engineering and Industry;
- Data Protection in Automation Systems;
- Cybernetics, Automation and Information Technologies;
- Ecology and Ecological Engineering;
- Power Engineering.

The Workshop took place in October 20, 2018 in Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations.

All the information about the workshop can be found at the website: domnit.ru.
CONTENTS

THE PROGRAMME COMMITTEE ........................................................................................................... 2

WORKSHOP ORGANIZERS AND SPONSORS .................................................................................. 11

OVERVIEW ........................................................................................................................................... 12

ABSTRACTS ......................................................................................................................................... 13

Section 1. Aerospace Technologies .................................................................................................. 18
Advancing methodology to specify cavitation characteristic of screw-type centrifugal pumps ........................... 18
V Nazarov, A Zuev, L Nazarova, M Savelyeva

Analysis of logic-time characteristics of subsystem supply functioning hardware elements of unmanned aerial vehicles ........................................................................................................... 18
N A Testoedov, I V Kovalev, M Fosner, A A Voroshilova, V V Losev

Application of cascade-connected regulation in the implementation of the software of weight component compensation system ........................................................................................................... 19
V I Kudymov, J O Badanina, I V Kovalev, V S Bashkarev, M V Karaseva

Automation system of communication satellite designing ........................................................................... 19
N A Testoedov, A V Kuzovnikov, Yu G Vygonsky, D A Matronitsky, A V Ankudinov, T V Strekalova

High-speed stream data collection and processing system of the Earth’s ionospheric sounding ........................... 19
Vladimir V. Kopytov, Andrey O. Shulgin, Nikita G. Demurchev, Pavel V. Kharechkin, Vladimir V. Naumenko

Direction-finding method solution phase ambiguity in determining the spatial orientation of space vehicle ........................................................................................................................................... 20
I N Kartsan, M O Petrosyan, S V Efremova, V V Khrapunov

Development of electric heaters with increased efficiency of unpressurized designed space vehicles ................................................................................................................................. 20
N V Lukonin, I Y Shestakov, E N Golevenkin, M M Mikhnev, I A Maksimov, S N Pankina

Efficient engineering approach to communication satellite design ............................................................ 21
N A Testoedov, A Yu Vshivkov, V I Kosenko, A V Ankudinov, M V Saveleva, E V Tuev

Electrodynamic analysis of materials for the antenna elements ....................................................................... 21
Alexandr Chabanenko, Elena Frolova, Victor Balashov, Maria Smirnova

Ensuring the quality of the materials used in the spacecraft engineering ..................................................... 22
V E Patraev, E A Shangina, V V Dvirny, A A Voroshilova, S A Borisov

Evaluation of visual characteristics of image perception in avionics .............................................................. 22
O O Zharinov, M O Kostishin, M A Trushkin, V V Markelov

Experimental research of the drawing process with forced thinning of thick billet for the formation of parts with specified wall thickness ....................................................................... 23
S Yu Zvonov, A G Shlyapugin, A A Halikova

Fast satellite imagery of lengthy territories with complex configuration ....................................................... 23
D K Mozgovoy, D N Svinarenko, R Yu Tsarev, T N Yamskikh

Focused antennas for diagnostics of spacecraft antenna systems ............................................................... 24
D A Veden’kin, J E Sedel’nikov, N A Testoedov, I J Danilov, A G Romanov, V I Kudymov

Choice of optimal multiversion software for a small satellite ground-based control and command complex ....................................................................................................................................... 24
I N Kartsan, S V Efremova, V V Khrapunova, M I Tolstopiatov
Investigation of the automation level of designing the software and hardware structure of the on-board equipment integrated modular avionics ................................................................. 25
A V Khakimov, V A Nechaev, M O Kostishin
Investigation of the surface relief of polyalkaneimide composites after treatment with oxygen plasma .................................................................................................................. 25
V I Pavlenko, N I Cherkashina
Laser reflection method for vegetation monitoring at eye-safe sensing wavelengths in the NIR spectral band .......................................................... 26
M L Belov, A M Belov, V A Gorodnichev, S V Alkov
Modelling of the welded seam parameters at electron-beam welding ........................................ 26
Yu N Seregin, A V Murygin, V S Tynchenko, A V Milov
On the efficiency of defocusing a large satellite multi-beam hybrid parabolic antenna .......... 26
Yu I Choni, A G Romanov, I Yu Danilov, V V Mochalov, V A Bartenev, A O Shemyakov
On the peculiarities of wear-resistant nanocoatings research under production conditions. Obtaining calculated dependencies ......................................................... 27
N A Chemborisov, I K Ustinov, O A Artemenko
Prediction of the vibration state of the GTE turbine rotor taking into account the influence of the geometric accuracy of parts .................................................................................. 27
M A Boltov, E J Kolchina, V A Pechenin, N D Pronichev
Optimization model of the hub airport schedule under uncertainty ..................................... 28
E D Guzha, V A Romanenko, M A Skorokhod
Peculiarities of precision space platform design for navigation satellites ......................... 28
V E Kosenko, V D Zvonar, M A Ilin, V E Chebotarev, A A Frolov
On the peculiarities of wear-resistant nanocoatings research under production conditions. Part 2. Experiment results .............................................................. 29
N A Chemborisov, I K Ustinov, O A Artemenko
Quality assurance of electrical components for spacecraft on-board equipment .................. 29
V E Patraev, V E Chebotarev, E A Shangina, A A Voroshilova, R Yu Tsarev, T N Yamskikh
Satellite imagery of coastlines .................................................................................................... 30
D K Mozgovoy, D N Svinarenko, R Yu Tsarev, T N Yamskikh, E V Burdina
Simulation of short-range navigation system based pseudolites and investigation of its accuracy characteristics .................................................. 30
D D Dmitriev, A B Gladyshev, V N Ratuschnyk, I N Kartsan
Solving navigation-temporal tasks in different coordinate systems .................................. 31
V E Chebotarev, V V Brezitskaya, I V Kovalev, I N Kartsan, Yu N Malanina, A O Shemyakov
Spacecraft protection from the negative effects of environmental factors and complex dynamic loads at the transportation stage ........................................... 31
E N Golovenkin, S N Lozovenko, A V Tsaitler, M V Karaseva, A A Melkomukov
Substantiation of the need to create the technology of stretch forming shells double curvature shell using new alloys ............................................................... 32
V A Mikheyev, S V Surudin, D V Agafonova, A T Tiabashvili, V O Agafonova
The automated system of telemetry data multiline reception, processing and analysing .................. 32
J V Vilkov, I A Maksimov, M V Nekrasov, R J Tsarev, T N Yamskikh, V V Kovalev

The development of the model of satellite orbital motion .......................................................... 33
A G Dubrovin, Yu N Baranov, A P Tryastsin

The electrodynamic modelling of netted linen ................................................................. 33
O Sh. Dautov, A G. Romanov, VA. Skachkov, A K Shatrov, E N Golovenkin

Variable neighbourhood search algorithm for K-means clustering .................................................. 33
VI Orlov, LA Kazakovtsev, IP Rozhnov, NA Popov, V V Fedosov

SECTION 2. MECHANICAL ENGINEERING AND INDUSTRY ........................................... 34
A description of the interface interaction model of specialized information and software of the
distributed automated process control systems .............................................................................. 34
I V Kovalev, V V Losev, M V Saramud, D I Kovalev, G D Voskoboinik

A method of measuring the depth of the penetration channel during electron-beam welding .... 34
A A Druzhinina, V D Laptenok, A V Murygin, V E Petrenko

Alkali silicate protective coatings ........................................................................................................ 35
L N Nazharova, G G Mingazova, R S Saifullin

Analysis and design of pressure sensors for micromechanical integrated pressure sensors ........... 35
M E Kalinkina, A S Kozlov, R Y Labkovskaiia, O I Pirozhnikova, V L Tkalich

Analysis of the intellectual interaction of mechanical autonomous systems .............................. 35
A V Lekanov, I V Kovalev, F K Sin’kovsky, A D Leonenko, M V Karaseva, S A Borisov

Application of imitation modelling means to create digital twins of the Industry 4.0 company
 technological equipment ...................................................................................................................... 36
D A Zakoldaev, A V Gurjanov, D R Kochubey, I O Zharinov

Artificial aging of hard-alloy cutting tool with titanium diffusion coating as a way to increase its
 persistence ........................................................................................................................................ 36
A G Sokolov, LI Svistun, RL Plomodyalo, E E Bobylyov

Automated process control quality improvement of technical systems electrochemical protection
 ........................................................................................................................................................... 37
Anatoly Yastrebov, Alexander Konovalov, Vladimir Sulaberidze, Victor Balashov

Basic requirements and principles for the compensation system development ............................. 37
E N Golovenkin, A K Shatrov, J O Badanina, E I Badanin, I V Kovalev, M V Karaseva

Calculating the geometric parameters of the distribution of electron beam energy density on its
 section in EBW ..................................................................................................................................... 38
A N Bocharov, A V Murygin, V D Laptenok

Characterization of microrelief forming on the hardened steel surface with ultrasonic reinforcing
 burnishing processing .......................................................................................................................... 38
Sergey Grigoriev, Aleksandr Selivanov, Igor Bobrovskij, Aleksandr Dyakonov, Igor Deryabin

Crystallization of aluminium alloys under pressure ........................................................................... 39
VF Korostielev, MS Denisov

Dependent failure in multifunctional automatic control systems ...................................................... 39
A S Degtyarev, VI Usakov, PA Kuznetsov, I V Kovalev, M V Karaseva

Designing High-Speed CNC-Operations ......................................................................................... 40
A Kh Nurkenov, VI Guzeev, PG Mazein, IP Deryabin
Determination of installation sites for anti-adhesive devices on the bucket of an EK-18 excavator ................................................................. 40
S A Zenkov

Determination of reliability of working position with rigid inter-aggregate relation ............. 41
Sergey Grigoriev, Boris Gorshkov, Nikolai Bobrovskij, Igor Bobrovskij, Natalya Samokhina

Device for measuring the electrical conductivity of a flame for the diagnosis of the combustion process in an ICE with spark ignition......................................................... 41
Natalya Smolenskaya, Igor Bobrovskij, Victor Smolenskii, Nikolaj Bobrovskij, Aleksey Lukyanov

Device for monitoring the temperature and diameter of an extended cylindrical object in the high-temperature manufacturing process........................................... 42
A Tomashuk

Diffusion saturation from fusible liquid metal media solutions by titanium of TK and WC-Co alloys as way to increase of tool durability ........................................................... 42
E E Boblyov

Engineering of the knife grinding machine milling process .................................................. 42
Sergey Vikharev

Estimating Safety of a Tractor Cab with the Protective System ROPS ................................ 43
I.P. Troyanovskaya, S.I. Serov, E.I.Kromskij, D.V. Kozminych

Expansion of technological capabilities of the laboratory unit for determining the longitudinal stability of rods ................................................................. 43
E V Shirokikh, T D Dikova, O B Shirokikh, E A Smirnova, O A Pogodina

Experimental stand for the study of cavitation flow regimes ............................................. 44
Vladimir A Kulagin, Alexander U Radzyuk, Elena B Istyagina, Tatyana A Pianykh

Features of the holes formation by counterboring tool ...................................................... 44
I P Deryabin, V G Shalamov

Formation of a complex part surface at the micro level during milling ................................ 44
N A Chemborisov, I D Sokolova, I K Ustinov

Formation of the diffusion barrier at the interface of Cr20Ni80 alloy - Ni-Cr-Al coating ........ 45
V G Shmorgun, A I Bogdanov, A O Taube, L M Gurevich

Heat exchange numerical modelling while cooling a high-temperature metallic cylinder by water and air medium flow ................................................................. 45
S S Makarov, M Y Alies

Implementation of the design concept of a high-speed processing cycle for CNC machines in the form of a software module CAM-system ............................................. 46
L V Shipulin, A Kh Nurkenov, P G Mazein

Influence evaluation of the tow ship oscillation on the towed system motion ....................... 46
N N Kamaletdinov, A L Gusev, E S Golovina

Influence of the electrolysis mode on corrosion resistance of metallic coatings .................. 46

Influence of ultrasonic burnishing on the durability of the burnisher ................................. 47
Sergey Grigoriev, Aleksandr Selivanov, Nikolai Bobrovskij, Aleksandr Dyakonov, Petr Mazein

Laser-aided direct metal tooling of manufacturing aviation details on CNC machine .......... 47
P Ogin, D Levashkin, F Vasilyev
Method of forming means for monitoring the process of electrochemical protection of pipeline systems ........................................................................................................................................... 48
Alexander Konovalov, Artemy Varzhapetyan, Anatoly Yastrebov, Victor Balashov

Methods of assessment of modernization of the tractor Belarus 922 to work on ethanol-containing fuel ................................................................................................................................................ 48
Sergey Plotnikov, Yury Lanskikh, Mikhail Smol’nikov

Model for stationary turn of an arbitrary vehicle .................................................................................................................... 49
I P Troyanovskaya, S A Voinash

Modelling of electron beam distribution in electron beam welding ........................................................................................................... 49
Yu N Seregin, A V Murygin, V D Laptenok, V S Tynchenko

Modelling of milling processes in knife grinding machines ................................................................................................................. 50
S N Vikharev, J D Alashkevich

Non-Newtonian effects of a lubricant flow through a T-shaped microchannel .................................................................................... 50
E R Kutuzova, A F Tazyukova, F Kh Tazyukov, A G Kutuzov

Optimization model controlling parameters of a roller drilling process based on energy criterion 50
A A Shigina, A O Shigin, A A Stupina, S M Antipina, N N Dzhioeva

Principles of construction of the technological system for the manufacture of construction polymer reinforcement........................................... 51
FA Urazbakhtin , Yu V Ganziy, M V Otrishko

Resistance to brittle fracture and availability of austenitic steels ............................................................................................................. 52
Boris Ermakov, Svetlana Vologzhanina, Igor Bobrovskij, Nikolai Bobrovskij, Yaroslav Erisov

Simulation of influence of cutting tool’s construction on specific heat energy in processing of bevel gears ........................................................................................................... 52
Nikita Kanatnikov, Nikolai Bobrovskij, Vladimir Tabakov, Petr Zibrov, Oleg Drachev

Specific features of mobile machine reverse movement .......................................................................................................................... 53
A S Pavlyuk, V I Poddubnyi, A S Baranov

Structure and thermophysical properties of polytetrafluoroethylene-aluminium composite materials produced by explosive pressing ........................................................................................................... 53
N A Adamenko, A V Kazurov, D V Savin, G V Agafonova

Study of ZrN-AlN formation solid-phase reaction in a nitrogen atmosphere during microwave heating ........................................................................................................ 54
R A Shishkin, V S Kudyakova, A V Chukin, A R Beketov

The integration of automatized systems and cyber and physical equipment of the Industry 4.0 item designing company ........................................................................................................... 54
A V Gurjanov, D A Zakoldaev, A V Shukalov, I O Zharinov

Wear resistance of composite coatings based on iron alloys .......................................................................................................................... 55
J E Kisel, G V Guryanov

Welded pipe geometry changing during the expanding process ........................................................................................................... 55
D B Frunkin, L M Gurevich, R E Novikov, A I Bannikov, A G Serov, N A Dyatlov

Working position with recomposed production systems .......................................................................................................................... 55
Igor Bobrovskij, Boris Gorshkov, Maksim Odnoblyudov, Nikita Kanatnikov, Pavel Melnikov
SECTION 3. CYBERNETICS, AUTOMATION AND INFORMATION TECHNOLOGIES

About algorithm of robust nonparametric estimation of regression function on observations ........................................... 56
M A Denisov, E A Chzhan, A A Korneeva V V Kukartsev

Activation of phase boundary and current-generating processes in plasma-electrochemical systems ........................................... 57
V A Mamaeva, A K Chubenko, A I Mamaev, E Yu Beletskaya T A Baranova

Analysis of spacecraft actuator mechanisms design process using tensor method ........................................... 57
N A Testoedov, V I Usakov, V A Levko, S Yu Piskorskaya, V A Bartenev

Analytical approaches for analysis of intracardiac bipolar electrograms during atrial fibrillation ........................................... 57
K S Mityagin, A P Zaretskiy, G A Gromyko A P Kuleshov

Application of the object model in the modelling process of locomotive drive units ........................................... 58
D Ya Antipin, V I Vorobyev, S O Kopylov

Automation of adjustment stages by high-performance semiconductor converters ........................................... 58
M A Grigorev, A A Gryzlov V S Katrichek

Developing the model of an automated rotary-cut veneer sorting system ........................................... 59
B M Shifrin, I V Eliseev, V A Sokolova, N V Melamed S A Voinash

Genetic algorithms of physical modelling with postcrossover survival ........................................... 59
A S Degtyarev, V I Usakov, P A Kuznetsov, I V Kovalev T S Karaseva

Method of intellectualization for geospatial processes control systems ........................................... 60
Yan Ivakin, Sergey Michurin, Vladimir Sulaberidze Valeriy Lipatnikov

Non-smooth regularization in radial artificial neural networks ........................................... 61
V N Krutikov, LA Kazakovtsev V L Kazakovtsev

Reduction of the asymptotic complexity of the assignment problem ........................................... 61
J V Vilkov, V A Bartenev, G M Rudakova, O V Korchevskaya E V Tseva

Simulation for dynamics of transient ischemic attacks with thermal infrared imaging ........................................... 62
K S Mityagin, A P Zaretskiy I B Prokhorov

Solution of the dynamics inverse problem with the copying control of an anthropomorphic manipulator based on the predictive estimate of the operator’s hand movement using the updated Brown method ........................................... 62
V I Petrenko, F B Tebueva, M M Gurchinsky, V O Antonov J A Shutova

The formalized approach of building a network controller for the information handling automated process control system of the technological control cycle ........................................... 63
J V Vilkov, V A Bartenev, I V Kovalev, V V Losev M N Chuvashova

The implementation of measures for reduction an inertia of the interaction components of the heterogeneous environment for the automated process control system ........................................... 63
A A Koltyshev, A K Shatrov, I V Kovalev, V V Losev M N Chuvashova

The method of forming a geometric solution of the inverse kinematics problem for chains with kinematic pairs of rotational type only ........................................... 64
V I Petrenko, F B Tebueva, M M Gyrchinsky, V O Antonov J A Shutova

The principles of the electric drive control of antennas and solar batteries rotation system for spacecraft based on a dual-fed switched reluctance drive ........................................... 64
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>S A Bronov, N A Nikulin, P V Avlasko, D V Volkov, E A Stepanova, D D Krivova, A A Bisov, R M Nikitin D E Alfimov</td>
<td>Transport system organization of an Industry 4.0 cyber and physical production company</td>
</tr>
<tr>
<td>D A Zakoldaev, A V Shukalov, I O Zharinov O O Zharinov</td>
<td>SECTION 4. DATA PROTECTION IN AUTOMATION SYSTEMS</td>
</tr>
<tr>
<td>I N Kartsan, M O Petrosian, S V Efremova, V V Brezitskaia</td>
<td>A method for the autonomous control of navigation information integrity</td>
</tr>
<tr>
<td>A G Samoylov, S A Samoylov, V S Samoylov A P Galkin</td>
<td>Adaptive encoding in remote digital telemetry and command systems</td>
</tr>
<tr>
<td>Margarita Favorskaya, Eugenia Savchina Aleksei Popov</td>
<td>Adaptive visible image watermarking based on Hadamard transform</td>
</tr>
<tr>
<td>Dmitry Plotnikov, Evgenii Sopov, Ilya Panfilov</td>
<td>An approach for automating the design of convolutional neural networks</td>
</tr>
<tr>
<td>R I Kuzmich, A A Stupina, M V Karaseva, L N Ridel T V Dubrovskaya</td>
<td>Application of informative patterns in the classifier for a logical data analysis method</td>
</tr>
<tr>
<td>Elena Doynikova, Igor Kotenko</td>
<td>Approach for determination of cyber-attack goals based on the ontology of security metrics</td>
</tr>
<tr>
<td>Ilya Ivanov, Evgenii Sopov, Ilya Panfilov</td>
<td>Comprehensive approach for solving multimodal data analysis problems based on integration of evolutionary, neural and deep neural network algorithms</td>
</tr>
<tr>
<td>Coverage verification by tests of program branches and conditions of software in environments of automatic testing</td>
<td></td>
</tr>
<tr>
<td>A H Li, I A Lyapunova N A Fomenko</td>
<td></td>
</tr>
<tr>
<td>V I Kudymov, V. V. Brezitskaya, P. V. Zelenkov, I. N. Karisan Yu. N. Malanina</td>
<td>Formation of optimal composition of the modules of single-function multiversion software for automated control system of the satellite communication system</td>
</tr>
<tr>
<td>A A Sidaras, S V Chentsov</td>
<td>Increasing of organizational and technical system reliability with a help of differential approach</td>
</tr>
<tr>
<td>O V Drozd, P A Russkikh, S V Chentsov, D V Kapulin</td>
<td></td>
</tr>
<tr>
<td>D D Dmitriev, A V Sokolovskii, I N Kartsan, V N Tyapkin, S V Efremova</td>
<td>Methods of beam forming adaptive digital array and their study using a computer model</td>
</tr>
<tr>
<td>Non-replicable object surface development for its automatic identification</td>
<td></td>
</tr>
<tr>
<td>L S Beckel, V D Shkilev</td>
<td></td>
</tr>
<tr>
<td>Artemy Varzhapetyan, Valeriy Lipatnikov, Sergey Michurin, Elena Frolova</td>
<td>Optimization of automatic exclusion algorithm of the vector network analyzer measuring equipment</td>
</tr>
<tr>
<td>D A Bolshakov, N N Burdulovskaya, K V Shugurova</td>
<td></td>
</tr>
<tr>
<td>A V Kolnogorov</td>
<td></td>
</tr>
<tr>
<td>Risk management of interactive electronic technical manual design projects</td>
<td></td>
</tr>
</tbody>
</table>

---

8

---

9
Salient region detection in the task of visual question answering ...................................................... 72
Margarita Favorskaya, Vladimir Andreev, Aleksei Popov

Simulation modelling of the heterogeneous distributed information processing systems ................. 73
G A Ontuzheva, E R Bruchanova, I N Rudov, N O Pikov, O A Antamoshkin

SECTION 5. ECOLOGY AND ECOLOGICAL ENGINEERING ................................................................. 73

A new approach to multiversion decision-making to improve the reliability of environmental monitoring parameters ...................................................................................................................... 73
M.V. Saramud, I.V. Kovalev, V.V. Losev, A S Kuznetsov, D I Kovalev, S S Ognerubov

Combined production of ammonia and methanol as the way to deal with the greenhouse gas ... 74
S V Afanasiev, M V Kravtsova, Yu N Shevchenko T P Guschina

Component selection model of the indoor automated system on the basis of system analysis .... 74
S A Ivanov, I J Kvyatkovskaya

Converting gaseous pollutants toxic to plants and humans into environmentally friendly compounds in artificial ecosystems .............................................................................................................. 74
A A Tikhomirov, S A Ushakova, N A Tikhomirova, S V Trifonov, G S Kalacheva

Selection of emission detection ranges for the laser method of plant stress revealing at a fluorescence excitation wavelength of 355 nm ....................................................................................................................... 75
Ju V Fedotov, M L Belov, D A Kravtsov, A A Cherpakov, V A Gorodnichev

Development and creation a model of a digital twin of the cubepart rectification installation for the separation of a binary water-alcohol mixture ...................................................................................... 75
R A Khakimov, N S Shcherbo

Development of low-waste technology for the processing of sulphur into polysulphides and materials based on them ................................................................................................................................. 76
A A Jusupova, R T Akhmetova, L R Baraeva, G A Medvedeva, Zh V Mezhevich

