CROATIAN METALLURGICAL SOCIETY (CMS)
HRVATSKO METALURŠKO DRUŠTVO (HMD)

17th INTERNATIONAL / 17. MEĐUNARODNI

SYMPOSIUM OF CROATIAN METALLURGICAL SOCIETY
SIMPOZIJ HRVATSKOG METALURŠKOG DRUŠTVA

S H M D ´2024

MATERIALS AND METALLURGY / MATERIJALI I METALURGIJA

BOOK OF ABSTRACTS / ZBORNIK SAŽETAKA

Obljetnice Hrvatskog metalurškog društva
Anniversaries of Croatian Metallurgical society

1952.–2024. HRVATSKO METALURŠKO DRUŠTVO / CROATIAN METALLURGICAL SOCIETY / 72 god./y

1962.–2024. ČASOPIS METALURGIJA / METALURGIJA JOURNAL / 62 god./y

HRVATSKO METALURŠKO DRUŠTVO
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http://pubweb.carnet.hr/metalurg

ZAGREB, CROATIA, April 18 – 19, 2024
ZAGREB, HRVATSKA, 18. – 19. travanj 2024.

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THE AIM OF SYMPOSIUM

The aim of this Symposium is to point out all the possibilities of the materials and achievements in metallurgy.

TOPICS OF THE SYMPOSIUM WERE:

Materials
- New Materials
- Refractory Materials
- The Development
- Applications
- Physical Metallurgy

Metallurgy
- Process Metallurgy and Foundry
- Plastic Processing of Metals and Alloys
- Technologies
- Energetics
- Ecology in Metallurgy
- Quality Assurannce and Quality Menagement

17th International Symposium of Croatian Metallurgical Society „Materials and Metallurgy“ was held as a part of Anniversaries:

1952.–2024. HRVATSKO METALURŠKO DRUŠTVO / CROATIAN METALLURGICAL SOCIETY

1962.–2024. ČASOPIS METALURGIJA / METALURGIJA JOURNAL

„Countries Participating at the 17th International Symposium of Croatian Metallurgical Society“ – total 50 „Organizer“, „Co-organizer“, „Co-operation with organizations“, same as 16th symposium, Please see Metalurgija 62 (2023) 1, 8-10

ACCEPTED ABSTRACTS

PATRONS (same as for 16th Symposium)
- World Steel Association (WSA)
- International Society of Steel Institutes (ISSI)
- European Steel Federation (ESF)
- European Steel Institute Confederation (ESIC)
- University of Slavonski Brod, Faculty of Mechanical Engineering, Croatia
- University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Croatia

NAPOMENA:

- Mnogi autori / koautori nisu se pridržavali zadanog oblika i dužine sažetaka referata. Znanstveni odbor je izveo usaglašavanje, te isprika ako postoje nedostaci. Moguće je i možebitni izostanak nekog sažetka. Sve Reklamacije se usvajaju do 30. ožujka 2024. god., posebice tisak, Metalurgija 63 (2024) 3.

NOTE:

- Many authors / co-authors have not observed the given form and length of abstracts of their reports. Scientific board has made adjustments, so we apologize if there are any faults.An abstract might be failing.
All Protests will be accept till March 30, 2024, and after separately publish, Metalurgija 63 (2024) 3.

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Content – Sadržaj

Dear Participants, Authors, Co-authors et al.,

Thirty years (1993-2023) have passed since foundation of International Symposiums of Croatian Metallurgical Society „Materials and Metallurgy“. First Symposium (September 15-17, 1993) was postponed due to war operations in Sisak, and subsequently held in Zagreb, February, 16-18, 1994. Till now total 16, Countries participing were about 50, over 70 differents Institutions, total 6 562 Abstracts of over 10 000 Authors and Co-authors.

Dear al., my thanks to You, because without You this Symposiums would have never come about.

Special thanks and compliments are to many Members of Committees Scientifics, Organizing, Honour Boards, Reviewers, Chairman of Sections etc.

I just hapen to be first amoving equals.

Leader of all Symposiums

Akad. I. Mamuzić, Prof.h.c.,dr.h.c.

Countries Participating at the 17th International Symposium of Croatian Metallurgical Society “Materials and Metallurgy”

1 Argentina	**18** Greece	**35** Portugal
2 Austria	**19** Hungary	**36** Romania
3 Belgium	**20** India	**37** Russia
4 Belarus	**21** Indonesia	**38** Saudi Arabia
5 Benelux	**22** Iran	**39** Serbia
6 Bosnia and Herzegovina	**23** Italy	**40** Singapore
7 Brazil	**24** Japan	**41** Slovakia
8 Bulgaria	**25** Kazahstan	**42** Slovenia
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13 England	**30** Mexico	**47** Turkey
14 Egypt	**31** Montenegro	**48** Ukraine
15 Finland	**32** Netherlands	**49** USA
16 France	**33** Philippine	**50** Viethnam
17 Germany	**34** Poland	

All 17 Symposiums have been held:

1st Zagreb: 1994, February, 16-18 (88 lectures)
2nd Split: 1996, June, 20-22 (150 lectures)
3rd Šibenik: 1998, June, 25-27 (192 lectures)
4th Opatija: 2000, June, 25-29 (333 lectures)
5th Šibenik: 2002, June, 23-27 (375 lectures)
6th Šibenik: 2004, June, 20-24 (368 lectures)
7th Šibenik: 2006, June, 18-22 (475 lectures)
8th Šibenik: 2008, June, 22-26 (615 lectures)
9th Šibenik: 2010, June, 20-24 (541 lectures)
10th Šibenik: 2012, June, 17-21 (641 lectures)
11th Šibenik: 2014, June, 22-26 (689 lectures)
12th Šibenik: 2016, June, 19-23 (546 lectures)
13th Šibenik: 2018, June, 24-29 (561 lectures)
14th Šibenik: 2020, June, 21-26 (435 lectures)
15th Zagreb: 2022, March, 22-23 (527 lectures)
16th Zagreb: 2023, April, 21-22 (362 lectures)
17th Zagreb: 2024, April, 18-19 (224 lectures)

Materials – Section „A"

1. **J.F. Huang, Y.F. Meng**

Preparation and performance study of magnetorheological (MR) foam. In this study, a new kind of magnetorheological (MR) sponge was prepared by combining carbonyl iron particles with polyurethane porous structure. The static compressive property of MR foam was studied using a commercial rheometer. The relationship between magnetic particle composition, magnetic field and rheological properties was summarized and analyzed. The research contributes to a deeper understanding of magnetorheological sponge materials, and provides inspiration and theoretical basis for the design of soft actuators ,which may provide inspiration for novel application field.

2. **E.Y. Sun, X.Z. Meng**

Study on the effect of metallurgical waste on the cracking resistance of magnesium oxysulfate cement coatings. In this paper, in order to achieve the resource utilization of metallurgical industry waste, the cracking resistance of magnesium oxysulfate cement coatings using granulated blast furnace slag powder and iron tailings powder as fillers was studied, x-ray Diffraction (XRD) and scanning electron microscope (SEM) were used to characterize the hydration products. The results show that an appropriate amount of slag powder and iron tailings powder can make the internal structure of the coating more compact, the surface smooth and effectively reduce the generation of cracks.

3. **X. Y. Fu, J. Zhao, Z. J. Chen**

Mechanical bearing fault detection based on two-stage neural network. The monitoring and analysis of the bearing state is very important. It can find the early weak fault of the bearing and prevent the loss caused by the fault. This paper proposes a long-term and short-term network combining the lightweight convolutional block attention module (CBAM-LSTM). In the field of bearing fault detection, the experimental results show that the CBAM-LSTM method can accurately identify a variety of mechanical bearing faults with an accuracy of 99,13 7 %.