Elaborating of the device for the importation of liquid ameliorants into the soil ...................... 76
S A Vasilyev, I I Maximov, A A Vasilyev, E AVasilyeva

Environmental management modelling in the areas of waste landfilling ................................ 77
T G Sereda, S N Kostarev

Geoinformation modelling system of natural technical complexes for simulation modelling and optimization of load distribution .............................................................................................................. 77
Natalia Zhilnikova

Investigation of seed uniformity under field and laboratory conditions ........................................ 78
E P Alekseev, S A Vasiliev, I I Maksimov

Measurement accuracy of real time parameters in environmental monitoring ............................ 78
M.V. Saramud, I.V. Kovalev, D I Kovalev, A.A. Voroshilova, A.S. Kuztensov

Microclimate Control System Development ..................................................................................... 79
S N Kostarev, T G Sereda

Numerical modelling of surge wave in downstreams of the waterworks .................................. 79
J G Ivanenko, A A Tkachev, K G Gurin, D J Ivanenko

Optimization of carbon dioxide compressing technology in the production of urea ................. 80
S V Afanasiev, M V Kravtsova, Yu N Shevchenko, T P Guschina, S A Sokov

Optimization of recycling strategy for solid industrial waste ......................................................... 80
A V Rubinskaya, E I Pister, A A Ioffe, A Yu Vititnev, M V Karaseva
Developing the technology of physicochemical processing of organic waste in closed life support systems for space applications ................................................................. 81
A A Tikhomirov, S V Trifonov, E A Morozov

System for personnel training in decision making of wildfires fighting ........................................... 81
G Dorrer, A Dorrer, I Buslov, S Yarovoy

SECTION 6. POWER ENGINEERING ........................................................................................................ 82
Automation and control of blow molding mechanisms according to the criterion of maximum energy efficiency ........................................................................................................ 82
V V Platonov, A T Tsirkunenko, S S Bukhanov

Automation of the design and development stages of semiconductor devices ...................................... 83
A A Imanova, V V Fediakov, E Tulegenov

Control of high-voltage pump motor using a frequency sine-wave filter converter ............................ 83
E Dresvianskii, M Pokushko, A Stupina, V Panteleev, V Yurdanova

Determination of the amount of entropy of non-recoverable elements of the technical system. .......... 84
Aleksander Dulesov, Denis Karandeev, Natalia Dulesova

Doubly fed induction motors control in positional electrical drives ...................................................... 85
P V Avlasko, S A Bronov, Z A Avlasko, D A Antonenko

Experimental study on the structure formation features of a filler of catalytic heating systems. .... 85
A A Medyakov, A D Kamenskih, D M Lastochkin, A P Ostasenkov

High-performance flux-switching DC motors for energy facilities .................................................. 85
A D Golykov, S P Gladyshev, A N Gorozhankin

Improving the reliability of the relay automation system for power facilities .................................. 86
S S Bukhanov, L A Zhuravleva, M N Kornienko

Increase of energy efficiency of energy generation due to utilization of waste heat on district heating systems .................................................................................. 86
D Karabarin, S Mihailenko

The research of the electric field intensity change in the air gap of the compact electrostatic filter ........................................................................................................... 87
F R Ismagilov, I Kh Khairullin, M V Okhotnikov, A A Nusenkis, D V Maksudov

Optimization model of power supply system of industrial enterprise .............................................. 88
V Panteleev, S Zilberman, G Pilyugin, R Petukhov, E Sizganova, M Mashukov

Power forecasting for a photovoltaic system based on the multi-agent adaptive fuzzy neurone. 88
A S Degtyarev, V I Kosenko, E A Engel, N N Engel, M V Saveleva

Prediction of improper operation of microprocessor relay protection devices during geomagnetic storms ........................................................................................................ 89
E V Platonova, V I Panteleev, G N Chistyakov, A V Mainagashev, V P Kochetkov

Increasing the efficiency of energy generation at Krasnoyarsk CHP-2 by utilization of waste heat .................................................................................................. 89
D Karabarin, S Mihailenko
THE PROGRAMME COMMITTEE

Chairman:
Evgeny V. Pimenov - Corresponding member of the Russian Academy of Sciences, Doctor of Sciences, Professor

Vice-Chairman:
Vitaly A. Akimenko - Director of Sochi Humanitarian and Economic College

Members:
Sergey P. Drukarenko - Candidate of Science, Vice-president, First Secretary of Russian Union of the International and Russian Union of Scientific and Engineering Associations
Igor V. Kovalev - Doctor of Technical Sciences, Professor, President of the Krasnoyarsk Regional Union of Scientific and Engineering Associations, Director of Krasnoyarsk Regional Science and Technology City Hall
Alexander S. Degterev - Doctor of Technical Sciences, Professor, General Director - Chief Designer of JSC "Central Construction Bureau "Geofizika", Russia
Viktor D. Lefter - Doctor of Technical Sciences, Professor, President of JSC "Republican Center for Space Communications", Republic of Kazakhstan
Wang Jiangsu - Ph.D., Professor, Rector of Xingtai University, People's Republic of China
Liu Hong - PhD, professor, Rector of the Dalian University of Foreign Languages, People's Republic of China
Sun Wei - PhD, Dean of the Department of Chinese Studies, People's Republic of China

Maja Fošner - PhD, Deputy Dean of the Faculty of Logistics, University of Maribor, Slovenia
Hans - Ruediger Fluk - Doctor of Science, Professor of Ruhr University in Bochum, Germany
Alexander Ivanov - PhD, Researcher at the Federal Polytechnic School of Lausanne (EPFL), Switzerland
Aleksey M. Zyzin - Chairman of the Board of Directors of the House of Science and Technology of Russian Union of Scientific and Engineering Associations, Honored Inventor of the Republic of Mordovia, Russia
Dmitry V. Kolbasinsky - Candidate of Sciences, Associate Professor, Sochi, Russia
Aleksey G. Vostretsov - Doctor of Technical Sciences, Professor, Vice-Rector of Novosibirsk State Technical University, Russia
Vladimir V. Delba - Vice-Minister of Abkhaz Republic
Mikhail N. Krasnyatsky - Doctor of Technical Sciences, Professor, Rector of Tambov State Technical University

The Editorial Board
Igor Kovalev - Doctor of Technical Sciences, Professor, President of the Krasnoyarsk Regional Union of Scientific and Engineering Associations, Director of Krasnoyarsk Regional Science and Technology City Hall
Alena A. Stupina - Doctor of Technical Sciences, Professor, Vice-Rector of the Siberian Federal University
Anna A. Voroshilova – Candidate of Philosophy Sciences, Vice-Director of Krasnoyarsk Regional Science and Technology City Hall

Grigory D. Voskoboinik, - Doctor of Sciences, Professor of Xingtai University, China
Maja Fošner - PhD, Deputy Dean of the Faculty of Logistics, University of Maribor, Slovenia
Sergey Ognerubov – Candidate of Technical Sciences, PhD, SDE II, Microsoft, USA, Karl-Erwin Grosspietsch – PhD, Chairman of The European Organization for Information and Microelectronics, Germany
WORKSHOP ORGANIZERS & SPONSORS

Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations, Krasnoyarsk, Russia

Russian Union of Scientific and Engineering Associations, Moscow, Russia

International Union of Scientific and Engineering Associations, Moscow, Russia

JSC “ACADEMICIAN M.F. RESHETNEV Information Satellite Systems”

JSC "Central Construction Bureau “Geofizika"
Overview of the International Workshop “Advanced Technologies in Aerospace, Mechanical and Automation Engineering – MIST: Aerospace”

Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations, 61 Uritskogo street, Krasnoyarsk, 660049, Russia

E-mail: krasnio@bk.ru

Abstract. The overview describes the main directions and results of the International Workshop MIST: Aerospace-2018 held in Krasnoyarsk in October 20, 2018. It gives the details about the participants and the proceedings.

The Volume contains Proceedings of the International Workshop “Advanced Technologies in Aerospace, Mechanical and Automation Engineering - MIST: Aerospace” which was held in Krasnoyarsk, Russian Federation in October 20, 2018 within the framework of the IX International Multidisciplinary Scientific and Research Conference “Modern Issues in Science and Technology” (Sochi, Russia, October 20-28, 2018).

The purpose of the Workshop is to share the results and prospects of the achievements in using advanced scientific, innovative and information technologies in aerospace industry, mechanical engineering and automation.

The Workshop was jointly organised by the International and Russian Union of Scientific and Engineering Associations (Moscow, Russia), Krasnoyarsk Regional Union of Scientific and Engineering Associations and Krasnoyarsk Science and Technology City Hall.

The Program Committee and Editorial Board included prominent professors and scientists from the Russian Academy of Sciences, University of Maribor (Slovenia), Xingtai University (China), Ruhr University in Bochum (Germany), Siberian Federal University (Russia), Reshetnev Siberian State University of Science and Technology (Russia) as well as specialists from Russian and foreign leading industrial enterprises.

The event has offered a platform for bringing together students, postdocs, innovative academics and industrial experts to exchange their ideas and contribute new engineering approaches to research mechanical and automation processes in various technological and information systems.

The program of the Workshop consisted of keynote and plenary talks and numerous presentations (figure 1). The Workshop provided the premier interdisciplinary and multidisciplinary forum for researchers, practitioners and educators to present and discuss the most recent innovations, trends, concerns, practical challenges encountered and the solutions adopted in the fields of aerospace technologies, materials sciences, mechanical engineering, cybernetics, data protection, ecological and power engineering, etc. Although the schedule of the Workshop was very tight, there were very vivid discussions among the participants.
Figure 1. Plenary talks and sections.
The participants represented more than 80 Russian and foreign universities and organisations:

- Academy of FGS of Russia
- Altay State Technical University
- ANO CPE MOMENTUM, Moscow
- Astrakhan State Technical University
- Bauman Moscow State Technical University
- Belgorod State Technological University named after V.G. Shoukov
- Bratsk State University
- Bryansk State Engineering Technological University
- Bryansk State Technical University
- Building Management - 33, Moscow
- Chuvash State Agricultural Academy, Cheboksary
- Gmbh Anvilex, Dresden, Deutschland
- Guibkin Russian State University of Oil and Gas, Moscow
- Igor Sikorsky Kyiv Polytechnic Institute, Kyiv, Ukraine
- Infocon-S, LLC, Stavropol, Russia
- Institute of Biophysics, Federal Research Center “Krasnoyarsk Science Center, Siberian Branch of the Russian Academy of Science
- Irkutsk State Transport University
- Joint-stock company «Research and Production Enterprise «Radar mms», Saint Petersburg
- JSC "Central Construction Bureau “Geofizika”, Krasnoyarsk
- JSC “Academician M F Reshetnev Information satellite systems”, Zheleznogorsk, Russia
- Kaluga branch of Bauman Moscow State Technical University
- Katanov Khakass State University, Abakan
- Kazan National Research Technical University named after A.N. Tupolev – KAI, Kazan, Republic of Tatarstan
- Khakas Technical Institute of Siberian Federal University, Abakan
- Korolev Samara National Research University
- Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations
- Krasnoyarsk State Agrarian University
- Kuban State Technological University, Krasnodar
- KURS, Ltd
- Main Military Clinical Hospital named after N.N. Burdenko, Moscow
- Novocherkassk engineering-ameliorative institute named after A. K. Kortunov of Don State agrarian university
- Oles Honchar Dnipropetrovsk National University, Dnipropetrovsk, Ukraine
- Omsk state technical university
- Orel State University
- Penza State University
- Perm Institute of the FPS of Russia
- Perm Military Institute of National Guard Troops of the Russian Federation
- Perm State Agro-Technological University named after academician D N Priainshnikov Russian Presidential Academy of National Economy and Public Administration. Perm branch, Perm
- Peter the Great St. Petersburg Polytechnic University, St. Petersburg
- Reshetnev Siberian State University of Science and Technology, Krasnoyarsk
- RiK-Energo ltd, Ekaterinburg and Chelyabinsk
- Rubtsovsk Industrial Institute (Branch) of Polzunov Altai State Technical University
- Russian Presidential Academy of National Economy and Public Administration. Perm branch, Perm
- Saint Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences, St. Petersburg
- Saint Petersburg National Research University of Information Technologies, Mechanics and Optics University (ITMO), Saint Petersburg
- Saint Petersburg Polytechnic University
- Saint Petersburg State Forest Technical University
- Saint Petersburg State University of Aerospace Instrumentation
- Saint Petersburg University of Management Technologies and Economics
- Samara National Research University
- Samara Scientific Center of the Russian Academy of Sciences
- SDE II, Microsoft, Washington, USA
- Siberian federal university, Krasnoyarsk
- South Ural State Agrarian University, Troitsk
- South Ural State University, Chelyabinsk
- Southern Federal University, Rostov-on-Don
- State University of Humanities and Social Studies
- Stock Company «Experimental Design Bureau
A wide range of fundamental and applied problems in various production and technological systems has undergone consideration during the meeting. The programme of the Workshop included the following sections: Aerospace Engineering; Mechanical Engineering and Industry; Data Protection in Automation Systems; Cybernetics, Automation and Information Technologies; Ecology and Ecological Engineering and Power Engineering.

All participants were invited to present their papers in this Volume and all submitted manuscripts went through the independent peer review process. We are very grateful to all reviewers from Russia, China, USA, Slovenia, Germany and Republic of Kazakhstan for their time and highly professional comments. We deeply believe that their reviews gave opportunity to improve the scientific quality of the presented papers which may be useful for academic, scientific and industrial partners.

More than 200 reports were submitted to the Organizing Committee. 152 reports were selected for inclusion into this Volume after the review process. All the papers were subjected to rigorous peer-review by conference committee members and international reviewers. The papers were selected based on their quality and relevance to the Workshop directions. The proceedings present to the readers the recent advances in the field of aerospace engineering, mechanical engineering and industry, materials science, data protection in automation systems, cybernetics, information technologies, ecological engineering and power engineering. These papers reflect modern engineering approaches in all Workshop directions.

We chose the IOP Conference Series: Materials Science and Engineering to provide all contributors with the opportunity to publish their papers in an international, peer-reviewed journal. This is understood and appreciated by all the participants of our Workshop, and therefore this Volume provides an excellent overview of the main topics of our Workshop.
Acknowledgements

We highly appreciate JSC “Academician M.F. Reshetnev Information Satellite Systems” and JSC “Central Construction Bureau “Geofizika” for financial support of the International Workshop “MIST: Aerospace”. On behalf of the conference committee and organizers, I would like to thank all the authors who contributed to this Volume as well as to the reviewers, speakers and all the conference participants for their support to MIST: Aerospace.

Scientific supervisor of “MIST: Aerospace 2018”
Doctor of Technical Sciences, Professor,
President of the Krasnoyarsk Regional Union of Scientific and Engineering Associations,
Director of Krasnoyarsk Regional Science and Technology City Hall

Igor V. Kovalev
Krasnoyarsk, October 20, 2018
SECTION 1. AEROSPACE TECHNOLOGIES

Advancing methodology to specify cavitation characteristic of screw-type centrifugal pumps

Vladimir Nazarov, Alexander Zuev, Larissa Nazarova and Marina Savelyeva
Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia
E-mail: dla2011@inbox.ru

Abstract. The research proposes a methodology of high-rate cavitation tests significantly decreasing testing period as well as increasing the accuracy of specifying a cavitation characteristic. To specify it, the tests without holding up consumption are conducted; however, at the pump inlet the rate to minimize pressure is increased. To decrease a test discrepancy, the data logging system is introduced. The research determines the high-rate pressure decreases without holding up consumption; it does not impact the accuracy to specify the cavitation characteristic and minimizes pump operation under the cavitation conditions diminishing erosive action. Automation significantly minimizes labour intensity during tests and improves the accuracy.

Analysis of logic-time characteristics of subsystem supply functioning hardware elements of unmanned aerial vehicles

Nikolay A Testoedov¹, Igor V Kovalev³,⁴,⁵, Maja Fošner², Anna A Voroshilova⁴,⁵,⁶ and Vasily V Losev⁴

¹ JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia
² Faculty of Logistics, Maribor University, 7 Mariborska street, Celje, 3000, Slovenia
³ Siberian federal university, 79 Svobodny avenue, Krasnoyarsk, 660041, Russia
⁴ Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia
⁵ Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations, 61 Uritskogo street, Krasnoyarsk, 660049, Russia
⁶ E-mail: kovalev.fsu@mail.ru

Abstract. To obtain the logical and temporal characteristics of the model of control loop process variable, an analysis of the subsystem hardware of the autonomous unmanned object onboard control system was conducted. The problem of time delays in the information transmission from the primary converter to the control element in automated process control systems is considered as equivalent of the subsystem of the onboard control system of an autonomous unmanned object. At present, there are no methods for estimating the effect of time delays of an information signal on the response time of a control loop, which leads to inefficient use of system resources. The increased time interval between the change in the process variable and the control effect can also
lead to negative consequences. Parametric identification of individual nodes with subsequent compilation of a closed loop model by a separate parameter is selected as a tool for system analysis.

**Application of cascade-connected regulation in the implementation of the software of weight component compensation system**

V I Kudymov¹, Yu O Badanina¹, I V Kovalev²,³,⁴, V S Bashkarev¹ and M V Karaseva³

¹ JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia
² Siberian federal university, 79 Svobodny avenue, Krasnoyarsk, 660041, Russia
³ Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsk Rabochy Av., Krasnoyarsk, 660037, Russia
⁴ Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations, 61 Uritskogo street, Krasnoyarsk, 660049, Russia

E-mail: badaninayo@iss-reshetnev.ru

**Abstract.** The paper considers the necessity to develop specialized technological equipment (a weight component compensation system) for ground-experimental testing of the functioning of high-technological large-size transformable reflectors for a spacecraft and their components. A simplified block diagram of the module layout of the weight compensation system with one carriage is presented. A mathematical model of cascade-connected regulation of a control system of a weight component compensation system was developed. An adaptive model has been presented. It determines the more appropriate settings for proportional–integral–derivative (PID-controller) through a fuzzy inference system applicable to test technological large-size transformable reflectors for a spacecraft.

**Automation system of communication satellite designing**

N A Testoedov¹, A V Kuzovnikov¹, Yu G Vygonsky¹, D A Matronitsky¹, A V Ankudinov¹,³ and T V Strekaleva²

¹ JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia
² Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsk Rabochy Av., Krasnoyarsk, 660037, Russia
³ E-mail: aav4567@gmail.com

**Abstract.** The selection of efficient alternative design of communication satellite architecture is impossible without solving the problem of Computer-Aided Design. The authors have offered the structure and the functions of communication satellite and data relay satellite. The prospects for further development have been defined as well.
High-speed stream data collection and processing system of the Earth’s ionospheric sounding

V V Kopytov, A O Shulgin, N G Demurchev, P V Kharechkin and V V Naumenko

“Infocom-S”, LLC, 7, Suvorova Street, Stavropol, 355035, Russian Federation

E-mail: p.harechkin@infocom-s.ru

Abstract. The paper describes the structure of the Earth’s ionospheric sounding system which allows to determine the geographic coordinates of ionospheric regions with intense small-scale structures of electron content by total electron content data analysis. The system is based on the high-speed stream data collection and processing technology that performs sensed data preprocessing and scheduled data processing, including the estimation of total electron content in the ionosphere by distributed scalable computer cluster using a stack of open-source services.

Direction-finding method solution phase ambiguity in determining the spatial orientation of space vehicle

I N Kartsan, M O Petrosyan, S V Efremova and V V Khrapunova

Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia

E-mail: kartsan2003@mail.ru

Abstract. When creating multichannel GNSS receivers that implement interferometric methods for measuring spatial orientation using GLONASS and GPS signals, the main problem is the resolution of phase ambiguity when measuring the phase difference for spatially separated antennas. In order to improve the accuracy of determining the spatial orientation, interferometers with the distance between the antennas (base length) reaching several meters are used. The ambiguity in measuring the phase shift is due to the fact that the wavelength of the measured signals is sufficiently small (about 19 cm), which is much smaller than the length of the bases of the interferometer. The methods for resolving phase ambiguity can be divided into two classes: one-stage ones that operate on the basis of the results of each measurement and methods based on filtering that require measurement of phase shifts over a certain time interval.

Development of electric heaters with increased efficiency of unpressurized designed space vehicles

N V Lukonin1, I Ya Shestakov1, E N Golovenkin1, M M Mikhnev1, I A Maksimov1 and S N Pankina2

1 JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia
Abstract. Ensuring the temperature mode of operation of the equipment and spacecraft units in a given temperature range and maintaining a balance between the received thermal energy and its impact with the redistribution of thermal energy between the structures of the apparatus is an important technical task. The authors have presented the main results and stages of development of electric heaters for unpressurized designed space vehicles based on the photolithography method and etching of the resistive layer, allowing to produce flexible film heaters of various shapes and sizes using materials produced by domestic industry in the framework of the import substitution program, with reduced mass-dimensional characteristics and high efficiency. The proposed method can be used to manufacture electric heaters of various designs, forms and properties: flexible, flat, flexible-flat, three-dimensional forms, with a given level of manufacturability and quality when creating modern and promising spacecraft. The presented results can be used in other areas of technology, where electric heating elements are made and used with given geometric properties, strength characteristics and normalized thermal output.

Efficient engineering approach to communication satellite design

N A Testoedov¹, A Yu Vshivkov¹, V I Kosenko¹, A V Ankudinov¹,³, M V Saveleva² and E V Tuev²

¹ JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia
² Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia
³ E-mail: aav@iss-reshetnev.ru

Abstract. Choosing the efficient options of communication satellites (CS) requires the computer-aided design and researching complex and super-complex technical systems; satellite systems are among them. Therefore, organising space vehicle design process reveals a clear tendency to its automation that is specific for both routine, stand-alone technical feature of designing process, and the intellectual aspects of design.

Electrodynamic analysis of materials for the antenna elements

Alexandr Chabanenko¹, Elena Frolova¹, Victor Balashov² and Maria Smirnova¹

¹Federal state autonomous educational institution of higher education «St. Petersburg State University of Aerospace Instrumentation» 67, Bolshaya Morskaya str., Saint Petersburg, 190000, Russia
²Joint-stock company «Research and Production Enterprise «Radar mms» 37, lit. A, Novoselkovskaya str., Saint Petersburg, 197375, Russia
Abstract. The electrodynamic problem of electromagnetic field propagation in a two-layer dielectric structure has been set and solved. A constructive solution is proposed for controlling the propagation conditions of a surface wave in the wall of a controlled radiant cone or antenna cover by introducing an additional dielectric layer between the fairing wall and the contact radiator.

Ensuring the quality of the materials used in the spacecraft engineering

V E Patraev¹, E A Shangina¹, V V Dvirny¹, A A Voroshilova²,³,⁴ and S A Borisov²

¹ JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia
² Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia
³ Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations, 61 Uritskogo street, Krasnoyarsk, 660049, Russia
⁴ E-mail: anvoroshilova@gmail.com

Abstract. The paper represents the principles and methods of perspective spacecraft quality assurance. The results of flight tests and operation of modern domestic and foreign spacecraft are taken into account. It is established that when planning scientific and methodological works aimed at ensuring the reliability of the spacecraft at the design stage, it is necessary to proceed from a number of principles that determine the order of spacecraft reliability index formation and constructive methods of ensuring reliability. The author's methodology includes an analysis of the main functions and their corresponding functional circuits. It is shown that when carrying out the functional analysis, special attention should be paid to identifying the mutual influence of the elements involved in performing various functions.