4. **H. Y. Dong, X. W. Cheng, J. Wang, L. C. Xiao, M. P. Liu**

Johnson-Cook (JC) constitutive equation for ZGMn18 high manganese steel. In the Finite element simulation, the constitutive equation of the material has an important influence on the simulation results. In order to obtain the constitutive model of ZGMn18 high manganese steel etc, according to the experimental results, the parameters of Johnson-Cook constitutive equation of ZGMn18 high manganese steel are deduced, and the Johnson-Cook constitutive model of ZGMn18 high manganese steel at room temperature is obtained. Finally, the prediction results of the model are compared with the experimental data, and the prediction curves are in good agreement, which verifies the feasibility of the model.

5. **I. Mamuzić, G.G. Shvachych, P.O. Shcherbyna**

Distributed systems for the analysis of temperature characteristics of heat treatment of metal with the network use of pyrometers. New industrial solutions in metallurgy actualized a certain number of problems of developing control systems for metal heat treatment modes in on-line mode. The use of built-in routing technologies in modern measuring devices allows you to create multipoint independent subnets at different distances. If a distributed system is chosen as a complex system for processing and managing subnets and equipment, it becomes possible to process certain data online. In this way, the speed of decision-making increases due to the separation of calculation and control processes.

6. **I. Mamuzić, G.G. Shvachych, P.O. Shcherbyna, J.S. Proydak**

Peculiarities of the application of the CUDA platform in the problem of heat treatment of a long-dimensional product. The selected equipment has the ability to use the CUDA platform, allows you to use the resources of the video card for non-graphical calculations. The advantages of the CUDA platform are its free, simple and flexible. A comparison of the existing means with the developed system showed the following. As a result of the application of software and hardware architecture based on the CUDA platform, it was possible to increase the amount of video memory by 16 GB in each computing node of the multiprocessor system, as well as increase the overall performance of the system nodes by 350 GFL.

7. **J. Deng, L.W. Chen, B.Y. Cui, Y.P. Li, H. C. Ji**

Arrhenius constitutive model of FV520B steel. To investigate the thermoplastic deformation behavior of FV520B steel, the Gleeble-3800 thermal simulation test machine is used to perform hot compression test on FV520B steel. Select a deformation temperature of 900 °C - 1 050 °C, set the strain rate to 0,005 s^{-1} - 5 s^{-1} . The results indicate that the Arrhenius constitutive model of FV520B steel with strain compensation correlation coefficient value is 0,99601, and the average relative error is 3,061 %, realizing the fitting of flow stress and prediction, verified the feasibility of the model.

8. **M.W. Liu**

Study on mechanical properties of 6061-T6 aluminum alloy. In order to obtain the accurate mechanical properties of 6061-T6 aluminum alloy, the tensile test of 6061-T6 aluminum alloy was carried out on a high-speed material testing machine, and the tensile test data of 6061-T6 aluminum alloy at different rates were obtained. Then, the Johnson-Cook constitutive model was introduced, and the formula was simplified based on the experimental conditions. The constitutive parameters were obtained by the stepwise estimation method, and the Johnson-Cook (JC) constitutive model of 6061-T6 aluminum alloy was established. Comparing the model prediction results with the experimental data, the prediction curves are in good agreement, which verifies the feasibility of the model.

9. **Z. C. Fu, Z. L. Zhao, F. Wang, T. K. Li, Y. Guo, H. C. Ji**

Tensile simulation of 6061 aluminum alloy. The quasi-static tensile simulation was carried out on the 6061 aluminum alloy round bar specimen, and the tensile specimen model was drawn. Three sets of simulation with uniaxial tensile velocity of 10 s^{-1}, 15 s^{-1} and 20 s^{-1} were set at normal temperature, and the numerical simulation of the tensile process was carried out by using ABAQUS software. The experimental data were imported into the model, and the relevant parameters such as damage model were set. The derived simulation results are in good agreement with the experimental results, indicating that the established simulation model can simulate the uniaxial tensile behavior of 6061 aluminum alloy well.