Evaluation of visual characteristics of image perception in avionics

O O Zharinov¹, M O Kostishin²*, M A Trushkin³ and V V Markelov²

¹ Department of Problem-Oriented Computing Complexes, Saint Petersburg State University of Aerospace Instrumentation, 67, Bolshaya Morskaya str., Saint Petersburg, 190000, Russia
² Department of Computer Design of On-Board Computer Equipment, Saint Petersburg National Research University of Information Technologies, Mechanics and Optics, 49, Kronverksky Av., Saint Petersburg, 197101, Russia
³ Research Center, Stock Company «Experimental Design Bureau «Elektroavtomatika» named after P A Yefimov, 40, Marshala Govorova St., Saint Petersburg, 198095, Russia

* E-mail: maksim@kostishin.com
Abstract. The task is being studied to evaluate the amount of quality to perceive the picture elements being projected on LCD screens of modern on-board visual means to display the information. A mean to display information is a multi-functional colorful indicator. The display itself (the frame being displayed) is a sign and symbol information. The symbol perception of different angle sizes is being studied. The families of probability characteristics have been received which characterize with numbers the quality of symbol perception being displayed under different screen resolutions.

Experimental research of the drawing process with forced thinning of thick billet for the formation of parts with specified wall thickness

S Yu Zvonov, A G Shlyapugin and A A Halikova
Samara National Research University, 34, Moskovskoye shosse, Samara, 443086, Russia
E-mail: sergei_zvonov@mail.ru

Abstract. The modern industry development requires high efficiency from production in the area of parts manufacture. Due to this reason, it is necessary to change conical parts manufacturing technology, with cylindrical corbels, which are widely used. The paper presents the results and methods of conducting experimental studies of the drawing process with forced thinning of parts with specified wall thicknesses used in aircraft. Various types of lubricants were considered to reduce the force of the process and the distribution of the material along the generator part. Recommendations have been developed to prevent rejection of drawing operations with forced thinning of a flat thick-walled billet.

Fast satellite imagery of lengthy territories with complex configuration

D K Mozgovoy¹, D N Svinarenko¹, R Yu Tsarev², T N Yamskikh²
¹ Oles Honchar Dnipropetrovsk National University, 72, Gagarin Prospect, Dnipropetrovsk, 49000, Ukraine
² Siberian Federal University, 79, Svobodny Prospect, Krasnoyarsk, 660041, Russia
E-mail: m-d-k@i.ua

Abstract. When solving a number of remote sensing problems, there arose a need for fast satellite imagery of arbitrarily-spaced lengthy territories with complex configuration (borders, roads, rivers, coastlines, etc.). The distinctive features of Earth remote sensing satellites equipped with optical-electronic scanners providing sub-meter spatial resolution are a narrow swath width, which does not allow to take images of arbitrarily-spaced lengthy territories in one-orbit period, and a small pixel size of CCD photocells (i.e., low sensitivity), which does not allow to take images of low-contrast objects, as well as take pictures from neighbouring orbits at low angles of the Sun. An effective technique for controlling the high-resolution remote sensing spacecraft orientation in the
process of retargeting (i.e., with non-zero angular velocities) is proposed, which allows to choose the best scan mode and take images of arbitrarily-spaced lengthy territories with complex configuration in one-orbit period, i.e. much faster. Moreover, non-zero angular velocities allow to increase the exposure time and take pictures of low contrast, low light or camouflaged objects. The main characteristics and disadvantages of Earth remote sensing satellites equipped with optical-electronic scanners providing sub-meter spatial resolution are shown in the article. The features of planning high-resolution satellite imagery and remote sensing data processing require consideration of a larger number of additional influencing factors than when using traditional imagery with optical-electronic scanners characterized by sub-meter spatial resolution. The main stages of modeling and planning ultra-fast satellite imaging of lengthy territories, as well as the basic design formulas are considered in the article. To approximate a lengthy object defined by the nodal points on the map, smoothing with a cubic interpolating spline is used. For short forecast periods and low earth circular orbits, sufficient accuracy is achieved with the propagator SGP4, which allows to work with the initial conditions in TLE files generated by NORAD.

Focused antennas for diagnostics of spacecraft antenna systems

D A Veden’kin1, J E Sedel’nikov1, N A Testoedov2, I J Danilov2, A G Romanov2,3 and V I Kudymov2

1 Kazan national research technical university named after A N Tupolev, 10 Marx street, Kazan, 420111, Russia
2 JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia
3 E-mail: romanov@iss-reshetnev

Abstract. The use of a focused radiating system principle opens up additional possibilities for solving a number of technological problems in the development and testing of spacecraft antenna systems. This paper presents the basic properties of antennas focused in the near radiated-field zone and the indicated applications. The paper deals with the tasks of diagnostics of the amplitude-phase distributions of antennas, materials of space antenna construction, cable lines.

Choice of optimal multiversion software for a small satellite ground-based control and command complex

I N Kartsan, S V Efremova, V V Khrapunova and M I Tolstopiatov

Reshetnev Siberian State Aerospace University, 31 Krasnoyarsky Rabocheh ave., Krasnoyarsk, 660037, Russia

E-mail: kartsan2003@mail.ru

Abstract. This paper discusses the criteria and restrictions, which arise during the solution of problems relevant to the synthesis of software for a ground-based control and command complex for small satellites. The authors suggest a number of models for forming multiversion software for this complex.
Investigation of the automation level of designing the software and hardware structure of the on-board equipment integrated modular avionics

A V Khakimov, V A Nechaev and M O Kostishin

Department of Computer Design of On-Board Computer Equipment, Saint Petersburg National Research University of Information Technologies, Mechanics and Optics, 49 Kronverksky Av., Saint Petersburg, 197101, Russia

E-mail: a.v.khakimov@mail.ru

Abstract. This article shows the complexity of the integrated modular avionics design of on-board equipment of large aircraft. A modern image of the integrated modular avionics of on-board equipment is presented on the basis of existing samples. The design process of the software and hardware of the integrated modular avionics of on-board equipment is analysed. The main tasks of its design are listed. The existing and currently used methods for solving design problems of integrated modular avionics of on-board equipment are described. The level of the design automation process is reviewed. Modern means of computer-aided design are presented and their comparative analysis is carried out. An assessment of the existing level of design automation is given. The design stage with the lowest level of automation is defined. Appropriate conclusions are given.

Investigation of the surface relief of polyalkaneimide composites after treatment with oxygen plasma

V I Pavlenko and N I Cherkashina

Belgorod State Technological University named after V.G. Shoukhov, 46 Kostyukov str., Belgorod, 308012, Russia

E-mail: cherkashina.ni@bstu.ru

Abstract. The paper presents data on the treatment of the flow of oxygen plasma of polyalkanimide and polyalkanimide composites. The hydrophobic SiO₂ was used as a filler. The fluency of oxygen atoms was 5.4 × 10¹⁸ at/cm² (equivalent to 10 years of exposure to atomic oxygen). Studies of the evolution of the surface relief of pure polyalkanimide and a composite containing 65 wt% SiO₂ under the action of oxygen plasma were performed by the probe method. It was shown that after oxygen plasma treatment of a sample of pure polyalkanimide or its composites, the surface acquires a peculiar grainy relief that was formed by depressions and elevated areas of conical and acicular shape oriented towards the flow of atomic oxygen. It has been established that the introduction of crystalline SiO₂ into polyalkanimide significantly increases the resistance of the polymer to the action of the oxygen plasma flow. Data on the change in the contact angle of wetting of the surface of polyalkanimide and polyalkanimide composites after treatment with an oxygen plasma flow are presented.
Laser reflection method for vegetation monitoring at eye-safe sensing wavelengths in the NIR spectral band

M L Belov, A M Belov, V A Gorodnichev and S V Alkov
Bauman Moscow State Technical University (BMSTU), 2nd Baumanskaya str., Moscow 105005, Russia
E-mail: belov@bmstu.ru

Abstract. The paper analyses capabilities of a laser reflection method for remote vegetation monitoring at eye-safe sensing wavelengths in the NIR spectral band and provides a statistical simulation of correct detection and false alarm probabilities to solve the tasks of vegetation monitoring. Shows that at the wavelengths of 1.54 и 2.03 μm, for example, the laser reflection method of sensing allows us to detect vegetation under adverse conditions with a probability of correct detection close to one and a probability of false alarm ~ second decimal places. The laser reflection method using two sensing wavelengths in the NIR spectral band can be accepted as a basis of the vegetation monitoring method using a high-flying aircraft.

Modelling of the welded seam parameters at electron-beam welding

Yu N Seregin, A V Murygin, V S Tynchenko and A V Milov
Reshetnev Siberian State University of Science and Technology, 31 Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russian Federation
E-mail: vadimond@mail.ru

Abstract. The article presents the results of technological parameters mathematical modeling when heating a titanium alloy by energy sources equivalent to an electron beam in electron-beam welding. Analysis and evaluation of simulation results was carried out using the criterion of optimality proposed by the authors. As a tool for calculations, the authors used a functional based on mathematical models of metal heating by a complex heat source consisting of mobile instantaneous point and linear energy sources. The results of calculations for a 0.12 cm thick plate are given in the paper. They were compared with the data obtained from prototypes from the VT-14 material using the design welding regimes carried out in the laboratory on an A306.13 electron beam unit.

On the efficiency of defocusing a large satellite multi-beam hybrid parabolic antenna

Yu I Choni1,4, A G Romanov2, I Yu Danilov2, V V Mochalov2, V A Bartenev2 and A O Shemyakov3
1 Kazan National Research Technical University, Kazan, 420111, Russia
2 Information Satellite Systems – Reshetnev Company, Zheleznogorsk, 662972, Russia
3 Moscow Aviation Institute (National Research University), 4 Volokolamskoe shosse, Moscow, 125993, Russia
Abstract. The article is devoted to the evaluation of the desirability of defocusing a large-sized multi-beam hybrid parabolic antenna (MBHPA). Defocusing means displacement of the antenna array (AA) from the focus, in the interests of rarefaction of the AA. Calculation of the MBHPA characteristics was carried out using a no strict but high-speed simulation program, the consistency of which was confirmed by comparison with the data of other authors. The results of our multivariate calculations with two strategies for the formation of feed clusters show that the idea of defocusing, which is tempting at first glance, does not benefit in the gain factor of the beams in comparison with un-displaced AA with the same spacing of the array elements. Therefore, in this capacity, defocusing is not effective.

On the peculiarities of wear-resistant nanocoatings research under production conditions. Obtaining calculated dependencies

N A Chemborisov¹, I K Ustinov and O A Artemenko
Kaluga branch Bauman Moscow State Technical University, 2 Bagenov street, Kaluga, 248000, the Russian Federation

¹E-mail: nche@mail.ru

Abstract. In this paper, we consider the main types of wear-resistant nanocoatings application, a method for determining the wear resistance is presented, which was developed based on experimental data on the wear resistance of cutting tools, with the deposition of a wear-resistant coating of titanium nitride. This article discusses the increase of the cutting tools effectiveness with the use of the cutting parts deposition with wear-resistant coating of titanium nitride. Axial tools, as well as cutters with wear-resistant coatings and without were studied within the framework of the PJSC "KAMAZ" production process. The data obtained from the studies of all groups of instruments are shown in the tables, they are presented in graphs and diagrams. Recommendations are given to increase the durability of the cutting tools, as well as to optimize the tool turnover in the production process.

Prediction of the vibration state of the GTE turbine rotor taking into account the influence of the geometric accuracy of parts

M A Boltov, E J Kolchina*, V A Pechenin and N D Pronichev
Institute of engines and power plants, Samara University, 34G Moscow road, Samara, 443086, Russia

*E-mail: ek-ko@list.ru

Abstract. The article deals with the problems of ensuring the vibration of gas turbine engines. A technique has been developed for assessing the level of vibration state depending on the geometrical errors of parts and assembly units. The studies of the level of vibration state are presented depending on the
following geometrical parameters: eccentricity of the inner hole of the shaft and eccentricity of the supports. A regression dependence of the level of vibration velocity on the considered geometrical errors is formed.

Optimization model of the hub airport schedule under uncertainty

E D Guzha, V A Romanenko* and M A Skorokhod

Department of transport organization and management, Korolev Samara National Research University, Russia 443086

*E-mail: vla_rom@mail.ru

Abstract. On the basis of a combination of fuzzy-multiple and theoretical probabilistic approaches, a model has been developed for optimizing the timetable for the movement of aircraft at an airport operating in the framework of the air transport system “hub & spoke”. The model can be integrated into mathematical and software environment designed to support decision-making at the stages of the formation and reconstruction of the hub & spoke system. The source of the initial data of the model is the databases of information production systems of airports and expert assessments. The purpose of optimizing the schedule is to reduce the lost profits of the hub-forming airline, arising from the failure of its services to those passengers who are potentially ready to be transported with a change in a hub, who consider the duration of the transfer to be unacceptable. Optimization consists in determining, on a given time interval, the points of time of arrival and departure minimizing lost profits due to the preservation of the potential transfer passenger traffic by ensuring a comfortable time of transfer. Restrictions on time and resource parameters of ground service processes are taken into account. The presence of fuzzy values in the composition of initial data is explained by the use of expert assessments and the difficult formalization of the subjective opinions of passengers with respect to the time spent in the hub. The stochastic nature of ground handling processes in a hub makes it necessary to use random variables in the model. The task with a fuzzy objective function and probabilistic constraints is reduced to the problem of mathematical programming. A description of the model example results is described. The possibility of a significant increase in income from transfer traffic is shown only by optimizing the schedule.

Peculiarities of precision space platform design for navigation satellites

V E Kosenko, V D Zvonar, M A Ilin, V E Chebotarev and A A Frolov

JSC Academichic M.F. Reshetnev Information Satellite Systems, 52, Lenin Street, Zheleznogorsk, 662972, Russia

E-mail: chebotarev@iss-reshetnev.ru

Abstract. Space radio navigation combines the latest achievements of computer and telecommunication technologies. The symbiosis of navigation satellite system, modern radio communication and electronic cartography allows to determine the location and speed of a moving vehicle, calculate distances, develop
efficient routes, monitor compliance, get information about cartographic objects. There are now two systems available: GPS (US) and GLONASS (Russia). Using both systems ensures more accurate determination of the coordinates of moving objects. The article deals with the issues related to the creation of a new type of space platform for navigation spacecrafts, namely, a precision space platform. The design requirements for precision space platforms of the navigation satellite are considered. The principles of designing the elements of precision platform that meet the requirements of a navigation satellite in terms of accuracy are determined. Finally, the dynamics of changes in the parameters of a precision space platform of navigation satellites that enhance the accuracy characteristics of the GLONASS system is shown.

On the peculiarities of wear-resistant nanocoatings research under production conditions. Part 2. Experiment results

N A Chemborisov, I K Ustinov and O A Artemenko
Kaluga branch Bauman Moscow State Technical University, 2 Bagenov street, Kaluga, 248000, the Russian Federation

E-mail: nche@mail.ru

Abstract. This article provides experimental data on improving the effectiveness of the use of cutting tools coated with wear-resistant nanocoatings along the cutting parts. Drills, countersinks, countersinks, reamers, mills, taps with wear-resistant coatings and without them are studied in the production process of public joint-stock company KAMAZ. The data obtained in the course of research of all groups of instruments were taken as the basis to develop calculated dependencies to improve the period of their useful life. Recommendations are given to increase the durability of the cutting tools, as well as to optimize the tool turnover in the production process.

Quality assurance of electrical components for spacecraft on-board equipment

V E Patraev¹, V E Chebotarev¹, E A Shangina¹, A A Voroshilova³, R Yu Tsarev²,⁵ and T N Yamskikh²

¹ JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia
² Siberian federal university, 79 Svobodny avenue, Krasnoyarsk, 660041, Russia
³ Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia
⁴ Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations, 61 Uritskogo street, Krasnoyarsk, 660049, Russia
⁵ E-mail: tsarev.sfu@mail.ru

Abstract. The paper considers the problems of ensuring high-level contractual requirements for single and complex reliability indicators of the spacecraft being
design. An original approach is proposed to ensure the quality of batches of electronic devices used to complete the on-board equipment of the spacecraft. The method of experimental quantitative estimation of coefficients taking into account changes in the operational intensity of failures from various factors, as well as the procedure for their reasonable assignment, is analysed.

**Satellite imagery of coastlines**

D K Mozgovoy¹, D N Svinarenko¹, R Yu Tsarev², T N Yamshikh² and E V Burdina³

¹ Oles Honchar Dnipropetrovsk National University, 72, Gagarin Prospect, Dnipropetrovsk, 49000, Ukraine
² Siberian Federal University, 79, Svobodny Prospect, Krasnoyarsk, 660041, Russia
³ Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia

E-mail: m-d-k@i.ua

**Abstract.** An advanced technique for satellite imagery of lengthy coastlines with complex configuration using Earth remote sensing satellites equipped with optical-electronic scanners characterized by ultrahigh spatial resolution has been developed. It has been proposed to image coastal areas directly in the process of satellite retargeting (i.e., with non-zero angular velocities). The paper provides an assessment of comparative efficiency of the technique implemented using automatic satellite attitude program control in the process of retargeting, both in terms of improving the efficiency of satellite imagery, and in terms of coverage in one-orbit period. Approximate methods for lengthy objects with complex configuration using cubic splines are described. When planning such imagery, besides the standard set of parameters (lighting conditions, swath width, onboard equipment constraints, instrument errors, etc.), it is necessary to consider the limits for the angular region and angular velocities of retargeting types of imagery were modelled, as well as the features of imagery with significant deviations of the viewing axis from nadir. The results of modelling various types of imagery for a given area using measurement data of cloud amount are presented.

**Simulation of short-range navigation system based pseudolites and investigation of its accuracy characteristics**

D D Dmitriev, A B Gladyshev, V N Ratuschnyak and I N Kartsan

Reshetnev Siberian State Aerospace University, 31 Krasnoyarsky Rabochy ave., Krasnoyarsk, 660037, Russia

E-mail: kartsan2003@mail.ru

**Abstract.** This paper considers a laboratory complex for studying the characteristics of short-range navigation system based pseudolites. The complex was built on the National Instruments hardware platform in the LabView programming environment. The complex is a real prototype of a navigation
system based on pseudosatellites. It provides simulation of the navigation field, analysis of received signals, determination of signal characteristics and navigation parameters. The article presents the results of experimental studies of the complex with the aim of determining the error in pseudo-range measurements from the signals of navigational spacecraft and pseudosatellites.

Solving navigation-temporal tasks in different coordinate systems

V E Chebotarev¹, V V Brezitskaya³, I V Kovalev²,³, ⁴, I N Kartsan³,⁷, Yu N Malanina⁵ and A O Shemyakov⁶

¹ JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia
² Siberian federal university, 79 Svobodny avenue, Krasnoyarsk, 660041, Russia
³ Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia
⁴ Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations, 61 Uritskogo street, Krasnoyarsk, 660049, Russia
⁵ Management Department, Irkutsk State Transport University, Irkutsk, Russia
⁶ Moscow Aviation Institute (National Research University), 4 Volokolamskoe shosse, Moscow, 125993, Russia
⁷ E-mail: kartsan2003@mail.ru

Abstract. Currently, lots of work is being done to improve the accuracy of navigation systems both from the hardware point of view [1-6] and from the software [7-11]. No less important issue is development of a single system within hardware and software complexes [12-14]. In this article we reveal the issues solving the navigation-temporal tasks in different coordinate systems. When creating multichannel GNSS receivers that implement interferometric methods for measuring spatial orientation on GLONASS and GPS signals, it is extremely important to solve navigation and time problems, especially in order to optimize the solution with missing satellite data. The article also presents proposals for the improvement of multichannel GNSS receivers in order to solve the problems of positioning in conditions of uncertainty and incompleteness of data.

Spacecraft protection from the negative effects of environmental factors and complex dynamic loads at the transportation stage

E N Golovenkin¹,³, S N Lozovenko¹, A V Tsaitler¹, M V Karaseva² and A A Melkomukov¹

¹ JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia
² Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia
³ E-mail: gne@iss-reshetnev.ru
Abstract. A paper presents a design version of the specialized container for transporting a spacecraft to a launch site. The goal is to ensure the safety of the spacecraft’s technical characteristics in the specialized container by meeting the requirements for temperature, humidity, air purity and dynamic loads. The developed version corresponds to the modern level of technology development and allows specialized containers development of any size in a short time. This design version of the specialized container provides the desired comfort conditions for a spacecraft during a prolonged impact to negative environmental factors.

Substantiation of the need to create the technology of stretch forming shells double curvature shell using new alloys

V A Mikheyev, S V Surudin, D V Agafonova, A T Tiabashvili and V O Agafonova
Samara National Research University, 34, Moskovskoye shosse, Samara, 443086, Russia

E-mail: vamicheev@rambler.ru

Abstract. The technology of stretch forming shells doubly curved shell should take into account the kinematic features of the stretching press and the plastometric characteristics of the sheet blanks when performing a sequential scheme of stretch forming. The technology is characterized by some parameters. They include the following groups: material properties; friction conditions; dimensions of the sheet blank; heat treatment conditions of the sheet material; the placement parameters of the stretch die on the bed of press; technological conditions of the process of obtaining shell details of the minimum thickness variation on stretching press with program control.

The automated system of telemetry data multilime reception, processing and analysing

J V Vilkov¹, I A Maksimov¹, M V Nekrasov¹, R J Tsarev²,³, T N Yamskikh² and V V Kovalev³,⁴
¹ JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia
² Siberian federal university, 79 Svobodny avenue, Krasnoyarsk, 660041, Russia
³ Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia
⁴ Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations, 61 Uritskogo street, Krasnoyarsk, 660049, Russia
⁵ E-mail: tsarev.sfu@mail.ru

Abstract. Modern automated control systems for spacecrafts are characterized by complex multicomponent architecture. The orbital group of spacecrafts is controlled from the mission control center which receives different types of office
and special data. The flows of telemetry data which allow to monitor the condition of a spacecraft take a special place among various types of information circulating within an automated control system. The article contains practical recommendations regarding the improvement of special automation software for technological processes of telemetry data multiline reception, processing and analyzing. It is shown that adherence to the principles of unified systems creation provides many advantages when designing modern tools for telemetry data processing and analyzing.

The development of the model of satellite orbital motion

A G Dubrovin¹, Yu N Baranov²,⁴ and A P Tryastsin³

¹ Academy of FGS of Russia, 35 Priborostroitelnaya street, Orel, 302015, Russia
² Orel State University, 95 Komsomolskaya street, Orel, 302026, Russia
³ E-mail: bar20062@yandex.ru

Abstract. The article presents the results of the development of an imitation model allowing in real time to simulate the orbits of most satellite communication systems. The main feature of the model is the use of Kepler orbital elements presented in the TLE format as initial data.

The electrodynamic modelling of netted linen

Osman Sh Dautov¹,³, Anatoly G Romanov², Evgeny N Golovenkin², Vladimir A Skachkov¹ and Alexander K Shatrov²

¹ Kazan National Research Technical University, Kazan, 420111, Russia
² JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia

E-mail: dautov_kstu@mail.ru

Abstract. In this work, we used the method of volume integral equations (CLI) to build a model of grid structures. The method allows to calculate the reflection and transmission coefficients, the losses in the reticle, taking into account the conductance of the fabric thread and its coating.

Variable neighbourhood search algorithm for k-means clustering

V I Orlov¹, L A Kazakovtsev¹,², I P Rozhnov¹, N A Popov¹ and V V Fedosov¹

¹ Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy av., Krasnoyarsk, 660037, Russian Federation
² Krasnoyarsk State Agrarian University, 90, Mira av., Krasnoyarsk, 660049, Russian Federation

E-mail: levk@bk.ru
Abstract. We propose new algorithms of Greedy Heuristic Method for solving the classical problem of cluster analysis, k-Means, which allows us to obtain results with better objective function values in comparison with known algorithms such as k-Means and j-Means. Their comparative efficiency is proved by experiment on various data sets including multi-dimensional data of non-destructive rejection tests of electronic components for the space industry.

SECTION 2. MECHANICAL ENGINEERING AND INDUSTRY

A description of the interface interaction model of specialized information and software of the distributed automated process control systems

I V Kovalev¹,²,³, V V Losev², M V Saramud², D I Kovalev²,⁵* and G D Voskoboinik⁴

¹ Siberian federal university, 79 Svobodny avenue, Krasnoyarsk, 660041, Russia
² Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochny Av., Krasnoyarsk, 660037, Russia
³ Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations, 61 Uritskogo street, Krasnoyarsk, 660049, Russia
⁴ Xingtai University, 3 Shizhuan Street, Qiaodong, Xingtai, 54001 Hebei, China

*E-mail: grimm7joW@gmail.com

Abstract. The analysis of the possibility of a revision of the algorithmic entity interface interaction was completed by authors. The algorithmic entity interface interaction is considered as technologies for organizing specialized information and software for automated process control systems. In the frame of an inertia reduction of interaction of the heterogeneous environment components of an automatic controlling system of the technological process, the paper is suggested for some ways to increase the capacity of the interaction interface of the systems. One of this is the organization of a connections pool based on the iterative calculations of the developed transaction formation approach.

A method of measuring the depth of the penetration channel during electron-beam welding

A A Druzhinina¹, V D Laptenok², A V Murygin² and V E Petrenko²

¹ Siberian Federal University, 79, Svobodniy Av., Krasnoyarsk, 660041, Russian Federation
² Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochny Av., Krasnoyarsk, 660037, Russian Federation

E-mail: druzhininasasha@gmail.com, avm514@mail.ru

Abstract. Penetration depth control is an important scientific and technical problem and the quality of welded joints largely depends on its solution. A mathematical model of the method of measuring the depth of the penetration
channel during electron-beam welding has been developed. In order to determine the depth of penetration, the thickness of the solid metal under the keyhole produced by an electron-beam is measured. The measurement method is based on the use of X-ray radiation from the processing zone. The use of harmonic components of the signal, which are multiples of the scanning frequency, is a distinctive feature of the presented mathematical model of the X-ray sensor to monitor the thickness of the solid material under the cavity.

**Alkali silicate protective coatings**

L N Nazharova, G G Mingazova and R S Saifullin

Kazan national research technical university, Kazan, Russia

E-mail: mingazova_gg@mail.ru

**Abstract.** The work has developed compositions of coatings based on alkali silicate. The influence of the composition of the mixtures on the drying process, resistance to temperature changes, the characteristics of the coating (adhesion, time and degree of drying, solubility in water) were studied. It has been established that the replacement of liquid glass with sodium metasilicate in the composition of the coating improves the characteristics of the coatings.

**Analysis and design of pressure sensors for micromechanical integrated pressure sensors**

M E Kalinkina, A S Kozlov, R Y Labkovskaia, O I Pirozhnikova and V L Tkalic

Faculty of information technology security, ITMO University, St. Petersburg, Russian Federation

E-mail: Mariia_Kalinkina@mail.ru

**Abstract.** Accelerometers, pressure sensors and gyros have good prospects for the future among the wide range of micromechanical instruments that are developing most dynamically. The paper describes the modified version of the design of the pressure sensitive element created by the author with improved metrological characteristics and increased accuracy rates.

**Analysis of the intellectual interaction of mechanical autonomous systems**

A V Lekanov¹, I V Kovalev²³⁴⁵, F K Sin’kovsky¹, A D Leonenkov¹, M V Karaseva³ and S A Borisov³

¹ JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia
² Siberian federal university, 79 Svobodny avenue, Krasnoyarsk, 660041, Russia
³ Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia
Abstract. A variant of synchronous systems interaction is developed. When the hierarchy of interaction between autonomous systems is introduced, the stages of the collective decision making process are highlighted. This ensures the selection of the best solution for its implementation.

Application of imitation modelling means to create digital twins of the Industry 4.0 company technological equipment

D A Zakoldaev¹, A V Gurjanov², D R Kochubey¹ and I O Zharinov¹

¹ Faculty of Information Security and Computer Technologies, Saint Petersburg National Research University of Information Technologies, Mechanics and Optics, 49, Kronverksky Av., Saint Petersburg, 197101, Russia

² Stock Company «Experimental Design Bureau «Electroavtomatika» named after P A Yefimov, 40, Marshala Govorova St., Saint Petersburg, 198095, Russia

E-mail: mpbva@mail.ru

Abstract. The task is being studied how to project digital twins of technological equipment in the example of remote control model computer model software realization. Digital twins of technological equipment are infrastructure components of production companies of the Industry 4.0 functioning in the level of cloud services. Technological equipment access to cloud services is done with protocols of the Internet of Things with guaranteed delivery of packages. The production technological equipment interacts in the level of physical devices and the level of virtual models (digital twins) which is a cyber and physical system. The results are given after a practical experience of designing and a research of a digital twin of the remote control which supports the internet protocol of TCP/IP made with LabView software.

Artificial aging of hard-alloy cutting tool with titanium diffusion coating as a way to increase its persistence

A G Sokolov, L I Svistun, R L Plomodyalo and E E Bobylyov

Kuban state technological university, 2A Moskovskaya street, Krasnodar, 350072, Russia

E-mail: ebobylev@mail.ru

Abstract. The paper describes the technology of applying titanium diffusion coating to the cutting tool from low-melting liquid metal solutions. The results of thermal treatment of the carbide cutting blades (WC and TiC type) after titanium diffusion coating from low-melting liquid metal solutions are given. The results of thermal treatment influence on the firmness of cutting tool having titanium
coating are shown. It is found out that thermal treatment temperature, its duration and material composition influence affect tool durability and coating micro-hardness. It is revealed that thermal treatment of the carbide instrument with titanium diffusion coating lets to increase its persistence by 1.79 times comparing to the tool without coating. But without thermal treatment persistence of the instrument with coating increases by 9 times in comparison to the tool without coating.

Automated process control quality improvement of technical systems electrochemical protection

Anatoly Yastrebov¹, Alexander Konovalov¹, Vladimir Sulaberidze¹ and Victor Balashov²

¹Federal state autonomous educational institution of higher education «St. Petersburg State University of Aerospace Instrumentation» 67, Bolshaya Morskaya str., Saint Petersburg, 190000, Russia
²Joint-stock company «Research and Production Enterprise «Radar mms» 37, lit. A, Novoselkovskaya str., Saint Petersburg, 197375, Russia

E-mail: balashov_viktor@mail.ru

Abstract. The article deals with the issues of quality improvement at the life cycle stages of means of automated monitoring of electrochemical protection of technical systems. The possibility of production of automated control facilities with robustness properties in relation to changes in external influences and environmental conditions is considered, which improve the quality of the process of electrochemical protection of technical systems. The article considers the stages of the process of designing the means for automated control of the electrochemical protection process. A set of local criteria for the formation of an integral quality criterion for solving the problem of choosing the optimal options for the location of the means for automated control of the electrochemical protection process is determined.

Basic requirements and principles for the compensation system development

E N Golovenkin¹, A K Shatrov¹, J O Badanina¹, E I Badanin¹, I V Kovalev²,³,⁴ and M V Karaseva⁵

¹JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia
²Siberian federal university, 79 Svobodny avenue, Krasnoyarsk, 660041, Russia
³Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia
⁴Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations, 61 Uritskogo street, Krasnoyarsk, 660049, Russia
⁵E-mail: secret398@mail.ru
Abstract. The paper considers the development and logic of disclosure of the transformable antennas of the spacecraft. The key requirements and principles of the compensation weight component are outlined. The necessity to compensate the weight component in the assembly and testing of the design is identified.

Calculating the geometric parameters of the distribution of electron beam energy density on its section in EBW

A N Bocharov, A V Murygin and V D Laptenok
Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russian Federation
E-mail: sibalexbo@gmail.com

Abstract. The article considers various ways of calculating the diameter of an electron beam. Analysis of the energy density distribution curves in the cross section of the electron beam shows that they differ from the normal law. In view of this, a method is proposed for calculating the width of the distribution of energy density in the cross section of an electron beam, considering the shape of the distribution curve. The method is based on calculating the entropy of the distribution. The method of calculating the width of the distribution according to the probe characteristics is considered.

Characterization of microrelief forming on the hardened steel surface with ultrasonic reinforcing burnishing processing

Sergey Grigoriev1, Aleksandr Selivanov2, Igor Bobrovskij2,3,5, Aleksandr Dyakonov4,5 and Igor Deryabin4

1 Moscow State Technological University Stankin, Moscow, Russian Federation
2 Togliatti State University, Togliatti, Russian Federation
3 Samara National Research University, Samara, Russian Federation
4 South Ural State University, Chelyabinsk, Russian Federation
5 Mechanical Engineering Research Institute of the RAS, Moscow, Russian Federation

E-mail: bobri@yandex.ru

Abstract. The numerical surface characterization makes it possible to compare two different machining technologies. Ultrasonic is one of the actual additional physical effects imposed during the processing. The article presents a comparison of surface topography after burnishing processing with and without ultrasonic. Workpieces made of hardened steel, ultrasonic frequency 22 kHz. It was discovered that the surface has a plastically deformed ordered structure after processing with ultrasonic vibrations.
Crystallization of aluminium alloys under pressure

V F Korostelev and M S Denisov*

Vladimir State University named after Alexander and Nikolay Stoletovs, 87 Gorkogo street, Vladimir, 600014, Russia

*E-mail: denisovmaxim90@mail.ru

Abstract. The paper presents the results of experimental studies helping to reveal the laws of the crystallization process of aluminium alloys under conditions of imposing pressure, reaching 300-400 MPa, ensuring the formation of a structure without shrinkage defects and an increase in density. Practical recommendations are given for automation of pressure overlay control and for creating metallurgical mini-productions based on a new process.

Dependent failure in multifunctional automatic control systems

A S Degtyarev¹, V I Usakov¹,⁵, P A Kuznetsov³, I V Kovalev²,³,⁴ and M V Karaseva²,³

¹ JSC "Central Construction Bureau “Geofizika”, 89 Kirenskogo street, Krasnoyarsk, Russia
² Siberian federal university, 79 Svobodny avenue, Krasnoyarsk, 660041, Russia
³ Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia
⁴ Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations, 61 Uritskogo street, Krasnoyarsk, 660049, Russia
⁵ E-mail: usakovvl@mail.ru

Abstract. The paper considers the components interference of the automated control system. The safety and survivability are investigated. The failure gradation is given. The failure consequences of components and modules of the system that cause failures of other components and modules, the capabilities to prevent these failures are considered. Some probable variants of the dependent failures are provided. It is shown that a possible source of danger can be both module failure and failure of redundant components in these modules. It is assumed that at least the potential danger is not reduced to zero due to the increase in the number of redundant components. The various logical structures of the compound components in the automated control systems (ACS) for spacecraft are discussed. A typical structure of reliability of the automated control system that performs several functions, i.e. a tree structure is presented. The process of failures development in multifunction systems, the mutual influence of components in case of simple linear and branching redundant structures are illustrated. The negative effects of redundancy are considered. An example of the reliability calculation of the system with a parallel connection of the components and their dependent failures caused by these components are given. The conclusion about the necessity of non-redundant methods for improving the reliability and dangerous impact prevention is made.
Designing high-speed CNC-operations

A Kh Nurkenov, V I Guzeev, P G Mazein and I P Deryabin
South Ural State University, 76 Lenin prospect, Chelyabinsk, Russia

E-mail: nurkenovak@susu.ru

Abstract. The research considers the technique of cycle's parameters calculation for high-speed operations on CNC machines. The methods of calculating the technological limits are developed to ensure the accuracy and surface quality requirements with regard to technological capabilities of the grinding's equipment and tools. It was determined that the performance of the designed cycle directly depends on the technological system stiffness and number of cycle steps depends on the stiffness of the technological system. The technique is invariant and works either when all the limits exist or some of them. Consequently, the calculation of limits will be performed in dependence on the design environment for each specific machining conditions.

 Determination of installation sites for anti-adhesive devices on the bucket of an EK-18 excavator

S A Zenkov
Bratsk State University, 40, Makarenko St., Bratsk, 665709, Russia

E-mail: mf@brstu.ru

Abstract. 3D rigid-body model of a bucket of power shovel EK-18 was built using modern CAD-software. A tetrahedral grid with 10-node second-order elements was chosen, and the given model was imported to APM WinMachine - model preparation preprocessor for finite element analysis. A finite element model was based on the geometrical model, imported from KOMPAS-3D to APM Studio. Calculation of stressed-strained state of the bucket was carried out under the forces emerging while digging with “back hoe” equipment. Shift, deformation and tension charts were planned and the most and the least strained areas were pointed out. Wet coherent soil excavation deals with soil adhesion to working bodies of power shovels and leads to reduced performance. Performance decrease is caused by reduction of useful bucket capacity and partial unloading, increased front resistance to cutting (digging) caused by wet soil adhesion to a working body, increased bucket entry resistance, increased idle time caused by necessity to clean working bodies. Also energy losses increase and quality of work drops because friction forces go up. Friction force while digging and levelling account for 30…70 percent of total digging resistance while performance decreases 1.2…2 times and more. However, the question of actuators location on the excavator bucket needs to be dealt with. The most suitable spots for mounting devices for reducing soil adhesion to the excavator bucket were defined. Such devices eliminates soil adhesion to bucket and increases efficiency of using power shovels with wet coherent soils.
Determination of reliability of working position with rigid inter-aggregate relation

Sergey Grigoriev¹, Boris Gorshkov², Nikolai Bobrovskij³, Igor Bobrovskij⁴,⁵ and Natalya Samokhina²

¹ Moscow State Technological University Stankin, Moscow, Russian Federation
² Volga Region State University of Service, Togliatti, Russian Federation
³ Togliatti State University, Togliatti, Russian Federation
⁴ Samara Scientific Center of the Russian Academy of Sciences, Samara, Russian Federation
⁵ E-mail: bobri@yandex.ru

Abstract. Machine-building enterprises implement the methods of operative transition from one nomenclature of production to another for preservation of competitiveness. The strategy of scientific and technological development of Russian Federation reflects this aspect in the form of one of the priorities: digitalization. One of the most time-consuming processes is the reconfiguration of automatic mass production lines. These lines consist of a number of working positions. The relation between units in mass production is rigid and inter-operational reserves are absent. Stopping one unit is equivalent to stopping the whole line. Therefore, the task of the time estimation of line’s operability of this type is relevant. The task is complex and requires consideration of many factors. This article presents a constructive scheme for reliability. The calculation of work and reliability indicators are carried out. The calculation of the reliability of positions with rigid inter-aggregate relation made it possible to obtain reliability indicators for the second line of development of recomposed work positions with automatic change of nodes. In this case, the rigid relation is not violated. In this calculation the probability of failure due to the simplicity the proposed nodes design was not taken into account.

Device for measuring the electrical conductivity of a flame for the diagnosis of the combustion process in an ICE with spark ignition

Natalya Smolenskaya¹, Igor Bobrovskij¹,²,³, Victor Smolenskii¹, Nikolaj Bobrovskij¹ and Aleksey Lukyanov¹

¹ Togliatti State University, Togliatti, Russian Federation
² Samara Scientific Center of the Russian Academy of Sciences, Samara, Russian Federation
³ Email: bobri@yandex.ru

Abstract. In this article the influence of the measurement system, such as material of the sensor electrodes, their location and their contact area with the combustion zone and also the characteristics of the electric field on the character of the flame’s electrical conductivity signal are considered. The impact of various engine performance parameters on the electrical conductivity of the flame was evaluated and the interrelation of the electrical conductivity characteristics with propagation conditions of the flame front in the sensors’ location area is shown. The influence of the fuel composition on the propagation conditions of the flame front and on its
electrical conductivity is shown. Critical analysis of problems and questions of using the flame conductivity measurement system for the combustion process diagnostics in an ICE with spark ignition is carried out.

**Device for monitoring the temperature and diameter of an extended cylindrical object in the high-temperature manufacturing process**

Alexander Tomashuk
Igor Sikorsky Kyiv Polytechnic Institute, Kyiv, Ukraine

E-mail: tomashuk.alexander@gmail.com

Abstract. The paper describes a method and a device for monitoring the temperature and diameter of an extended cylindrical object in the high-temperature manufacturing process, such as hot rolling, die-less drawing, etc. The proposed integrated approach based on optical phenomena, such as Fresnel diffraction, makes it possible to monitor parameters of the heated object both on a focused and a defocused image with high measurement accuracy.

**Diffusion saturation from fusible liquid metal media solutions by titanium of TK and WC-Co alloys as way to increase of tool durability**

E Bobylyov
Kuban state technological university, 2A Moskovskaya street, Krasnodar, 350072, Russia

E-mail: ebobylev@mail.ru

Abstract. The technology of applying titanium diffusion coatings on cutting tools of medium of fusible liquid-metal solutions has been describe. The results of research of process of heat treatment of carbide inserts of type WC-8%Co and TC after diffusion tianation from medium of fusible liquid-metal solutions has been describe. The results of influence of heat treatment of the cutting tool with diffusion titanium coating to its durability has been describe. It founded that the wear resistance of the tool and the microhardness of the coating influenced by the temperature of heat treatment and its duration, and the composition of the coated material. It is established that thermal treatment of carbide tools, the diffusion of titanium has a coating, allows to increase its durability in 1,5-2 times compared to the coated tool, but without heat treatment, relative to the tool without coating, durability is increased 7 times.

**Engineering of the knife grinding machine milling process**

Sergey Vikharev
Ural State Forest Engineering University, Siberian tract, 36, Ekaterinburg, 620100, Russia

E-mail: cbp200558@mail.ru
Abstract. The paper investigates milling process in knife grinding machines. Engineering process of these machines involves determining a degree of knife garniture wear as well as rotor and stator misalignment without the stop of the machines. To find these parameters a series of experimental researches were conducted at the enterprises of the industry. Vibrating diagnostics methods are the most informative ones for exploiting engineering of the knife grinding machine milling process. Methods of determining a degree of knife garniture wear and rotor and stator misalignment without the stop of the machines are protected by patents of the Russian Federation. Use of the developed methods and means by support and diagnostic team specialists at the enterprises increased the efficiency of the engineering process of knife grinding machine milling. Proposed methods can be used in other businesses, for example, in mining and steel industries.

Estimating safety of a tractor cab with the protective system ROPS

I P Troyanovskaya\textsuperscript{1,2}, S I Serov\textsuperscript{3}, E I Kromskij\textsuperscript{1} and D V Kozminych\textsuperscript{1}

\textsuperscript{1} Department of Automobiles and Crawler Vehicles, South Ural State University, Chelyabinsk, Russia
\textsuperscript{2} Department of Applied Mechanics, South Ural State Agrarian University, Troitsk, Russia
\textsuperscript{3} Scientific and educational center of Energy and resource-efficient technologies in diesel engine building for armored vehicles and engineering vehicles, South Ural State University, Chelyabinsk, Russia

E-mail: tripav63@mail.ru

Abstract. The safety of the cab is an important requirement in the certification of the tractor at present. Roll-over protective structures (ROPS) protects the driver when the tractor is overturned. The safety assessment of the protective system ROPS is carried out on the basis of real tests in accordance with the requirements of GOST. Computer programs allow you to conduct safety assessments using the calculation method. The article presents a mathematical model of the protective structure of the ROPS of the industrial tractor B10. The finite element method has confirmed the safety of the ROPS protection system for a tractor weighing up to 25 tons. The deformation energy of 40 867 joules is achieved with a displacement of 261 mm and a lateral force of 229 kN. The magnitude of the lateral force in a real experiment differs from the calculated value by less than 4 %.

Expansion of technological capabilities of the laboratory unit for determining the longitudinal stability of rods

E V Shirokikh, T D Dikova, O B Shirokikh, E A Smirnova, O A Pogodina\textsuperscript{*}

State Educational Institution of Higher Education of Moscow Region «State University of Humanities and Social Studies», Kolomna

\textsuperscript{*}E-mail: olakolomna@yandex.ru

Abstract. Creation of educational laboratory equipment with high operational efficiency associated with improving the use of the installation by increasing the
accuracy and increasing the convenience of measuring as well as fixing when conducting experimental research, expanding its functionality and improving the accuracy of measuring parameters to implement a wider range of studies.

**Experimental stand for the study of cavitation flow regimes**

**Vladimir A Kulagin, Alexander U Radzyuk, Elena B Istyagina and Tatyana A Pianykh**

Siberian federal university, 79 Svobodny avenue, Krasnoyarsk, 660041, Russia

E-mail: d327@mail.ru

**Abstract.** The urgency of the flow regime determining is related to its effect on the hydraulic, power and performance characteristics of the equipment. The article describes an experimental stand for investigating of the cavitation processes. The technical capabilities of the experimental installation for determining cavitation modes of process fluids are investigated. A number of experiments were conducted with technical tap water, which allowed to confirm the reliability of the obtained results by comparing them with the literary values.

**Features of the holes formation by counterboring tool**

**I P Deryabin and V G Shalamov**

South Ural State University, 76 Lenin prospect, Chelyabinsk, Russia

E-mail: deryabinip@susu.ru

**Abstract.** The article discusses the process of shaping holes with three-bladed counterboring tools, taking into account the inaccuracies of sharpening the cutting part and feed fluctuations arising due to axial beats of the machine spindle. The shaping schemes have been constructed, equations have been derived for calculating the areas of cut-off allowance sections for which the radial cutting forces are calculated. A comparison obtained by mathematical dependencies and in the scale model in a three-dimensional modeling system for the values of the cut section areas was made. Vector sum of radial cutting forces allows to determine the point’s coordinates of the resulting surface, which can determine the parameters of machining accuracy.

**Formation of a complex part surface at the micro level during milling**

**N A Chemborisov, I D Sokolova¹ and I K Ustinov**

Kaluga branch of Bauman Moscow State Technical University, 2 Bagenov street, Kaluga, 248000, the Russian Federation

¹E-mail: iren.d.sokolova-2013@ya.ru

**Abstract.** The article discusses formation aspects of micro irregularities (roughness) on a screw surface by a designed cutting tool (disk milling cutter). The cutting process is affected by various factors of a random nature: fluctuations
of the removed allowance due to deviations of the surface shape of the workpiece, grain hardness, heterogeneity of the metal structure, microvibration. The amount of asperities in the machined surface depends on the cutting conditions and the geometrical parameters of the cutting tool. The question of predicting the formation of roughness is of great practical importance in the preparation of the technological process of manufacturing parts with a helical surface. To ensure the required amount of microroughness when milling the screw surface of the workpiece, a technique has been developed that allows controlling the roughness due to the discreteness of the cutting process: the main cutting edge of the tool leaves its mark in the form of roughness comb. Modelling is performed on the basis of an invariant method of profiling the cutting tool.

Formation of the diffusion barrier at the interface of Cr20Ni80 alloy - Ni-Cr-Al coating

V G Shmorgun, A I Bogdanov, A O Taube and L M Gurevich
Department of Materials Science and Composite Materials, Volgograd State Technical University, 28 Lenin Avenue, Volgograd 400005, Russian Federation

E-mail: mv@vstu.ru

Abstract. The effect of thermal influence conditions on the structure and chemical composition of the self-organizing diffusion barrier formed during high-temperature (1100 °C) long-term (up to 500 h) heating between the Cr20Ni80 alloy and the coating of the Ni-Cr-Al system is investigated. It is shown that the formation of a barrier, which is a Cr(Al) solid solution of variable composition, is due to the limited solubility of Cr in Ni aluminides. It is established that the growth of the thickness of the diffusion barrier is mainly due to the alloy Cr20Ni80, and the intensity of its growth and the content of chromium in it are determined by the temperature and time conditions of heating. With a diffusion barrier thickness of 55-60 μm, its further growth is stopped by blocking the diffusion flux of Ni from the alloy Cr20Ni80 into the coating.