10. **Z. Y. Xuan, J. L. Miao**

Neural network-based intrinsic structure relationship of TC20 titanium alloy for medical applications. Isothermal constant strain rate compression experiments were carried out on TC20 titanium alloy using a Gleeble-1500 thermal simulation tester to investigate its high temperature flow behaviour at deformation temperatures of 750 - 900 °C and strain rates of 0,001 - 1 s^{-1}. The results show that the flow stress basically decreases with increasing deformation temperature and increases with increasing strain rate. The correlation coefficients and mean relative errors were 0,998 and 5,06 % respectively, proving that the BP neural network-based intrinsic structure model is effective in predicting the flow stress of the alloy.

11. **L. L. Meng, L. Zheng, X. Cui, R. Liu**

Research on surface defect detection method of metallurgical saw blade based on YOLOV5. As a typical cutting tool with good performance and high processing efficiency, metallurgical saw blades are widely used in various industries, but surface defects are inevitably generated in the manufacturing process. To solve this problem, this paper proposes a YOLOV5-based surface defect detection model for product quality, which can distinguish three common metallurgical sawblade surface defects with mAP value of 96,1 % in each defect category detection of metallurgical sawblades and detection time of 139,8 ms per image.

12. **S.Y. Sui, Y. Wang, J.F. Chen**

Effect of tempering temperature on microstructure and properties of 65Mn steel for metallurgical saw blade. The continuous tempering treatment of 65 Mn steel for metallurgical saw blade was carried out in the temperature range of 200-620 °C by means of metallographic observation and mechanical property test. The results show that with the increase of tempering temperature, the strength and hardness of the pattern decrease continuously, and the impact value, section shrinkage and elongation change significantly. The experimental results provide a technical reference for preventing the failure of the saw blade during operation.

13. C. Xu, H. J. Xu, X. D. Shu, X. B. Lu, L. L. Jiang

Effect of cold rolling process on texture evolution of gradient microstructure in Fe-3,0 % Si non-oriented silicon steel. The results show that the initial hot band has gradient microstructure. After normalizing, the surface is consisted of fine recrystallized grains, the central layer has elongated α-fiber and γ-fiber grains, the subsurface shows a mixed grain structure with strong Goss texture. After cold rolling with a thickness reduction of 40 %, α-fiber and γ-fiber textures are strengthened, and unstable Goss texture disappears. After annealing at 700 °C for 5 min, gradient recrystallization occurs and γ-fiber texture is weakened. The central and subsurface layers show frequently nucleation phenomena in the grain interior and grain boundaries, resulting in strong θ-fiber, α*-fiber and Goss components.

14. M. Góral, M. Mokrzycka, A. Przybyło, M. Drajewicz, P. Kwaśniewski, W. Głuchowski

The influence of plasma nitriding on the microstructure of X153CrMoV12 and X165CrV12 steels. This study presents the results of research into the influence of the time of the plasma nitriding process on the microstructure of the coatings obtained on cold-work tool steels X153CrMoV12 and X165CrV12. The processes were carried out under industrial conditions using an Ionit system (Oerlikon Metaplas) with variable process times of 2, 4 and 6 hours. Nitriding mixture consisting of 5 % nitrogen and 95 % hydrogen was chosen, which allowed the expected diffusion layer to be obtained without a white layer (composed of iron nitrides). Analysis of relative elemental concentrations indicates that the presence and content of nitride-forming elements influences the formation of alloy additive nitrides in the microstructure of the diffusion layer. Nitrides of alloying additives, present in the diffusion layer, indicating that investigated steels are the most suitable for plasma nitriding.

15. M. O. Sobolenko, I. Mamuzić

The influence of initial structure on the spheroidization rate of low-carbon boron-containing steels. The effect of hot plastic deformation and interrupted cooling on the kinetics of transformations in boron-containing steel is of significant interest in the study of the dependence of carbide spheroidization speed in steel during the annealing process based on the initial structure of the billet. The structural formation in the material samples was analyzed, and optimal conditions for spheroidization treatment were established for steels with initial bainite-ferritic and ferrite-pearlite-bainitic structures. The total annealing time was 0,5 hours.