Heat exchange numerical modelling while cooling a high-temperature metallic cylinder by water and air medium flow

S S Makarov and M Y Alies
Udmurt Federal Research Center of the Ural Branch of the Russian Academy of Sciences, 34, T Baramzina Street, Izhevsk, 426067, Russia

E-mail: ssmak15@mail.ru

Abstract. The results of numerical modeling of heat transfer during the cooling of a metal cylinder by a stream of water-air medium in a vertical annular channel are presented. The results are obtained on the basis of the mathematical model of the conjugate heat transfer of the water-air medium flow and a metal cylinder in a two-dimensional nonstationary formulation, taking into account the axisymmetry of the cooling medium flow with respect to the longitudinal axis of the cylinder. To solve the system of differential equations, the control volume method is used.
The flow field parameters are calculated by the SIMPLE algorithm. For the iterative solution of linear algebraic equation systems, the Gauss-Seidel method with lower relaxation was used. The results of calculating the heat transfer parameters for cooling high-temperature metal cylinder by a stream of a water-air medium stream are obtained taking into account the evaporation. The values of a metal cylinder temperature are determined when cooled by a laminar flow medium. The intensity of the change in the cooling rate of the cylinder is analyzed depending on the proportion of air in the liquid and the time of the cooling process.

Implementation of the design concept of a high-speed processing cycle for CNC machines in the form of a software module CAM-system

L V Shipulin¹ and A Kh Nurkenov and P G Mazein
Department of Automation Engineering, South Ural State University, 76, Lenin Avenue, Chelyabinsk, 454080, The Russian Federation

¹ E-mail: shipulinlv@susu.ru

Abstract. In this paper, the authors considered the factors of the technological system that affect the performance of high-speed operation, and formulated recommendations for designing high-speed operations on CNC machines, as well as the directions for automating calculation data based on CAM systems.

Influence evaluation of the tow ship oscillation on the towed system motion

N N Kamaletdinov, A L Gusev and E S Golovina
Department for Aircraft Design and Construction, Kazan National Research Technical University named after A.N. Tupolev – KAI, 10 Karl Marx str., Kazan, Republic of Tatarstan, 420111, Russian Federation

E-mail: n_levshonkov@mail.ru

Abstract. Influence of the tow ship oscillation on the value of hydrodynamic force, acting on the towed system at different tow speeds is considered. Influence of tow speed on running depth is shown. Based on computational studies, an estimation of the effect of the ship-towing pitch on the movement of the towed system was carried out.

Influence of the electrolysis mode on corrosion resistance of metallic coatings

S Yu Kireev, Yu P Perelygin and S N Kireeva
Penza State University, Faculty of Machine Building and Transport 40, Krasnaya street, Penza, Russia

E-mail: Sergey58_79@mail.ru
Abstract. Research has been carried out to determine the dependence of corrosion resistance of galvanic zinc and nickel coatings, formed from acid electrolytes with addition of lactic acid, on the electrolysis mode. It is shown that the galvanostatic mode of pulse electrolysis makes it possible to obtain coatings having improved corrosion resistance in the moisture chamber and neutral salt spray. Corrosion resistance of coatings was assessed by changing of the transient electrical resistivity values before and after accelerated corrosion tests. Coatings formed using potentiostatic pulses of rectangular shape are of higher corrosion resistance, which is explained by the positive effect of pulse electrolysis modes on the morphological features of galvanic sludge, and is confirmed by the results of atomic force microscope (AFM) studies.

Influence of ultrasonic burnishing on the durability of the burnisher

Sergey Grigoriev¹, Aleksandr Selivanov², Nikolai Bobrovskij²–⁵, Aleksandr Dyakonov³,⁴ and Petr Mazein³

¹ Moscow State Technological University Stankin, Moscow, Russian Federation
² Togliatti State University, Togliatti, Russian Federation
³ South Ural State University, Chelyabinsk, Russian Federation
⁴ Mechanical Engineering Research Institute of the RAS, Moscow, Russian Federation
⁵ E-mail: bobrnm@yandex.ru

Abstract. The group of surface plastic deformation technologies includes a well-known burnishing technology. Adding the effects of ultrasonic vibrations to the process allows to obtain a certain topography of surface. However, the process of interaction between the tool and the part during processing redistributes the occurrence of wear centres on the tool’s surface. The article also describes the effect of cavitation of lubricoolant agents on the resulting defects on the tool’s surface. It was concluded that it is necessary to use an impact-resistant material for processing by ultrasonic burnishing technology.

Laser-aided direct metal tooling of manufacturing aviation details on CNC machine

P Ogin¹, D Levashkin¹ and F Vasilyev²

¹ Togliatti State University, 14, Belorusskaya St., Togliatti, Russian Federation
² Moscow Aviation Institute (National Research University), 4 Volokolamskoe shosse, Moscow, 125993, Russian Federation

E-mail: LevashkinD@gmail.com, laser.163@yandex.ru, fedor@niit.ru

Abstract. This paper discusses the effectiveness of the use of hybrid technology based on Laser-aided Direct Metal Tooling with subsequent machining as an alternative to traditional methods for producing products of a complex profile for the aviation industry. The aspects of the application of Laser-aided Direct Metal Tooling in the production cycles of manufacturing products passing through the final assembly operations are considered. The paper proposes an alternative
manufacturing technology through the use of Laser-aided Direct Metal Tooling at the stage of design and technological study of the manufacturing cycles of individual assembly units. The objective function of ensuring high requirements for the accuracy of the relative position of the part in the assembly, reducing the mass and dimensions of the product, which is important for modern aviation systems. A technological solution is proposed to provide technical indicators of the objective function based on combining the advantages of laser, hybrid, and additive technologies in the working area of technological equipment. Considered technical solutions for the implementation of the proposed hybrid technology in the manufacture of critical parts of the aviation industry. The aspects of the production of parts are considered from the point of view of reducing the error in the relative position of the actuating surfaces of the product, an analysis is made of the machining errors in the process of the proposed production technology, with respect to the errors arising from traditional production cycles of parts of this type.

**Method of forming means for monitoring the process of electrochemical protection of pipeline systems**

Alexander Konovalov¹, Artemy Varzhapetyan¹, Anatoly Yastrebov¹ and Victor Balashov²

¹Federal state autonomous educational institution of higher education «St. Petersburg State University of Aerospace Instrumentation» 67, Bolshaya Morskaya str., Saint Petersburg, 190000, Russia
²Joint-stock company «Research and Production Enterprise «Radar mms» 37, lit. A, Novoselkovskaya str., Saint Petersburg, 197375, Russia

E-mail: balashov_viktor@mail.ru

**Abstract.** The current issue of ensuring the quality of electrochemical protection processes by developing and selecting options for the location of control, measuring and automation equipment for multiparameter and multichannel systems using pipelines as an example is considered in the article. The possibility of use the Mahalanobis-Taguchi provisions, as well as the Mahalanobis metric, to select the basic version of the location of monitoring facilities is described. The stages of diagnostics of possible options for the location of control, measurement and automation equipment for pipeline systems are determined.

**Methods of assessment of modernization of the tractor Belarus 922 to work on ethanol-containing fuel**

Sergey Plotnikov, Yury Lanskikh and Mikhail Smol’nikov

Vyatka State University, Kirov, Russia

E-mail: lyuv@inbox.ru

**Abstract.** The relevance of this work is due to the need to reduce environmental damage from the use of diesel engines, which can be achieved using alternative fuels. The aim of the work is a technical and economic analysis of the ecological
efficiency of the use of ethanol-fuel emulsions. The work was carried out using a standard methodology for determining the economic efficiency of implementing environmental measures and assessing economic damage. The authors made an integrated assessment of the hazard of exhaust gases as a sum of hazard categories of substances included in these gases. The economic efficiency of using ethanol-fuel emulsion with 40% ethanol was calculated. Moreover, the authors performed a calculation and a comparative assessment of the ecological class of diesel fuel and ethanol-fuel emulsion. Based on the results of the research, conclusions were drawn on reducing the amount of harmful substances (carbon monoxide, carbon dioxide, nitric oxide, and soot particles) in waste gases using an ethanol-fuel emulsion and the economic effect of this solution. Using ethanol-fuel emulsion in the work of the tractor makes it possible to reduce the criterion of the environmental hazard of exhaust gases by more than 6 times and obtain an annual economic benefit from reducing the environmental hazard to 8500 rubles. The results of the research can be applied to developing alternative fuels which are used further in diesel engines in various sectors of the national economy.

Model for stationary turn of an arbitrary vehicle

I P Troyanovskaya\textsuperscript{1,2} and S A Voinash\textsuperscript{3,4}

1 Department of Automobiles and Crawler Vehicles, South Ural State University, Chelyabinsk, Russia
2 Department of Applied Mechanics, South Ural State Agrarian University, Troitsk, Russia
3 Department of Land Transport Systems, Rubtsovsk Industrial Institute (Branch) of Polzunov Altai State Technical University, Rubtsovsk, Russia
4 E-mail: sergey_voi@mail.ru

Abstract. The authors of the article propose a block-modular approach to constructing a mathematical model of stationary rotation of an arbitrary vehicle. This new method allows us to describe the curvilinear motion of a machine with any number of wheels and the type of transmission. Unknown ground reactions (driving force, shear force and stabilization moment in the wheel-to-ground contact) are functions of unknown coordinates of the instantaneous slip centre. The connection between the problem of force and the kinematic problem allows us to solve these problems simultaneously. Additional equations of holonomic (geometric) constraints reflect the position of the wheel and its installation angle relative to the vehicle frame. Equations of non-holonomic (kinematic) constraints describe the type of transmission and the way the wheel is moved. The advantage of the proposed approach is the ability to predict the behaviour of the machine during the design phase.

Modelling of electron beam distribution in electron beam welding

Yu N Seregin, A V Murygin, V D Laptenok and V S Tynchenko

Reshetnev Siberian State University of Science and Technology, 31 Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russian Federation
Abstract. The results of mathematical simulation of the electron beam distribution during heating of AMG-6 alloy by moving instantaneous energy sources equivalent to a beam in electron-beam welding are presented in the article. The calculations were carried out using the functional developed by the authors. The paper presents the results of calculations and an algorithm for searching for the optimal technological regime of electron beam welding, which can be recommended for designing electron-beam welding technology for new construction materials or for upgrading old process technology. The results of modeling the technological process for welding a 2.4-cm thick plate made of AMG-6 material, which were compared with the experimental data obtained under laboratory conditions, are presented in this paper.

Modelling of milling processes in knife grinding machines

S N Vikharev¹ and Yu D Alashkevich²

¹ Ural State Forest Engineering University Siberian tract, 36, Ekaterinburg, 620100, Russia
² Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy av., Krasnoyarsk, 660037, Russian Federation

E-mail: cbp200558@mail.ru

Abstract. Knife grinding machines present the basic process equipment for fibrous material grinding in a pulp and paper industry. The article is devoted to research of hydrodynamic processes at milling. The theory of steam dynamics in this machine is considered. Researches with the use of modelling in program environment Ansys fluent are carried out. The results of the researches can be used to design and operate knife grinding machines and similar equipment, for example, in centrifugal pumps.

Non-Newtonian effects of a lubricant flow through a T-shaped microchannel

E R Kutuzova¹, A F Tazyukova²,⁴, F Kh Tazyukov³ and A G Kutuzov²

¹ Control system department, Kazan National Research Technological University, Kazan, K. Marx st., 68, 420015, Russia
² Chemical Cybernetics Department, Kazan National Research Technological University, Kazan, K. Marx st., 68, 420015, Russia
³ Mechanical Engineering Department, Kazan National Research Technological University, Kazan, K. Marx st., 68, 420015, Russia
⁴ E-Mail: Near221291@gmail.com

Abstract. In this paper, the importance of non-Newtonian effects of a lubricant flow through a T-shaped microchannel with a moving lead are investigated. The lubricant flow is represented by Navier-Stokes equation for viscous, incompressible and steady fluid flows. Non-Newtonian characteristics are simulated by FENE-P constitutive equation. Finite Volume method was used to solve the case numerically. PSD distribution for Reynolds number Re=0.01 and
Weissenberg number $\text{We} = 1$ were compared with Newtonian case. Clear numerical evidence of a higher stresses for non-Newtonian case is discussed.

**Optimization model controlling parameters of a roller drilling process based on energy criterion**

A A Shigina\textsuperscript{1}, A O Shigin\textsuperscript{2}, A A Stupina\textsuperscript{1}, S M Antipina\textsuperscript{1} and N N Dzhioeva\textsuperscript{1}

\textsuperscript{1} Department of Economics and Information Technologies of Management, Siberian Federal University, 3 Vuzovsky Lane, Krasnoyarsk, 660025, Russia

\textsuperscript{2} Department of Mining Machines and Complexes, Siberian Federal University, 95 Krasnoyarskiy Rabochiy ave., Krasnoyarsk, 660025, Russia

E-mail: shigina_a@mail.ru

**Abstract.** The article is concerned with development and research of an optimization model controlling parameters of a roller drilling process using correcting values of operating parameters. The optimization model proposes the use of an energy criterion that provides the ratio of performance and drilling bit resource, corresponding to the minimum cost of a roller drilling process. The proposed model allows to determinate the optimal values of the technological process operating parameters, as also the maximum values of the drilling bit resource and performance under the information uncertainty associated with an unpredictable change in the properties of drilled rocks, which is necessary for the effective control of the process parameters under research.

**Principles of construction of the technological system for the manufacture of construction polymer reinforcement**

FA Urazbakhtin\textsuperscript{1}, Yu V Ganziy\textsuperscript{2} and M V Otrishko\textsuperscript{3}

\textsuperscript{1} Department of Rocket Engineering of the Votkinsk branch of Izhevsk State Technical University named after M.T. Kalashnikov, Votkinsk, Russia

\textsuperscript{2} Udmurt Federal Research Center of the Ural Branch of the Russian Academy of Sciences, 34 Tatyana Baramzina str., Izhevsk, 426067, Russia

\textsuperscript{3} JSC “Building Management – 33”, 14/4 Dorogobuzhskaya str., Moscow, 121354, Russia

E-mail: uras_51@mail.ru, ganziy@list.ru, mtosu@mail.ru

**Abstract.** The features of the technological operation of thermosetting the rod of composite reinforcement, which is performed in the polymerization chamber, are considered. Conditions are created to ensure the guaranteed quality of the thermosetting process, which consists in maintaining the stability of the main process parameters for a given speed of rod pulling. These parameters are identical to the set of influence factors recorded during definitive tests of rod samples at the certification of production. The factors influencing the quality of the product, which include 35 parameters of the curing process, are identified. A system for maintaining the stability of the parameters of the curing process, based on creating a forced, adjustable gas-air mixture flow rate and assessing the quality
of the curing process by the heat flux, is proposed. This heat flux is carried by the rod and applicable to industrial conditions on real production lines.

**Resistance to brittle fracture and availability of austenitic steels**

*Boris Ermakov¹, S Vologzhanina², Igor Bobrovskij³, Nikolai Bobrovskij³ and Yaroslav Erisov⁶*

¹ Peter the Great St. Petersburg Polytechnic University, St. Petersburg, Russian Federation
² Saint Petersburg National Research University of Information Technologies, Mechanics and Optics University ITMO, Saint Petersburg, Russian Federation
³ Togliatti State University, Togliatti, Russian Federation
⁴ Samara Scientific Center of the Russian Academy of Sciences, Samara, Russian Federation
⁵ Samara National Research University, Samara, Russian Federation
⁶ E-mail: bobri@yandex.ru

**Abstract.** The paper presents the results of studies on the availability and resistance to brittle fracture of perspective austenitic chromium-nickel-manganese cryogenic steels, depending on the concentration and ratio of the nitrogen and vanadium content. The optimum content of these elements in deformed steels determined, the results of the studies and recommendations on the doping system are confirmed by the results of full-scale tests of low-temperature equipment under internal pressure in liquid nitrogen.

**Simulation of influence of cutting tool’s construction on specific heat energy in processing of bevel gears**

*Nikita Kanatnikov¹,⁴, Nikolai Bobrovskij², Vladimir Tabakov³, Petr Zibrov² and Oleg Drachev²*

¹ Orel State University, Orel, Russian Federation
² Togliatti State University, Togliatti, Russian Federation
³ Ulyanovsk State Technical University, Ulyanovsk, Russian Federation
⁴ Email: nkanatnikov@yandex.ru

**Abstract.** To achieve the required performance characteristics of the bevel gear, optimization of the tooth cutting process is necessary. At the same time, in order to predict the wear of the tool, the quality and accuracy of the processed profile, it is important to understand the course of the thermal processes that occur during cutting. The paper presents the results of a study on modelling the effect of the design of a cutting tool on the thermal phenomena that arise during processing. The standard analysis of temperature fields does not allow determining the influence of rack and clearance cutting angles on thermal processes, other characteristics of the heat exchange process are considered in the work: heat flux and specific thermal energy. The basis for the work was the new mathematical model. The model developed by the authors represents a set of two different approaches to modelling: analytical and numerical. The developed model makes it
possible to perform a numerical experiment with given conditions that are close to real practical ones.

Specific features of mobile machine reverse movement

A S Pavlyuk, V I Poddubniy and A S Baranov

Altay State Technical University, 46 Lenina avenue, Barnaul, 656038, Russia

Abstract. The study deals with questions related to mobile machine manoeuvring when reversing. When the mobile machine is moving backward kinematics of processing various manoeuvres coincides with kinematics of forward movement. This fact gives the possibility to use analytical dependences obtained when the mobile machine is moving forward to describe reverse movement. To estimate the effectiveness of training mobile machine driving when moving backward both laboratory research using a hardware and software complex and full-scale tests using an automobile were conducted. The process of simulation the driver’s impact on the mobile machine steering system when moving backward is effectively implemented using a hardware and software complex. Maximal discrepancies in the results of theoretical and experimental studies do not exceed 10…15 per cent. The obtained results of experiments with an automobile were close to the results of experiments with hardware and software complex, the divergence was relatively small: from 3 to 9 per cent. This fact confirms the possibility of using the given complex to impart elementary skills of driving a mobile machine when moving backward. To simplify driving a mobile machine when moving backward the method of driving a mobile machine when moving backward was suggested.

Structure and thermophysical properties of polytetrafluoroethylene-aluminum composite materials produced by explosive pressing

N A Adamenko, A V Kazurov, D V Savin and G V Agafonova

Volgograd State Technical University, 28 Lenin avenue, Volgograd, 400005, Russia

Abstract. Metal filled composite materials on the basis of polytetrafluoroethylene (PTFE) are widely used in tribotechnical units of different equipment. Amongst the metal fillers for PTFE, aluminum is the most perspective, it has high thermal conductivity and low density, which is relevant for the aircraft industry. Due to low adhesion of PTFE to metals, the thermal conductivity and strength properties of these CM are low, so it is perspective to use explosive pressing (EP) which provides the conditions for an increase in physical-chemical interaction between CM components. The work researches the influence of EP on the structure, thermal expansion and thermal conductivity of composite materials on the basis of PTFE containing 10 and 30% vol. of aluminum. It has been established that EP, as well as sintering in a closed volume, contributes to a decrease in thermal
expansion and an increase in the thermal conductivity of composite materials, which is connected to structural changes accompanied by an intensification of adhesive interfacial interaction. At the same time, with an increase in aluminum concentration, the efficiency of EP increases due to the increase in the number of contacts between metal particles, as well as the occurrence of an interphase zone, with peculiar properties.

**Study of ZrN-AlN formation solid-phase reaction in a nitrogen atmosphere during microwave heating**

R A Shishkin, V S Kudyakova, A V Chukin and A R Beketov

Rare metals and nanomaterials department, Institute of Physics and Engineering, Ural Federal University, Yekaterinburg, Russia, 620002.

E-mail: roman.shishkin@urfu.ru

**Abstract.** This paper is devoted to the discussion of the experimental results on the solid-phase synthesis of the nitride material ZrN-AlN. A mixture of powders of metallic zirconium and aluminum nitride was heated by means of microwave radiation in a nitrogen atmosphere for 90 minutes. Phase composition by sample volume and electron microscopy of the surface were studied to confirm the solid-phase reaction of zirconium with aluminum nitride. Thermodynamic calculations showed that several possible processes happen at once and lead to the formation of the nitride material ZrN-AlN in a nitrogen atmosphere. Experimental results showed a relatively low content of zirconium nitride (32.8 mol.%) and a significant content of metallic zirconium residues (8.8 at.%) in the upper layers of the sample despite contact with the gas phase. While in the sample volume, the conversion of metallic zirconium to nitride was almost complete (the content is 74.9 mol.%). Experimental observations have shown that, due to microwave heating, the formation of characteristic coral-like growths on the surface of particles with the concentration of chemical impurities, due to the purity of the initial reagents, is evident.

**The integration of automatized systems and cyber and physical equipment of the Industry 4.0 item designing company**

A V Gurjanov¹, D A Zakoldaev², A V Shukalov² and I O Zharinov²

¹ Stock Company «Experimental Design Bureau «Electroavtomatika» named after P A Yefimov, 40, Marshala Govorova St., Saint Petersburg, 198095, Russia
² Faculty of Information Security and Computer Technologies, Saint Petersburg National Research University of Information Technologies, Mechanics and Optics, 49, Kronverksky Av., Saint Petersburg, 197101, Russia

E-mail: mpbva@mail.ru

**Abstract.** The task is being studied how to integrate information structure of an item designing company and its industrial and technological equipment. The main attention is paid to the information structure of an Industry 4.0 company: digital factory, smart factory, virtual factory. They supposed a scheme how to integrate
internal and external components of an ecosystem which are used for project and production processes of an item designing component manufacturing applying digital technologies.

**Wear Resistance of Composite Coatings Based on Iron Alloys**

**J E Kisel**¹ and **G V Guryanov**²

¹ Department of Mechanics, Bryansk State Engineering Technological University, Bryansk, Russian Federation  
² Department of Energy Systems, Bryansk State Agrarian University, Bryansk, Russian Federation  

E-mail: kafseo@bgsha.com, ypk2@mail.ru

**Abstract.** The influence of the volume content of a solid dispersed phase on the coefficient of variation of the microhardness of composite electrochemical coatings is shown. A theoretical model of the description of the relationship between the volume content of a solid dispersed phase and the coefficient of variation of the micro-hardness is given.

**Welded pipe geometry changing during the expanding process**

**D B Frunkin**¹, **L M Gurevich**², **R E Novikov**²,⁴, **A I. Bannikov**², **A G Serov**² and **N A Dyatlov**³

¹Volzhsky Pipe Plant, Volzhsky, Russia  
²Volgograd State Technical University, Volgograd, Russia  
³Promteh, Volzhsky, Russia  
⁴E-mail: NovikovRome@gmail.com

**Abstract.** The simulation of the expanding process of large-diameter welded pipes was carried out. It was shown that a pipe's metal stress-strain state has a significant effect on the value of the final ovality of the pipe ends. The front end of the pipe is expanding under conditions when the entire body of the pipe is non-expanded and this leads to a significant distortion of the shape of the pipe after springback. While the rear end is expanding in conditions when the entire body of the pipe is expanded, whereby the rear pipe end has a smaller ovality.

**Working position with recomposed production systems**

**Igor Bobrovskij**¹,²,⁶, **Boris Gorchkov**³, **Maksim Odnoblyudov**⁴, **Nikita Kanatnikov**³ and **Pavel Melnikov**¹

¹ Togliatti State University, Togliatti, Russian Federation  
² Samara Scientific Centre of the Russian Academy of Sciences, Samara, Russian Federation  
³ Volga Region State University of Service, Togliatti, Russian Federation  
⁴ St. Petersburg Polytechnic University, St. Petersburg, Russian Federation
Abstract. High productivity and flexibility with a different range of production type can be achieved by using the recomposed production systems. These systems combine the advantages of aggregate machines and turning centres due to the design features described in this article. The types of nodes and system elements in the compiled and decompiled state are given. Algorithms and schemes for the functioning of recomposed work stand (RWS) in comparison with the working stand of automatic lines (WSAL) were developed. Equation for determining the average time between failures of the RWS is presented. The visualization of the system element and the scheme of the system element - the intermodular element of locating (IEB) was performed. In the conditions of the actual machine-building production, the accuracy of estimating the economic effect requires the use of robust design models implemented not only in the form of algorithms, but also in programs. In the future, it is planned to develop a special software allowing to determine the reliability of the RWS relative to the stand with a rigid interaggregate relation.

SECTION 3. CYBERNETICS, AUTOMATION AND INFORMATION TECHNOLOGIES

About algorithm of robust nonparametric estimation of regression function on observations

M A Denisov¹, E A Chzhan¹, A A Korneeva¹ and V V Kukartsev¹,²

¹Siberian Federal University, Institute of Space and Information Technologies, Krasnoyarsk 660074, Russian Federation
²Siberian State Aerospace University, Krasnoyarskiy Rabochiy Ave., 31, Russian Federation

E-mail: max_denisov00@mail.ru

Abstract. The field of research presented in the paper is aimed at studying the methods of robust statistics for the modeling of multidimensional processes of discrete-continuous type. The model of the investigated process is constructed using identification methods. In one case, it is used parametric methods of identification where priori information about the object of research is sufficient to build the model accurate within vector of parameters. The second case is specific to lack of priori information. The researchers do not know the structure of the model and represent the object in the form of a "black box", therefore, nonparametric identification methods could be used. The accuracy of models is estimated using a relative error of approximation, which shows how much the model output value corresponds to the output value of the object. The paper proposes a new method of outliers’ detection in the initial sample of observations, which is subsequently used for parametric and nonparametric identification of processes. The developed robust algorithm is applied to both types of models in order to determine in which case accuracy of outliers’ detection is higher. In
addition, the above algorithm is compared with an algorithm based on the interquartile range.

**Activation of phase boundary and current-generating processes in plasma-electrochemical systems**

V A Mamaeva, A K Chubenko, A I Mamaev, E Yu Beletskaya and T A Baranova

National Research Tomsk State University, 46 Lenina avenue, Tomsk, 634050, Russia

E-mail: ch@qwertynet.ru

**Annotation.** This paper reviews and presents the principles for implementing a microplasma fuel cell. Conducting work in this direction can in the long run ensure the creation of low-temperature fuel cells that operate without the use of expensive catalysts, ion-separation membranes and are capable of quickly reaching the operating mode.

**Analysis of spacecraft actuator mechanisms design process using tensor method**

N A Testoedov¹, V I Usakov², V A Levko³, S Yu Piskorskaya³ and V A Bartenev¹

¹ JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia
² JSC "Central Construction Bureau “Geofizika”, 89 Kirenskogo street, Krasnoyarsk, Russia
³ Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia

⁴ E-mail: levko@sibsau.ru

**Abstract.** There is high topicality of more and more complicated systems analysis currently. One of the means to do such analysis is to use Gabriel Kron tensor method. The process of spacecraft driving gear design is analysed by using tensor method. The problematic stages of the process are determined.

**Analytical approaches for analysis of intracardiac bipolar electrograms during atrial fibrillation**

K S Mityagin¹, A P Zaretskiy¹, G A Gromyko² and A P Kuleshov³

¹ Moscow Institute of Physics and Technology (State University), Dolgoprudny, 141707, Russia
² Main Military Clinical Hospital named after N.N. Burdenko, Moscow, 105229, Russia
³ National Medical Research Center for Transplantology and Artificial Organs named after V.I. Shumakov, Moscow, 123182, Russia
E-mail: mityagin@phystech.edu

Abstract. Atrial fibrillation is the most common type of cardiac arrhythmias encountered in clinical practice, in which heart muscles shows chaotic atrial depolarization and uncoordinated contraction. Underlying mechanisms of atrial fibrillation are incompletely understood and widely discussed in the scientific community. The abnormal electrical discharges in atrial repolarization is associated with localized drivers and multiple wavefronts that support the asynchronous heart rhythm. In this paper, a briefly overview of conventional techniques focus on mapping drivers of myocardial fibrillation and their application are discussed. We also introduce a novel mapping algorithm which is aimed to identity features of wavefront propogation and analyze the relative changes of generalized instantaneous dominant frequency calculated from intracardiac recordings. Our clinical trials showed that proposed algorithm provides insightful and useful information about triggered abnormal activity during atrial fibrillation, that potentially can be used for catheter ablation therapy.

Application of the object model in the modelling process of locomotive drive units

D Ya Antipin, V I Vorobyev and S O Kopylov
Rolling Stock, Bryansk State Technical University, 7 50 October Blvd., Bryansk, 241035, Russia
E-mail: adya2435@gmail.com

Abstract. The article deals with the problem of selecting the object model of technical solutions to the mechanical part of the locomotive traction drive. The basis of the accepted model is a concept that considers a technical object as a set of internal elements, external elements of the environment, as well as relations between their sets. The proposed model is adapted for use with modern CAD systems. Approbation of the model is carried out on the example of the synthesis of a rational design of the suspension of the locomotive traction drive, reducing the possibility of self-oscillations. As a result of the use of the proposed model, two patentable variants of the suspension of the locomotive traction drive were created, which solve the problem of reducing the likelihood of self-oscillations of the carriage.

Automation of adjustment stages by high-performance semiconductor converters

M A Grigorev, A A. Gryzlov and V S Katrichek
South Ural State University, 76 Lenina av, Chelyabinsk, Russia
E-mail: grigorevma@susu.ru

Abstract. In this paper, methods of frequency synthesis of semiconductor converter control are proposed, allowing automation of the commissioning stages of high-performance semiconductor frequency converters. Attention is paid to
increasing the reliability of the synthesis of the regulation system using the method of synchronous detection of measured signals. It is shown that the proposed frequency synthesis methods allow us to construct a mathematical model of the object being identified. The proposed generalized methods for the synthesis of current control loops, electromagnetic moment, based on the method of experimental frequency characteristics can be useful for technological objects, which allow the study of frequency characteristics without disturbing the conditions of the process. The proposed method has been quite successfully tested on the example of objects of drilling rigs: electric drive for lifting winch and electric drives for drilling pumps. By increasing the reliability of the synthesis of the current control loops and the electromagnetic torque of semiconductor converters, it was possible to significantly expand the uniform transmission band of the current control loop by about 20%. It is established that an experimental technique for determining the frequency characteristics of CCL has been proposed and tested, which makes it possible to evaluate the capabilities of CCLs of various electric drives and indicates the possibilities for expanding the band of uniform transmission of the frequencies of the CCLs under investigation. On the other hand, the extension of the band of uniform transmission of CCL allows increasing the limiting values of the rotational speed of the motor. This allows you to raise the speed of powerful compressor units without the use of multipliers to 6000 - 9000 rpm.

Developing the model of an automated rotary-cut veneer sorting system

B M Shifrin¹, I V Eliseev¹, V A Sokolova¹, N V Melamed¹ and S A Voinash²

¹ Department of Mathematical Methods in Management, Saint Petersburg State Forest Technical University, Saint Petersburg, Russia
² Department of Land Transport Systems, Rubtsovsk Industrial Institute (Branch) of Polzunov Altai State Technical University, Rubtsovsk, Russia

E-mail: shifrinb@mail.ru

Abstract. The paper suggests an approach to developing the veneer sorting model based on fuzzy logic. Wide implementation and development of automated rotary-cut veneer sorting system is inhibited by the difficulties when creating analytical models. The reasonability of using fuzzy logics for veneer sorting is due to the large number of factors having significant impact, and rich expertise of engineers. The model was built and tested for two main factors: the number of healthy and deformed knots. Further studies shall be aimed at increasing the number of factors considered, collecting statistic and expert information in order to build membership functions for linguistic variables, and forming the base of rules bringing relation between the input and output variables.

Genetic algorithms of physical modelling with postcrossover survival

A S Degtyarev¹, V I Usakov¹, V A Kuznetsov³, I V Kovalev²,³,⁴ and T S Karaseva³

¹ JSC "Central Construction Bureau “Geofizika”, 89 Kirenskogo street, Krasnoyarsk, Russia
Abstract. This paper describes the peculiarities of the system synthesis algorithms realization. The system synthesis algorithms are divided into some categories. They are divided according to the synthesized system as algorithms of the mathematical models synthesis and algorithms of physical models synthesis. Mathematical modelling is a setting process of the corresponding mathematical object (a mathematical model) to the real object. In physical modelling a real investigated system is replaced by another fitting physical model reproducing properties of the model that keeps its physical nature. Applying randomness and probabilistic processes the algorithms can be divided into stochastic and deterministic algorithms. A deterministic algorithm is an algorithm with the strictly defined rules. The deterministic algorithms involve all the determined rules. Stochastic algorithms have some uncertainty and use random values at some stage of its functioning. The choice of the algorithm depends on the problem’s requirements.

Method of intellectualization for geospatial processes control systems

Yan Ivakin¹, Sergey Michurin¹, Vladimir Sulaberidze¹ and Valeriy Lipatnikov²

¹ Federal state autonomous educational institution of higher education «St. Petersburg State University of Aerospace Instrumentation» 67, Bolshaya Morskaya str., Saint Petersburg, 190000, Russia
² Federal state military educational institution of higher Education «Marshall of the Soviet Union S.M. Budenny Military academy of communication» 3, Tikhoretskiy pr., Saint Petersburg, 194064, Russia

E-mail: yan_a_ivakin@mail.ru

Abstract. Modern means of management intellectualization or dispatching of geospatial processes do not allow to take into account quickly and with sufficient degree of adequacy the changing properties of the natural environment that affect the managerial decisions made in dispatching by complexly distributed sets of geospatial processes. At the same time dispatching is the final manifestation of a multifaceted process of managing geospatial processes. Traditionally, the task of managing objects implementing geospatial processes is solved in isolation from the current state of the natural environment of their flow, without taking into account the variability of its radio technical, physical and other characteristics. Only issues of changes in navigational and meteorological conditions, as well as issues related to ensuring spatial security, are subject into account. Considerable interest in modern conditions presents a more complex variant of the problem of intelligent dispatching of spatial processes: when the variability of the
environment determines unique conditions for dispatching at each point of the coordinated geographical space. Especially such a statement of the problem is relevant in the context of the introduction of modern adaptive means of monitoring and sensing the natural environment, as subsystems for monitoring the corresponding control systems for spatial processes. The novelty of this formulation and the method of solving this version of the problem lies in the merging of data from the domain of representation of spatial processes with knowledge, data corresponding to typical models of digital data sets, integration of software mechanisms for working with information on geospatial processes and programs for working with cartographic data sets. The development of a well-founded formulation and a method for solving this variant of the problem is the essence of this article.

Non-smooth regularization in radial artificial neural networks

V N Krutikov¹, L A Kazakovtsev² and V L Kazakovtsev³,⁴

¹ Kemerovo State University, 6 Krasnaya street, Kemerovo, 650000, Russia
² Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia
³ Saint Petersburg National Research University of Information Technologies, Mechanics and Optics, 49, Kronverksky Av., Saint Petersburg, 197101, Russia
⁴ E-mail: levk@bk.ru

Abstract. We propose a new approach to the approximation of an arbitrary function by the sum of radial basis functions using non-smooth regularization method combined with a new algorithm in determining the initial approximation which ensures an acceptable quality of approximation uniformly over the data area.

Reduction of the asymptotic complexity of the assignment problem

E A Morozov¹, V A Bartenev¹, G M Rudakova²,³, O V Korchevskaya² and E V Tueva²

¹ JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznyogorsk, Krasnoyarsk region, 662972, Russia
² Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia
³ E-mail: gmrfait@gmail.com

Abstract. The assignment problem belongs to an extensive class of managerial decision-making tasks. One of the urgent tasks related to this class is the problem of effectively combining various streams (resources). The main purpose of the method modifications is to reduce the asymptotic complexity and to consider the specifics of the subject area. The article describes the solution of the assignment problem on a bipartite sparse graph. The main purpose of the method modifications is to reduce the asymptotic complexity and to consider the specifics of the subject area. A modification of the Hungarian method is proposed. The
method is based on the successive shortest path algorithm and Dijkstra's bidirectional search algorithm. The modification led to a decrease in the asymptotic complexity of the problem.

Simulation for dynamics of transient ischemic attacks with thermal infrared imaging

K S Mityagin, A P Zaretskiy and I B Prokhorov
Moscow Institute of Physics and Technology (State University), Dolgoprudny, 141707, Russia
E-mail: mityagin@phystech.edu

Abstract. Stroke is characterized by the sudden loss of blood circulation to an area of the brain, resulting in a corresponding loss of neurologic function in a patient. According to current methodological recommendations, it is possible to perform surgical and drug treatment to minimize the damage from acute stroke in the first 3-6 hours after the onset of transient ischemic attacks, which is often difficult to identify for emergency physician or clinician. Thermal infrared imaging could serve as a fast non-invasive test to detect asymmetrical pattern in facial temperature of patient as a predictor for vessel occlusion during acute stroke. We develop a software-driven model to simulate for dynamics of facial surface temperature distribution with transient ischemic attacks. The implemented model is designed to develop and debug algorithms for automated analysis of the temperature dysregulation at the processing of patient thermal infrared recording.

Solution of the dynamics inverse problem with the copying control of an anthropomorphic manipulator based on the predictive estimate of the operator’s hand movement using the updated Brown method

V I Petrenko, F B Tebueva, M M Gurchinsky, V O Antonov and J A Shutova
Institute of information technologies and telecommunications, North-Caucasus Federal University, 1 Pushkina street, Stavropol, 355009, Russia

1E-mail: shutova.job@bk.ru

Abstract. The aim of the article is the implementation of a dynamic copying control by an anthropomorphic manipulator. Dynamic control would create greater accuracy of movement and less wear on parts. A feature of the copy control is the formation of the motion law in the process of the manipulator movement, which creates difficulties for the implementation of copy control. To solve the problem, it is proposed to exchange defining the motion law of the operator’s hand by its predictive estimate obtained using the updated Brown method. The results of simulation carried out on a large number of test movements show the effectiveness of the proposed solutions.
The formalized approach of building a network controller for the information handling automated process control system of the technological control cycle

J V Vilkov, V A Bartenev, I V Kovalev, V V Losev and M N Chuvashova

Abstract. The article discusses the use of a formalized approach to building a network controller which bases on a graph of Mealy machine. This approach can be applied in modern automated control systems (ACS), since ACS can be considered as network systems, intended for transportation (transmission) and distribution of flows, including energy and information. A comparison of a fragment of the graph of Mealy machine and a fragment of the flowchart of the algorithm and basic interpretations of their elements is presented. The technological process of applying protective coatings is considered, as well as basic operations that are deterministic. Considered minimization of the state of the graph automaton and the transformation into the flowchart of the technological process operations is obtained. The proposed approach allows obtaining the deterministic characteristics of the information handling automated process control system of the technological control cycle.

The implementation of measures for reduction an inertia of the interaction components of the heterogeneous environment for the automated process control system

A A Koltyshev, A K Shatrov, I V Kovalev, V V Losev and M N Chuvashova

Abstract. Authors have proposed the model of a specialized data management system in the automated process control system. This model is proposed by based on the results of research into the interaction of heterogeneous systems, as well as
trends in the development of information support. The software instances, information support, and the interface of their interaction are considered. The implementation of measures for reduction an inertia of the interaction components of these types of a software by applying the formation transactions approach are suggested. The implementation of measures is connected with a revision of an algorithmic essence of the heterogeneous environment components of the automated process control system is expressed by organization of connections pool, which based on using ODBC API functions and the exclusion of gateway transport. The numerical effect of these measures were a reduction the inertia of an inertia of the interaction components of the heterogeneous environment of the automated process control system.

The method of forming a geometric solution of the inverse kinematics problem for chains with kinematic pairs of rotational type only

V I Petrenko, F B Tebueva, M M Gyrchinsky, V O Antonov and J A Shutova

Institute of information technologies and telecommunications, North-Caucasus Federal University, 1 Pushkina street, Stavropol, 355009, Russia

1 E-mail: shutova.job@bk.ru

Abstract. The goal of the article is to provide researchers with a method that allows to form a geometric solution to the inverse kinematics problem for any kinematic chain containing kinematic pairs of rotational type only by performing a specified sequence of simple steps. The developed method is based on the Denavit-Hartenberg representation and analytic geometry. The input data for the geometric solution of the inverse kinematics problem obtained with its help are the Cartesian coordinates of the chain nodes. The essence of the method is to identify typical modules in the configuration of the kinematic chain and to apply the derived formulas for calculating the generalized coordinates.

The principles of the electric drive control of antennas and solar batteries rotation system for spacecrafts based on a dual-fed switched reluctance drive

S A Bronov1,2,3, N A Nikulin1, P V Avlasko1, D V Volkov1, E A Stepanova1, D D Krivova1, A A Bisov1, R M Nikitin1 and D E Alfimov1

1 Institute of Space and Information Technologies, Siberian Federal University, Krasnoyarsk, Svobodny 79, Russia, RU-660041
2 Department of Information Technologies and Systems, Krasnoyarsk State Agrarian University, Krasnoyarsk, Mira 90, Russia, RU-660049
3 E-mail: nulsapr@mail.ru

Abstract. A perspective electric drive based on a dual-fed switched reluctance drive with two multiphase windings on the stator and a toothed rotor has been considered. The electric drive can be used in spacecrafts for antenna and solar panels rotation systems. The possibilities of the electric drive control to achieve a high smoothness of rotation at low speed have been studied. The possible control
options with different combinations of frequencies and amplitudes of supply voltages of two windings were shown.

Transport system organization of an Industry 4.0 cyber and physical production company

D A Zakoldaev\(^1\), A V Shukalov\(^1\), I O Zharinov\(^1,3\) and O O Zharinov\(^2\)

\(^1\) Faculty of Information Security and Computer Technologies, Saint Petersburg National Research University of Information Technologies, Mechanics and Optics, 49, Kronverksky Av., Saint Petersburg, 197101, Russia

\(^2\) Department of Problem-Oriented Computing Complexes, Saint Petersburg State University of Aerospace Instrumentation, 67, Bolshaya Morskaia str., Saint Petersburg, 190000, Russia

\(^3\) E-mail: mpbva@mail.ru

Abstract. The problem dealing with transport production system equipped with cyber and physical technological equipment is considered. The scheme of forming route production lines of an item designing component in the Industry 4.0 company with application of cloud services is given. Cyberphysical production transport system is based on robotized equipment (physical level) and algorithms for dispatching production tasks (cyber level). Information exchange between the level of physical equipment and the cyber one is done based on the protocol of the industrial Internet of Things. The paper gives examples of route sheets used for manufacturing instrumentation products at digital enterprises of the Industry 4.0.

SECTION 4. DATA PROTECTION IN AUTOMATION SYSTEMS

A method for the autonomous control of navigation information integrity

I N Kartsan, M O Petrosyan, S V Efremova and V V Brezitskaia

Reshetnev Siberian State University of Science and Technology, 31 Krasnoyarsky Rabochy ave., Krasnoyarsk, 660037, Russia

E-mail: kartsan2003@mail.ru

Abstract. Currently, the key task of developing navigation systems is to reduce faults in determining the pseudo-range and pseudo-speed of objects. The quality of the solution of this problem significantly affects the accuracy of navigation and time security.

Adaptive encoding in remote digital telemetry and command systems

A G Samoylov, S A Samoylov, V S Samoylov and A P Galkin

Vladimir State University named after Alexandr and Nikolay Stoletovs, Vladimir, Russia
Abstract. The article considers the priority objective of reducing data transfer time in remote digital telemetry and command networks. To achieve this objective, some adaptive encoding principles have been proposed. There are expressions allowing to determine the optimal number of redundant components for different sizes of data blocks with a given noise resistance and data transmission bit rate. The paper proposes several flow charts of decoders and encoders using remote command systems with adaptive coding.

Adaptive visible image watermarking based on Hadamard transform

Margarita Favorskaya*, Eugenia Savchina and Aleksei Popov
Reshetnev Siberian State University of Science and Technology, 31 Krasnoyarsky Rabochy ave., Krasnoyarsk, 660037 Russian Federation
*E-mail: favorskaya@sibsau.ru

Abstract. One of the ways for implicit protection of rightful copyright information deals with application of visible watermark embedded in the host image. In this paper, we study behaviour of the proposed function, which makes the embedding of visible watermark smoother compared to the well-known sigmoid function, linear function, and Zernike moments. The Hadamard transform allows us to reduce the computational resources for watermarking processes. The proposed technique is especially useful in fragile watermarking as the additional level for protection.

An approach for automating the design of convolutional neural networks

Dmitry Plotnikov, Evgenii Sopov and Ilia Panfilov
Reshetnev Siberian State University of Science and Technology, Krasnoyarsk, Russia
E-mail: dmitry.plotnikov.1995@gmail.com, evgenysopov@gmail.com, crook_80@mail.ru

Abstract. Image recognition is an independent field of the computer science nowadays. Image classification is one of its main domains, in which investigated objects can be represented by an image or a video stream. The objective of the image classification is correct assigning of objects to corresponding classes, and there exist many effective approaches for solving this problem. One of the most popular approaches is artificial neural networks, which are a method from the field of machine learning. Despite the fact that neural networks cover a wide range of machine learning problems, they are also able to solve the problem of the image classification. However, there is one more specific approach for neural networks-based images classification that applies the deep learning conception. The best-known deep learning algorithm is called the convolutional neural network (CNN). The CNN uses a principle of using the same parts of a neural network to manipulate with different local parts of an input image. As well as the standard neural network architecture, the convolutional neural network should be
fine-tuned for solving a certain problem. Because of the CNN’s depth and complexity, the tuning process usually is complex and needs huge computational efforts. In this study, we have proposed an approach for creating ensembles of previously trained convolutional neural networks. The approach allows to increase the performance of the image classification. The results of experiments for image classification problems are presented and discussed. The experiments show that the proposed approach is able to outperform the standard perceptron and single convolutional neural network.

Application of informative patterns in the classifier for a logical data analysis method development

R I Kuzmich¹, A A Stupina¹,², M V Karaseva¹,², L N Ridel³ and T V Dubrovskaya³

¹ Department of Economics and Information Technology of Management, Siberian Federal University, Krasnoyarsk, Russia
² Department of System Analysis and Operation Research, Reshetnev Siberian State University of Science and Technology, Krasnoyarsk, Russia
³ Department of Economics and Organization in Branches of Chemical and Forest Complex, Reshetnev Siberian State University of Science and Technology, Krasnoyarsk, Russia

E-mail: h677hm@gmail.com

Abstract. The paper proposes a new method of a classifier for a logical data analysis method development. It is based on the information content of the patterns that forms the obtained classifier. The empirical confirmation of the expediency of this method on the problem of predicting complications of myocardial infarction is given.

Approach for determination of cyber-attack goals based on the ontology of security metrics

E Doynikova¹ and I Kotenko²

¹ Laboratory of Computer Security Problems, St. Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences, St. Petersburg, Russia
² Laboratory of Computer Security Problems, St. Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences, St. Petersburg, Russia

E-mail: doynikova@comsec.spb.ru

Abstract. The research aims to determinate cyber-attack goals in the information systems of various types for the further selection of the optimal countermeasures. We propose an approach based on the ontology of security metrics to achieve the research goal. The developed ontology provides the features for the determination of attack goals using neuro-fuzzy network. The paper describes the proposed ontology combining security components, classes of security metrics, various data
sources, and relations between them. The concept of using the security metrics as features for training neuro-fuzzy network is given. Application of the approach is shown on the case study.

**Comprehensive approach for solving multimodal data analysis problems based on integration of evolutionary, neural and deep neural network algorithms**

I Ivanov, E Sopov and I Panfilov
Reshetnev Siberian State University of Science and Technology, 31 Krasnoyarsky Rabochy ave., Krasnoyarsk, 660037, Russia

E-mail: ilyaiv92@gmail.com, evgenysopov@gmail.com, crook_80@mail.ru

**Abstract.** In this work we propose the comprehensive approach for solving multimodal data analysis problems. This approach involves multimodal data fusion techniques, multi-objective approach to feature selection and neural network ensemble optimization, as well as convolutional neural networks trained with hybrid learning algorithm that includes consecutive use of the genetic optimization algorithm and the back-propagation algorithm. This approach is aimed at using different available channels of information and fusing them at data-level and decision-level. The proposed approach was tested on the emotion recognition problem. SAVEE database was used as the raw input data, containing visual markers dataset, audio features dataset, and the combined audio-visual dataset. The best emotion recognition accuracy achieved with the proposed approach on visual markers data is 65.8%, on audio features data - 52.3%, on audio-visual data - 71%.

**Coverage verification by tests of program branches and conditions of software in environments of automatic testing**

A H Li¹, I A Lyapunova¹ and N A Fomenko²*
¹ Southern Federal University, 105/42 Bolshaya Sadovaya Str., Rostov-on-Don, Russian Federation,344006
² Gubkin Russian State University of Oil and Gas, 65-1, Leninsky prospect, Moscow, Russian Federation, 119991

*E-mail: fomenko.nata.alex@gmail.com

**Abstract.** Software verification is a discipline of software engineering that focuses on compliance of software requirements. In critical areas such as the aviation industry, the quality of military software is subject to strict control. Covering the requirements allows you to assess the completeness of a set of tests in relation to the functionality of the system, but does not allow you to assess the completeness in relation to its software implementation. The same function can be implemented using completely different algorithms that require a different approach to the organization of testing. Our approach uses "concolic" testing to automatically generate test cases.
Formation of optimal composition of the modules of single-function multiversion software for automated control system of the satellite communication system

V I Kudymov\(^1\), V V Brezitskaya\(^2\), P V Zelenkov\(^2\), I N Kartsan\(^3,6\) and Yu N Malanina\(^5\)

\(^1\) JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia
\(^2\) Siberian federal university, 79 Svobodny avenue, Krasnoyarsk, 660041, Russia
\(^3\) Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia
\(^4\) Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations, 61 Uritskogo street, Krasnoyarsk, 660049, Russia
\(^5\) Management Department, Irkutsk State Transport University, Irkutsk, Russia
\(^6\) E-mail: kartsan2003@mail.ru

Abstract. When creating the automated control systems (ACS) for satellite systems, the main task is to ensure high quality and reliability of all hardware and software complex components. It concerns not only spacecrafts but also the ground segments of system. In this direction there is an active work. In this article we want to focus on the development of software for satellite communication systems that can be implemented in both space and ground segments. One of the promising directions in this area is the introduction of multiversion technology. The proposed model significantly develops the approach of development of highly reliable software, as it deals with multiversion software for ACS of satellite communication systems, consisting of one or more programs, and each program consists of a number of modules, the serial execution of which corresponds to the successful implementation of the function. Below is a model that is applicable to various structures of multiversion software for ACS of satellite communication systems (from a very simple structure to a more complex) and gives the designer the flexibility in choosing the appropriate modules for the designed software of the system.

Increasing of organizational and technical system reliability with a help of differential approach

A A Sidaras\(^1,3\) and S V Chentsov\(^2\)

\(^1\) Chair of Applied mathematics and computer safety, Siberian Federal University, 79 Svobodny ave., 660041, Krasnoyarsk, Russia
\(^2\) Chair of Systems of automatic equipment, automated management and design, Siberian Federal University, 79 Svobodny ave., 660041, Krasnoyarsk, Russia

\(^3\) E-mail: asidaras@sfu-kras.ru

Abstract. This article is devoted to the application of the competence approach for increasing of the stability of the information systems functioning taking into account the human factor. The method of accounting for human factors is proposed. The results of using the competence approach in the construction of
reliable organizational and technical systems based on information technologies are presented.

Integration of hardware and software tools for VLSI SoC class design support

O V Drozd, P A Russkikh, S V Chentsov and D V Kapulin
Siberian Federal University, 79, Svobodny Ave., Krasnoyarsk, 660041, Russia
E-mail: odrozd@sfu-kras.ru

Abstract. Design of radio-electronic equipment is connected with formation of the heterogeneous design environment that contains hard and soft solutions from different company. The heterogeneous design environment generates the set of problems. Most of them does not have unified information solutions, in particular, complexity of operating decisions- making and data transmission of design information. One of the well-known way to solve the problem is the integration and formation of unified information environment. The paper presents the method of integration of heterogeneous hardware and software design support tools of the radio-electronic equipment in the unified information environment. As an example, the stage of system design of the digital goniometric satellite navigation receiver using the Global Navigation Satellite System GLONASS is presented. For information exchange between elements of the information environment the transformer to the uniform data format on the basis of the XML language is used. The implementation of the automated workstation for the GNSS receiver design and testing is also considered.

Methods beamforming adaptive digital array and their study using a computer model

D D Dmitriev\(^1\), A V Sokolovskii \(^1\), I N Kartsan\(^2\), V N Tyapkin\(^1\) and S V Efremova\(^2\)

\(^1\) Siberian Federal University, Krasnoyarsk, Russia
\(^2\) Reshetnev Siberian State University of Science and Technology, Krasnoyarsk, Russia
E-mail: kartsan2003@mail.ru

Abstract. The article describes the computer model of an adaptive digital antenna array. We considered in detail its features and specifications. The results of experimental research methods beamforming digital adaptive antenna array using a computer model. We studied four methods of providing independent beams forming the directivity pattern, calibration of the receiving channels, interference suppression and measurement navigation parameters.
Non-replicable object surface development for its automatic identification

L S Beckel and V D Shkilev
Kaluga branch Bauman Moscow State Technical University, 2 Bagenov street,
Kaluga, 248000, the Russian Federation
E-mail: milla2606@rambler.ru

Abstract. Each object has a set of attributes that help determine its essence and distinguish it from many other similar ones. Solving the problem of automatic identification to prevent counterfeiting is currently an urgent task, since the existing technologies cannot guarantee reliable protection from falsification of production.

Optimization of automatic exclusion algorithm of the vector network analyzer measuring equipment

D A Bolshakov, N N Burdukovskaya and K V Shugurova
JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street,
Zheleznogorsk, Krasnoyarsk region, 662972, Russia
E-mail: burdukovskayann@iss-reshetnev.ru

Abstract. Automatic elimination of measuring equipment (deambedding) in measuring S-parameters has become widespread with the development of modern vector network analyzers. This handy feature allows to get the measurement results in the "ready form", eliminating the need to perform calculations manually with the transformation of S-parameters matrices many times (by the number of points in the source *.s2p file). At the same time, this function has certain limitations that become critical with the exclusion of measuring equipment with large (more than 30 dB) losses. This paper describes the experience of determining the limitations of the applicability of the deambedding operation, provides an analysis of the reasons for their existence, and also suggests a method for eliminating these limitations.

Optimization of two-alternative batch data processing

A V Kolnogorov
Yaroslav-the-Wise Novgorod State University, Velikiy Novgorod, Russia
Email: Alexander.Kolnogorov@novsu.ru

Abstract. We consider optimization of batch data processing if there are two alternative processing methods available with different unknown efficiencies. One should determine more efficient method and provide its predominant usage. Formally, the problem is presented as Gaussian two-armed bandit problem with a priori unknown mathematical expectations and variances of incomes. We consider the problem in robust (minimax) setting. According to the main theorem of game theory, minimax strategy and minimax risk are sought for as Bayesian ones
corresponding to the worst-case prior distribution of parameter. We describe the properties of the worst-case prior distribution and present corresponding recursive equations for determining Bayesian risk and expected losses. Some numerical examples are presented. We show that the control performance almost does not depend on the number of processed batches if this number is large enough.

**Risk management of interactive electronic technical manual design projects**

*Artemy Varzhapetyan*, *Valeriy Lipatnikov*, *Sergey Michurin* and *Elena Frolova*

1Federal state autonomous educational institution of higher education «St. Petersburg State University of Aerospace Instrumentation» 67, Bolshaya Morskaya str., Saint Petersburg, 190000, Russia
2Federal state military educational institution of higher Education «Marshall of the Soviet Union S.M. Budenny Military academy of communication» 3, Tikhoretskiy pr., Saint Petersburg, 194064, Russia

E-mail: frolovaelena@mail.ru

**Abstract.** The analysis, assessment and minimization of risks for projects on the development of interactive electronic technical manual of different thematic focus is one of the classic examples of application of the results of modern scientific risk management in the subject area of creating software and information products. The need for these analyses and assessments is due to the fact that the creation of modern, high-technology interactive electronic technical manual integrated both in the operation of complex equipment and in the training of exploiters is a resource-intensive and expensive process. This provision fully applies to the interactive electronic technical manual for the operation and repair of aviation equipment.

**Salient region detection in the task of visual question answering**

*Margarita Favorskaya*, *Vladimir Andreev* and *Aleksei Popov*

Reshetnev Siberian State University of Science and Technology, 31 Krasnoyarsky Rabochy ave., Krasnoyarsk, 660037 Russian Federation

*E-mail: favorskaya@sibsau.ru*

**Abstract.** Salient region detection in Visual Question Answering (VQA) is an attempt to simulate a human ability to quickly perceive a scene by selectively looking on image fragments instead of processing a whole scene. The conventional approach deals with a neural network application. However, the Convolutional Neural Networks (CNNs) have many disadvantages compared with traditional methods for salient region detection. We modified the basic algorithm of salient region detection for VQA task by selecting such image fragments, which have a high probability to be included in a questionnaire. The experiments have been conducted on images from MS-COCO dataset and provided good segmentation results.
Simulation modelling of the heterogeneous distributed information processing systems

G A Ontuzheva\textsuperscript{1,2}, E R Bruchanova\textsuperscript{1}, I N Rudov\textsuperscript{1}, N O Pikov\textsuperscript{1} and O A Antamoshkin\textsuperscript{1,2,3}

\textsuperscript{1} Department of Information Technologies in Creative and Cultural Industries, Siberian Federal University, Krasnoyarsk, 79, Svobodny Ave., Krasnoyarsk, 660041, Russia
\textsuperscript{2} Reshetnev University, 31, Krasnoyarsky Rabochy Ave., Krasnoyarsk, 660037, Russia
\textsuperscript{3} Krasnoyarsk State Agrarian University, 90, Mira Ave., Krasnoyarsk, 660049, Russia

E-mail: galya679@mail.ru

Abstract. This study reviews simulation modelling of the heterogeneous distributed information processing systems. The relevance of simulation modelling for the considered class of systems is substantiated. The purpose of the study is outlined and solutions of the tasks required for its achievement are described. Based on the structural modelling carried-out earlier, main types of the model elements and the relations between them are allocated. The network structure generation algorithm is presented. The behaviour and the structure of model elements are described. Results of the modelling are displayed. At the conclusion, the possibilities for further development of the model are considered, and the conclusion on its practical application for real systems is made.

SECTION 5. ECOLOGY AND ECOLOGICAL ENGINEERING

A new approach to multi-version decision-making to improve the reliability of environmental monitoring parameters

M V Saramud\textsuperscript{1}, I V Kovalev\textsuperscript{1,2,3}, V V Losev\textsuperscript{1}, A S Kuznetsov\textsuperscript{2}, D I Kovalev\textsuperscript{1} and S S Ognerubov\textsuperscript{4}

\textsuperscript{1} Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia
\textsuperscript{2} Siberian federal university, 79 Svobodny avenue, Krasnoyarsk, 660041, Russia
\textsuperscript{3} Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations, 61 Uritskogo street, Krasnoyarsk, 660049, Russia
\textsuperscript{4} SDE II, Microsoft, Snoqualmie, Washington, USA

E-mail: msaramud@gmail.com

Abstract. The article is described a new decision-making algorithm in multi-version environments using the developed process models as versions. It permits to compare the measured values of various parameters and diagnose failures in the measurement systems of each of the parameters. As a whole, it will increase the reliability of the obtained parameters of the technological process. A simulation
environment is described, which allows to study the applicability and effectiveness of the proposed model, algorithm, and it obtains to estimates of its characteristics.

**Combined production of ammonia and methanol as the way to deal with the greenhouse gas**

S V Afanasiev¹, M V Kravtsova², Yu N Shevchenko and T P Guschina³
Togliatti State University, Togliatti, 445020, Russia

E-mail: ¹svaf77@mail.ru, ²m.v.kravtsova@yandex.ru, ³kuzya130494@yandex.ru

**Abstract.** Technological processes in the energy sector and at the enterprises of nitrogen fertilizers, accompanied by the release of large amounts of greenhouse gas - carbon dioxide into the atmosphere are considered. Optimal options for its utilization are proposed, based on the bicarbonate conversion of natural gas to produce methanol and gas-cyclic CO₂ injection into oil producing wells in order to increase oil recovery.

**Component selection model of the indoor automated system on the basis of system analysis**

S A Ivanov¹³ and I J Kvyatkovskaya²
¹ Department of Information Technologies and Mathematics, Saint Petersburg University of Management Technologies and Economics, Saint Petersburg, Russia
² Institute of Information Technologies and Communications, Astrakhan State Technical University, Astrakhan, Russia
³ E-mail: kemsit@mail.ru

**Abstract.** The paper aims at solving the task of the greenhouse automation in the conditions of resource minimization. It gives the analysis of the agro-industries involved in growing greenhouse vegetables as well as describes the main development tendencies of this market. The model of component parts choice for indoor ground automation system is carried out. The task of multi-criteria choice and alternative ranging is solved. The proposed management system model combines both criteria system developed by the experts in greenhouse production and the algorithm of component part choice based on three principles: construction, sensors and greenhouse coating.

**Converting gaseous pollutants toxic to plants and humans into environmentally friendly compounds in artificial ecosystems**

A A Tikhomirov, S A Ushakova, N A Tikhomirova, S V Trifonov and G S Kalacheva
Institute of Biophysics SB RAS, Federal Research Center “Krasnoyarsk Science Center SB RAS”, Akademgorodok, Krasnoyarsk 660036, Russia
Abstract. The present study describes detection of potential gaseous pollutants that can produce a toxic effect on plants and humans in the system with wheat plants cultivated on solutions containing liquid products of mineralization of human waste and fish waste. These gaseous pollutants do not inhibit plant growth and development under the experimental conditions, but they may accumulate in closed ecosystems functioning for extended periods of time. Ways to convert gaseous pollutants into environmentally friendly compounds have been proposed.

Selection of emission detection ranges for the laser method of plant stress revealing at a fluorescence excitation wavelength of 355 nm

Yu V Fedotov, M L Belov, D A Kravtsov, A A Cherpakov and V A Gorodnichev

Bauman Moscow State Technical University (BMSTU), 2nd Baumanskaya str., Moscow 105005, Russia

E-mail: belov@bmstu.ru

Abstract. The paper considers the development of a laser fluorescent method for the detection of plant stress conditions. The results of experimental studies of laser-induced fluorescence spectra of plants in normal and various stress conditions caused by various pollutants in the soil are presented for the laser wavelength of fluorescence excitation of 355 nm. A comparative analysis of various options has been carried out for choosing the spectral ranges of laser-induced fluorescent radiation plant registration. It is shown that for the task of monitoring the state of plants, the most effective (from the point of view of reliability of correct detection of stress conditions) ranges of fluorescent radiation registration are spectral ranges with central wavelengths of 685 and 740 nm.

Development and creation a model of a digital twin of the cubepart rectification installation for the separation of a binary water-alcohol mixture

R A Khakimov and N S Shcherbo

Faculty of Magistracy and Elite Education Omsk state technical university, 644050, Omsk, Pr. Mira, 11, Russia

Abstract. In article the way of creation of development of the digital twin of a cube part of a rectification column for the separation of a binary water-alcohol mixture, using the software Matlab/Simulink is considered. The technology solution on creation and verification of the digital twin of the available laboratory installation and structure of digital model, which is the basis for the digital twin, are developed.
Development of low-waste technology for the processing of sulphur into polysulphides and materials based on them

A A Jusupova, R T Akhmetova, L R Baraeva, G A Medvedeva and Zh V Mezhevich

Kazan national research technological university, 68 Marx street, Kazan, 420015, Russia

E-mail: alsu16rus@yandex.ru

Abstract. The interaction of sulphur with silicate and aluminium chloride was studied, the regularities of inorganic polysulfide formation, its structure and properties were established. The materials obtained on their basis have high physicomechanical properties, which are due to the chemical interaction of sulphur with aluminium, fixed on the surface of the silica-containing material, as well as with oxygen and silicon of the silica itself through the donor-acceptor mechanism with the formation of polysulphides. The results of IR spectroscopy, X-ray, electron-paramagnetic analysis, and quantum-chemical calculations are presented. Modification of silicate with aluminium chloride contributes to an increase in the active centres of the surface of silicate, the disclosure of sulphur rings. The use of electrophilic activator (aluminium chloride) contributes to the binding of sulphur with the formation of polysulphides and the question of the formation of toxic sulphur compounds.

Elaborating of the device for the importation of liquid ameliorants into the soil

S A Vasilyev¹,², I I Maximov², A A Vasilyev¹ and E A Vasilyeva¹

¹ Nizhny Novgorod state engineering and economic university, 22a Oktyabrskaya street, Knyaginino, Nizhny Novgorod Region, 606340, Russia
² Chuvash state agricultural academy, 29 Karl Marx street, Cheboksary, Russia

E-mail: vsa_21@mail.ru, alexei.21@mail.ru

Abstract. Ameliorants (materials which have very high ionic capacity and hold moisture) are applied for long-term improvement of soil's features in production of crops. A device is elaborated for liquid ameliorants’ importation into the subsoil space which allows increasing uniformity of an importation and quality of their dispersion in the space under a flat hoe at sweep soil cultivation. This tool contains supply pipe-line with the distributive openings which are evenly located on its length, a material stream divider, the channel of supply of material and the air duct with openings. We have conducted preliminary laboratory researches in which two types of springs were applied: with the equidistant coils and with the decreasing step-by-step distance of coils to an extreme last opening. In the second case the identical rate of flow from openings was observed because the pressure was supported on all length of the pipeline. Thus, as a result of the theoretical analysis and laboratory experiments we established dependence of design data’s change of the coil on the created pressure on width of the developed device for the local importation of liquid ameliorants into the soil at sweep soil cultivation.
Environmental management modelling in the areas of waste landfilling

T G Sereda¹,³ and S N Kostarev¹,²,⁴

¹Perm State Agro-Technological University named after academician D N Prianishnikov, 23 Petrozavodskaja St., Perm, 614990, Russia
²Perm Military Institute of National Guard Troops of the Russian Federation, 1, Gremyachiy log St., Perm, 614030, Russia
³Russian Presidential Academy of National Economy and Public Administration. Perm branch, 10 Gagarina Boulevard, Perm, 614990, Russia
⁴National Research Perm Polytechnic University, 29 Komsomolski Avenue, Perm, 614990, Russia

E-mail: iums@dom.raid.ru

Abstract. The article justifies the need to reduce the landfill impact zone of municipal solid waste (MSW) landfills by methods of rational design and effective management. The physicochemical characteristics of the waste and products of their biodegradation, as well as the choice of engineering structures of the MSW within the territory alienated for the construction of the MSW land, were selected as controlled factors. It is shown that the load and environmental impact of a high-loading landfill will extend over longer distances and over a longer time even after its recultivation, and this fact should be taken into account when predicting the zone of impact of such landfills to clarify and justify the size of the sanitary protection zone. In order to minimize air pollution from the MSW landfills on the border of the nearest territories to normalized indicators of habitat quality, a spatial-dynamic model for managing emissions from the MSW has been developed. The numerical calculation of the emission of impurities in the atmosphere was carried out using the AnsysWorkbench.

Geoinformation modelling system of natural technical complexes for simulation modelling and optimization of load distribution

Natalia Zhilnikova

Federal state autonomous educational institution of higher education «St. Petersburg State University of Aerospace Instrumentation» 67, Bolshaya Morskaya str., Saint Petersburg, 190000, Russia

E-mail: nataliazhilnikova@gmail.com

Abstract. To create a system of environmental management of natural-technical complexes the organization of algorithmic support load quotas for each subject by geoinformation modelling tools is necessary. Proposed structure of geoinformation modelling system allows analysing and processing of data by geoinformation system tools with estimation for each parameter value used in accordance with proposed method. Determined criteria for load distribution between water users include the best available technologies, object social significance, ecological status of water bodies in target water points of territorial natural-engineering complex. Presented results open up new approaches, methods and techniques based on technical and new generation software. Practical relevance: algorithm and method of geoinformation project development on
environmental management of territorial natural-engineering complex are able to analyse of characteristics on monitoring results, to distribute load quotes taking into account ecological level of production on the proposed criteria in accordance with developed methodology of enterprise management efficiency increasing.

Investigation of seed uniformity under field and laboratory conditions

E P Alekseev, S A Vasiliev and I I Maksimov
Chuvash State Agricultural Academy, 29, K. Marx St., Cheboksary, Russia, 428003
E-mail: zhenia_alex@mail.ru

Abstract. Seed uniformity in the soil at the appropriate seed depth is achieved when the seeds are at an equal distance from each other. This allows to create equal conditions for obtaining by each plant of the same amount of light, heat, water and nutrients affecting seed germination, sprouting, tillering, stemming, ear formation, earing, flowering and ripeness development. The method of sowing seeds and the selection of tillage and seeding machines are critical for fulfilling the conditions listed above.

Measurement accuracy of real time parameters in environmental monitoring

M V Saramud1*, I V Kovalev1,2,3, D I Kovalev1, A A Voroshilova1,3 and A S Kuztensov2
1 Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochny Av., Krasnoyarsk, 660037, Russia
2 Siberian federal university, 79 Svobodny avenue, Krasnoyarsk, 660041, Russia
3 Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations, 61 Uritskogo street, Krasnoyarsk, 660049, Russia
*E-mail: msaramud@gmail.com

Abstract. The article deals with the problem of environmental monitoring execution in case of thermal power plants impact on the environment. The regulating documents in compliance with which this problem is solved have been provided. The problem of obtaining valid values under multi-metering of environmental monitoring parameters has been described. The method for this problem solution via application of multi-version approach of decision-making has been offered. Simulation environment for the research of the offered approach has been delivered. Results received in the environment have been analyzed.
**Microclimate Control System Development**

**S N Kostarev**¹,²,⁴ **and T G Sereda**¹,³

¹Perm State Agro-Technological University named after academician D N Prianishnikov, 23 Petrropavlovskaja St., Perm, Russia, 614990
²Perm Military Institute of National Guard Troops of the Russian Federation, 1, Gremyachiy log St., Perm, Russia, 614030
³Russian Presidential Academy of National Economy and Public Administration. Perm branch, 10 Gagarina Boulevard, Perm, Russia, 614990
⁴Perm Institute of the FPS of Russia, 125, Karpinskogo St., Perm, Russia, 614012

E-mail: iums@domraid.ru

**Abstract.** The microclimate is a fundamental factor of a healthy life, and is determined by the temperature, humidity and speed of moving air. These factors determine whether a person feels a thermal comfort. The three factors are to some extent interchangeable with regard to the feeling of comfort and thermoregulation needs. The system for monitoring and controlling microclimate parameters based on OMRON software and hardware was developed and investigated. Control system considers internal and external ambient factors related to the regulation process. Microclimate standards have been studied. The technical standards for the temperature conditions required for comfort are not applicable to all regions owing to the different climatic conditions and clothing traditions. A combinational machine for controlling the microclimate parameters is constructed. This system was designed for climate control of a building and for increasing or lowering the temperature and relative humidity. The program is developed in the language of ladder diagrams.

---

**Numerical modelling of surge wave in downstreams of the waterworks**

**J G Ivanenko, A A Tkachev, K G Gurin** and **D Yu Ivanenko**

Novocherkassk engineering-ameliorative institute named after A. K. Kortunov of Don State agrarian university, 111 Pushkiskaya street, Novocherkassk, Rostov region, 346428, Russia

* E-mail: lxtkachev@gmail.com

**Abstract.** Basic requirements for water measuring and water accounting devices developed to fulfil static control of water distribution have not changed virtually in recent decades. It is due primarily to the use of water accounting and measuring instruments developed and used in conditions of steady uniform water flow when unique dependence on depth and water discharge on the rise and decline of the waterline levels is observed. Under operation of watercourses in the unsteady water flow regimen, the existing means of water measurement are not applicable. Simultaneous direct measurement of hydraulic parameters in controlled cross sections of waterways is complicated even under steady water flow regimen. Nowadays there is the lack of data to predict extreme values of discharges and water depth in downstreams of the waterworks due to the absence of tested and feasible methods of water depth and discharge measurement in calculated cross...
sections of waterways. With the application of the complete integral theory, a hydraulic calculation of the changes in the flow rate and the depth of flow in fixed sections of the downstream of the waterworks was performed. It is based on the analytical method of linearized system solution of one-dimensional differential equations in partial derivatives of Saint-Venant hyperbolic type.

**Optimization of carbon dioxide compressing technology in the production of urea**

S V Afanasiev¹, M V Kravtsova², Yu N Shevchenko, T P Guschina³ and S A Sokov

Togliatti State University, Togliatti, 445020, Russia

E-mail: ¹svaf77@mail.ru, ²m.v.kravtsova@yandex.ru, ³kuzya130494@yandex.ru

Abstract. In the article the questions of optimization of technological schemes of obtaining liquid carbon dioxide directed to the carbamide synthesis plant are considered. The main drawback of traditional technical solutions is high energy costs, mainly due to the need to compress CO₂ before it is fed to the synthesis reactor. Traditionally, technical solutions are proposed, based on the production of liquid low-temperature carbon dioxide, which increase the yield of nitrogen fertilizer. However, their significant disadvantage is high energy costs, which is largely due to the need to compress CO₂ before it is fed to the synthesis reactor. To solve the optimization of the technological stage of obtaining high-pressure carbon dioxide by combining the use of compression and pumping equipment, multifactor methods for modelling chemical-technological processes and software were used. With regard to urea aggregates of different power, several technological schemes are considered. The paper presents a variant of modernization of the turbocharger aggregate, due to which it is possible to achieve a significant increase in the yield of the final product of urea units in order to reduce CO₂ emissions into the atmosphere.

**Optimization of recycling strategy for solid industrial waste**

A V Rubinskaya, E I Pister, A A Ioffe, A Yu Vititnev and M V Karaseva

Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia

E-mail: pisterelizaveta@yandex.ru

Abstract. The rational and efficient use of natural resources is an important element for sustainable development. Waste is significant loss of material and energy resources. Recycling and disposal of the generating waste can cause the environmental pollution and human exposure to harmful substances and infectious organisms. The waste generation indicator is closely related to the level of economic activity in the country and reflects the structures of production and consumption formed in the society. The reduction in waste generation is an indicator of the progress of economic sectors towards less material-intensive
structures of production and consumption. Plant origin waste is mainly generated in the lumber industry and it is a large-scale source of environmental pollution. The constant generation and accumulation of these wastes is a serious environmental problem. The main reason for the current state is the insufficient capacity for timber processing. It aggravates the problem of the integrated use of low-grade, small-scale wood and wood waste. As a result, the main competitive products in the forest complex of the Krasnoyarsk Region are currently lumber and round wood. The solution to the current problem concerning the optimal use of waste generated on the territory of the Krasnoyarsk Region must be solved with the help of mathematical modeling and optimization of the recycling process of lump plant waste. The rational use of lump plant waste is one of the most serious and unsolved problems.

Developing the technology of physicochemical processing of organic waste in closed life support systems for space applications

A A Tikhomirov, S V Trifonov, and E A Morozov

1Institute of Biophysics SB RAS, Federal Research Center “Krasnoyarsk Science Center SB RAS”, Akademgorodok, Krasnoyarsk 660036, Russia
2Reshetnev Siberian State University of Science and Technology, 31 “Krasnoyarskiy Rabochiy” pr., Krasnoyarsk 660037, Russia

E-mail: trifonov_sergei@inbox.ru

Abstract. Closed life support systems for space applications need a technology of processing organic waste produced in the system that would enable incorporating the recycled waste into the mass transfer of the system. Researchers of the Institute of Biophysics SB RAS have developed a method of waste processing that meets these requirements: a physicochemical method of organic waste oxidation in the hydrogen peroxide aqueous solution under application of an alternating current electric field – wet combustion. The mineralized solution produced by this method can be used as a mineral nutrient supplement for higher plants in the life support system. The present study describes technical implementation of the wet combustion method and reports results of developing this method in the last few years. The study addresses problems associated with the design and positions of individual components and different configurations of the wet combustion reactor, showing the way to automate operation of the reactor and reporting optimal parameters of the current applied to the electrodes, which reduce time and power consumption by waste processing.

System of personnel training in decision making in fighting wildfires

Georgy Dorrer, Alexandra Dorrer, Igor Buslov and Sergey Yarovoy

Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia

E-mail: g_a_dorrer@mail.ru
Abstract. Wildfires fighting is a complex and often dangerous process connected with cooperation of many organizations and crews that requires good organization. An important role in this process plays the qualitative training of personnel involved in the fire fighting. Training of personnel in the techniques and tactics of combating wildfires is conducted in educational systems of various levels, but, regardless of the level, members of firefighting crews should have basic knowledge of fire safety techniques, methods, and tactics. It is known that one of the most effective forms of personnel training is the use of interactive computer systems that allow individual approach to the trainees. Given the dynamic nature of the wildfire spread and the need to make rapid decisions, training system should include an imitation subsystem, which can help a trainee to observe the development of the fire situation on the map, make decisions and evaluate their effectiveness. In the work presented, an interactive simulation system FIREMAN is discussed. The system is designed to train personnel in basic knowledge and decision making in combating wildfires. The structure of the system is described, and an example of how it works is given.

SECTION 6. POWER ENGINEERING

Automation and control of blow moulding mechanisms according to the criterion of maximum energy efficiency

V V Platonov, A T Tsirkunenko and S S Bukhanov
RiK-Energo ltd, Ekaterinburg, Russian Federation
E-mail: m9191236713@mail.ru

Abstract. The article presents the control algorithms that allow to increase the energy efficiency of the metallurgical production facilities’ blow molding mechanisms by impacting on the actuating elements of electrical engineering complexes. A mathematical model is proposed that allows the calculation of energy efficiency. It is shown that this effect is achieved due to: a systematic approach to the design of electrical systems; the use of new types of electric machines; selection of control and regulation algorithms; transition of unregulated control systems to adjustable electric drives; rational choice of elements of electrical systems; increasing the level of staff skills. Energy efficiency assessment was performed for the object, which proposed the mutual influence of the elements of the system. The proposed control laws were compared with systems based on unregulated electric drives and structures in which the air flow was controlled by the guide vanes. It has been established that while transitioning to new control algorithms, it is possible to reduce losses in the system by about 35%.
Automation of the design and development stages of semiconductor devices

A A Imanova¹, V V Fediakov¹ and E Tulegenov²

¹ Gmbh Anvilex, Deutschland, Dresden, Enderstrasse 94
² ANO CPE MOMENTUM, Presnenskaya naberezhnaya, 6, Moscow, Russian Federation

E-mail: 74uc1@mail.ru

Abstract. In the scientific article, automation of optimization of driver control nodes for semiconductor frequency converters feeding mechatronic modules was performed. The selection and justification of the design scheme of the control board nodes examined, the analysis of the possible operating modes of the control boards, the calculation of the system variables (voltage, currents), the calculation and comparison of various control options, and analysis of the results; development of recommendations for the practical use of research results. It was determined that the use of uncontrolled power supplies entails huge losses power allocated to the elements of the amplifier, which requires optimization. The efficiency of the amplifier is also unstable and lies in the range from 15 to 67%; The use of controlled power sources allowed to significantly reduce the power allocated to the elements of the amplifier (2 – 7 times). Also, the efficiency of the amplifier becomes approximately constant and is about 75%; The maximum thermal power dissipation in all modes is 1304 watts for the whole amplifier, including for each module 186 watts; To increase the reliability of the device, we select the safety factor for the power dissipation 3 and calculate the efficiency of the heat removal and recycling system at a thermal power of 600 W.

Control of high-voltage pump motor using a frequency sine-wave filter converter

E Dresvianskii², M Pokushko¹, A Stupina¹, ³, V Panteleev² and V Yurdanova⁴

¹ School of Business Management and Economics, Siberian Federal University, 3, Vuzovsky Lane, Krasnoyarsk, 660025, Russia
² Department of Electrical systems, Siberian Federal University, 26 «а» Kerensky street, Krasnoyarsk, 660074, Russia
³ Department of International Management, Krasnoyarsk State Agrarian University, 90 Mira avenue, Krasnoyarsk, 660049, Russia
⁴ Foreign Languages Department for Engineering Specialties, Institute of Philology and Language Communication, Siberian Federal University, 82 «а» Svobodny avenue, Krasnoyarsk, 660074, Russia

E-mail: dresvegor@mail.ru, mvp1984@mail.ru, h677hm@gmail.com, pvi0808@rambler.ru.

Abstract. The method of control of a pump motor using a frequency converter as the most promising for saving energy in pumping units is described in the article. The installation of a two-transformer circuit with a low-voltage frequency converter at a pumping station in Krasnoyarsk with three network pumps
equipped with DASO4-450X high-voltage asynchronous electric motors with a power of 630 kW and a voltage of 6 kV was also tested. The introduction of a two-transformer circuit and a low-voltage frequency converter with the inclusion of a sinus filter reduces the energy costs by 37%, reduces the temperature of the entire pump unit to 44 °C and reduces the number of stops by 10%. In addition, the use of a frequency converter allows to increase the reliability of the entire system, as well as to reduce the risk of a breakthrough of the pipeline network, which is achieved by automatically maintaining pressure within the specified limits.

**Determination of the amount of entropy of non-recoverable elements of the technical system**

A S Dulesov¹, D J Karandeev¹ and N V Dulesova²

¹ Katanov Khakass State University, 92, Lenina ave., Abakan, 655017, Russia
² Khakas Technical Institute of Siberian Federal University, 15, Komarova ave., Abakan, 655017, Russia

E-mail: den_dr_house_1991@mail.ru

**Abstract.** A mathematical model for determining the amount of information applied to non-recoverable elements of the technical system is proposed. The quantitative indicators of the model are the probability of failure-free operation; frequency of failure; failure rate and mean time to the first failure. One of the criteria for assessing the reliability of the system adopted information entropy, which is considered as a measure of uncertainty of the outcome of a random event. The model allows to express the reliability indicators through information entropy for the analysis of the state of elements and the system. Multiplicative and additive properties of entropy growth in the case of aging and testing of system elements for resistance to failures are considered. An integral part of the model is a method for calculating the information entropy of systems consisting of non-recoverable elements. The method is based on the Shannon’s model to determine the amount of information and allows to calculate the entropy for both operable and non-operable states of the system. The peculiarity of the method is as follows: 1) the probabilities of the operable state and the probability of failure in the case of considering the flow process of system states without taking into account the individual properties of the element are used to determine the information entropy. In this case, the result of the calculation allows to monitor the manifestation of randomness in the opposite states of the system; 2) it uses the individual properties of the element characterized by private (or own) entropy. With this approach to the calculations, the obtained quantitative values of entropy allow to monitor the growth rate of the states of each element and system as a whole. The method is tested on the presented example.
Doubly fed induction motors control in positional electrical drives

P V Avlasko, S A Bronov, Z A Avlasko and D A Antonenko

Siberian Federal University, 79, Svobodny ave., Krasnoyarsk, 660041, Russia

E-mail: pavlasko@sfu-kras.ru

Abstract. The article discusses the phase control of doubly fed induction motors for positional electric drives and an assessment of their capabilities. The advantage of all variants of such control is the possibility of fixing the rotor position even in open systems when the windings are powered with nominal voltages and high smoothness of movement at very low speeds. The proposed methods for implementing the phase control of the doubly fed induction motors open up wide possibilities for solving specific problems of developing positional electric drives, providing high dynamic, accuracy and weight and dimensions rates.

Experimental study on the structure formation features of a filler of catalytic heating systems

A A Medyakov, A D Kamenskiih, D M Lastochkin and A P Ostashenkov

Volga State University of Technology, 3 Lenin square, Yoshkar-Ola, Mari El Republic, Russian Federation

E-mail: MedyakovAA@volgatech.net

Abstract. In the paper, we present an experimental study on the structure formation of a filler of catalytic heating systems. As a result, the dependences of the parameters of technological processes for the preparation of catalysts on their structure being formed were identified.

High-performance flux-switching DC motors for energy facilities

A D Golykov¹, S P Gladyshev¹ and A N Gorozhankin²

¹ Michigan-Dearborn University, Detroit, United States
² South Ural State University, Chelyabinsk, Russia

E-mail: DetroitUniver@gmail.com

Abstract. An overview of flux–switching DC Motor, which received an impetus to development due to progress in the field of information and power electronics, is given. The relevance of the optimization procedures that would allow to determine the best ratios of the elements of the magnetic system in terms of increasing the specific torque in each dimension is shown. Based on the ratios of elements of the magnetic system obtained using a finite element analysis, fragments of the electromagnetic calculation technique of a machine are given. According to the proposed method of calculation, an electric machine with a
power of 18 kW was designed. It is shown that the specific torque and its pulsations in the studied electric machine are close to those of an asynchronous machine with a squirrel–cage rotor of the same size. At the same time, it is superior to the asynchronous machine in terms of its adjustment characteristics, overload capacity, speed control range, and manufacturability. The field of application of such an electric machine is mechanisms with a large range of speed control, large overload torques and high requirements for specific indicators of torque and power. An example of such a mechanism is electric and hybrid transport.

**Improving the reliability of the relay automation system for power facilities**

S S Bukhanov¹, L A Zhuravleva¹ and M N Kornienko²
1 RiK-Energo Ltd, 15, Tarasova St., Chelyabinsk, 454048, Russia
2 Gmbh Anvilex, Deutschland, Dresden, Enderstrasse 94

E-mail: m9191236713@mail.ru

**Abstract.** The main reasons of the false (incorrect) operation of the microprocessor relay protection system are analyzed in the article. The methods of increasing the reliability indicators of the relay automation system are presented. Analysis of statistical data submitted by PAO Rosseti showed that the probability of failure-free operation of microprocessor relay protection systems is not lower than 0.998. Increasing the reliability of microprocessor protection systems does not dictate the revision of the Electrical Installation Rules, but requires the use of high-quality cable products with normalized technical characteristics, the transition to a digital data transfer format with the limitation of the number of variables fed through one serial channel. Exemplary upper and lower bounds are established for the cost of improving the reliability of the microprocessor system. For example, reducing the failure rate by half will require increasing the capital costs of protection from electromagnetic interference by about (3–4) times. Preservation of the reliability level of the microprocessor system in the process of operation is possible only if the planned measures are taken to assess the electromagnetic situation. As shown by statistical data, the most likely cause of incorrect operation of relay automation is atmospheric phenomena (lightning). Therefore, at the stage of estimating the electromagnetic state, it is necessary to pay attention to the state of the earthing system, and the fault diagnosis is most rationally performed by the half-division method, considering the probability of failure-free operation.

**Increase of energy efficiency of energy generation due to utilization of waste heat on district heating systems**

D Karabarin and S Mihailenko
Termal power station of Polytechnic Institute of Siberian Federal University, 79 Svobodny avenue, Krasnoyarsk, 660041, Russia

E-mail: DKarabarin@sfu-kras.ru
Abstract. The relevance of the work is due to the implementation of the Federal law "on energy saving and energy efficiency and on amendments to certain legislative acts of the Russian Federation" and is aimed at reducing the cost of production of electric and heat energy in the Northern regions of decentralized energy of Russia. The aim of the work is improving the energy efficiency of thermal energy production through the modernization of coal-fired boilers, the rationale for the choice of an alternative technology to convert thermal energy into electricity in the areas of decentralized energy. Creation of the installations competing with diesel power plants on development of thermal and electric energy, increase of economic efficiency of production of energy in Northern regions of Russia. Research methods is analysis of existing technologies for the production of thermal energy in the areas of decentralized energy; Thermal, technical and economic analysis of technologies that allow to convert low potential thermal energy into electrical energy; Simulation of installation parameters based on the organic Rankine cycle using the software package Smoweb software package. Results are a comparative analysis of the existing technologies for the production of thermal energy in the areas of decentralized energy and selected the most effective option for improving energy efficiency; was made thermal and technical and economic analysis of the use of technologies that allow to convert low potential thermal energy into electrical energy for the district heating systems DHS-22 of villages Podtesovo.

The research of the electric field intensity change in the air gap of the compact electrostatic filter

F R Ismagilov¹, I Kh Khairullin¹, M V Okhotnikov¹, A A Nusenkis² and D V Maksudov¹

¹ Federal State-Funded Educational Institution of Higher Education «Ufa State Aviation Technical University» (USATU), Ufa, Russia
² «KURS», Ltd

E-mail: oxothukob@mail.ru

Abstract. In the article the parameters of an electrostatic filter were considered, including the level of the electric field intensity and the magnitude of the breakdown voltage. A computer simulation of the electric field between flat parallel electrodes with different potentials was performed. The change pattern of the electric field at the penetration of electrically conductive soot particles is considered. With the help of the "ANSYS" software complex, the pattern of change of the electric field intensity between these electrodes was investigated depending on the concentration of particles between them. A computer model that simulates the creation of a maximal level of electric field intensity in a symmetric electric field with a fixed air gap is proposed. The decrease of the level of the breakdown voltage at these electrodes at the placing between them of elements simulating diesel soot particles with average sizes mentioned in the literature is estimated. According to the simulation results, it was determined that the presence of particles of electrically conductive soot significantly influence on the electric field pattern, due to which a local change in the pattern of the resultant field intensity occurs. With aim of confirming of the obtained data the experimental
Optimization model of power supply system of industrial enterprise

V Panteleev, S Zilberman, G Pilyugin, R Petukhov, E Sizganova and M Mashukov

Siberian Federal University 79 Svobodny, Krasnoyarsk, 660041, Russia

E-mail: pvi0808@rambler.ru

Abstract. In this paper, the problem of optimizing the generated reactive power distribution for reducing the loss of active power in the elements of industry power supply system presented. The problem of optimal distribution of generated reactive powers by synchronous motors in the power supply systems belongs to the nonlinear mathematical programming class and can be solved by using the Lagrange multiplier method. The Lagrange method allows one to reduce the problem of conditional optimization (that is, finding the relative extremum of the objective function with certain limitations) to the simpler problem of unconditional optimization (the search of an absolute extremum). A complete mathematical model of optimization problem of the rational distribution of the generated reactive power by the synchronous motors in order to reduce the loss of active power in the power supply system elements of an industrial enterprise developed. The obtained mathematical problem allows one to consider a number of limitations related to both the mode of operation for the individual power supply system elements and the entire system as it is.

Power forecasting for a photovoltaic system based on the multi-agent adaptive fuzzy neuronet

Alexander S Degtyarev¹, Viktor I Kosenko², Ekaterina A Engel³⁵, Nikita N Engel³ and Marina V Savelyeva³

¹ JSC "Central Construction Bureau “Geofizika”, 89 Kirenskogo street, Krasnoyarsk, Russia
² JSC “Academician M F Reshetnev Information satellite systems”, 52 Lenin street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia
³ Katanov Khakass State University, 92, Lenina ave., Abakan, 655017, Russia
⁴ Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russia
⁵ E-mail: ekaterina.en@gmail.com

Abstract. This article presents a multi-agent adaptive fuzzy neuronet for a two days ahead forecasting of the hourly power from a photovoltaic system under random perturbations. In this research we consider a 5 KW Solar Power Plant for a residential building (model SA-5000M). The main objective of this research is to fulfil the multi-agent adaptive fuzzy neurone for hourly power forecasting for a photovoltaic system. The agents of the multi-agent adaptive fuzzy neuronet are fulfilled as two-layered recurrent networks. The standard Levenberg-Marquardt
algorithm is described. The analysis of the evolving errors shows the potential of the multi-agent adaptive fuzzy neuronet in the hourly power forecasting for a photovoltaic system.

**Prediction of improper operation of microprocessor relay protection devices during geomagnetic storms**

E V Platonova¹, V I Panteleev², G N Chistyakov¹, A V Mainagashev² and V P Kochetkov¹

¹ Khakassky technical institute - Branch of Siberian federal university, 27 Schetinkina street, Abakan, 655017, Russia
² Siberian federal university, 79 Svobodny avenue, Krasnoyarsk, 660041, Russia
³ Email: eplatonova@yandex.ru

**Abstract.** The authors described a model for predicting the improper operation of microprocessor relay protections caused by the flow of geo-induced currents in the secondary circuits during geomagnetic storms. The model is based on the mathematical method of Takagi-Sugeno. The simulation was performed using an adaptive neural fuzzy network. The ANFIS-editor of the Fuzzy Logic Toolbox extension package in Matlab was used. Since the parameters under study are probabilistic in nature, Gaussian functions were used in the prediction. Input parameters are the date, time and variations of the components of the geomagnetic field. The output data are predictions of malfunctioning microprocessor relay protection in the power system. Using the model, the dependencies between the studied parameters were revealed, the influence of these parameters on each other was evaluated.

**Increasing the efficiency of energy generation at Krasnoyarsk CHP-2 by utilization of waste heat**

D Karabarin¹ and S Mihailenko²

¹ Department for Thermal power stations of Polytechnic Institute of Siberian Federal University, 79 Svobodny avenue, Krasnoyarsk, 660041, Russia
² E-mail: DKarabarin@sfu-kras.ru

**Abstract.** The relevance of the work is due to the implementation of the Federal law "on energy saving and energy efficiency and on amendments to certain legislative acts of the Russian Federation" and is aimed at reducing environmental pollution from the production of electricity and heat at the CHP. The aim of the work is to increase the energy efficiency of electric energy generation by upgrading the coal thermal power plant, reducing environmental pollution from the enterprise by reducing the amount of fuel burned at the same capacity. Research methods are Analysis of existing technologies for utilization of low-potential thermal energy in the energy sector; Thermal, technical and economic analysis of technologies that allow converting low potential thermal energy into electrical energy; Simulation of installation parameters based on the organic Rankine cycle using the Smoweb software package; Analysis of modern manufacturers of organic Rankine cycle technology in order to select the most suitable. Results are a comparative analysis of existing technologies for utilization of low-potential heat energy was carried out and the most effective option for
energy efficiency was chosen. Heat and techno-economic analysis of the application of technologies to convert low-grade thermal energy into electrical energy was performed; modeling installation using the principle of organic Rankine cycle utilizing heat energy from the boiler BKZ-420-140-PT1 was designed