16. A.P. Bilyi, T.V. Kimstach, S.I. Repyakh, I. Mamuzić

Structure formation and properties of cast bronze of increased strength. Structure formation and properties of cast bronze of increased strength depend on its composition. Foundry alloys are multi-component metallic substances with a complex of foundry properties, which ensures the production of castings of the required configuration with high operational capacity, specified dimensional accuracy and surface quality. The most important characteristics of the casting properties of alloys are fluidity, shrinkage, tendency to liquation, tendency to the appearance of internal stresses and cracks, non-metallic inclusions and degree of gas absorption.

17. X.B. Lu, X.D. Shu, S.Y. Chen, C. Xu, Z.X. Li, H.J. Xu

Effect of process parameters on forming quality of SiCp/TC11 titanium matrix composites by selective laser melting (SLM). In this paper, SiCp/TC11 titanium matrix composites were prepared by selective laser melting. The influence of laser process parameters on the forming quality of composites was studied by control variable method. The results show that the process parameters have a significant effect on the forming quality of the composite material. The laser power has the greatest influence on the density, followed by the scanning spacing, and the scanning speed has a relatively small influence. When the laser power is 160 ~ 180 W, the scanning speed is 1 000 ~ 1 200 mm/s, and the scanning spacing is 0,1 mm, the forming quality of the sample is better.

18. E. Tastanov, A. Ultarakova, E. Kuldeyev, N. Sadykov, Zh. Yerzhanova, A. Tastanova

Chemical sulfatization of chrome-containing sludges from Dubersay tailing dump. Waste chromium production sludge from the Dubersay tailings dump is present in huge quantities with a magnesium oxide content of up to 40 %. The chrome-containing waste was sintered at 1 100 °C, the resulting sinter was mixed with sulphuric acid when heated to 300 °C. The resulting mixture after heating was leached with water at 90 °C, the solid precipitate was washed and dried to yield a chrome concentrate containing 55,4 % Cr_2O_3, 8,2 % SiO_2. Evaporation of the purified solution produces magnesium sulphate which is a magnesium fertilizer.

19. A. Naizabekov, S. Lezhnev, I. Volokitina, E. Panin, A. Tolkushkin, S. Belsky, M. Pishchov

Investigation of the effect of combined thermomechanical processing on the brass microstructure evolution and the microhardness change. The article investigates the effect of combined thermomechanical processing, including pre-heat treatment and radial-shear rolling on the brass microstructure evolution and the microhardness change. As a result of combined thermomechanical processing, a gradient structure was obtained, so in the resulting rods with a diameter of 16 mm in the surface layer, a structure with an average grain size of 9 μm was obtained. In rods with a diameter of 12 mm, a fine–grained, equal-grained structure of 3 μm was obtained in the surface layer.

20. J.P. Hui, G.Y. Lian, J.S. Wu

The weld seam detection method based on the infocrnet model. Weld seam detection is particularly crucial within industrial systems, as it promptly reflects the quality of product fabrication and performance, ensuring the final metallurgical product's quality while mitigating potential losses stemming from product quality issues. This paper proposed the InfoFPN Cross Refinement Network (InfoCRNet) for the weld seam detection, achieving an accuracy rate of 98,90% and F1 score of 98,85%.

21. L. Xue, H.Y. Gao, F. D. Wang, G. L. Tan, W. Zhang

Studied on the kinetics of austenitizing phase transition of 1Cr13 steel. In this article, the Differential scanning calorimetry(DSC) was used to measurement the enthalpy change for the austenitizing process of 1Cr13 steel at different heating rates. The kinetic parameters were obtained based on the data of the enthalpy change for the austenitizing process of 1Cr13 steel. The result is shown that the activation energy of austenitizing process of 1Cr13 steel is dependence of the phase transition fraction. The kinetics mechanism function of the austenitizing process is nucleation and growth model, $[-\ln(1-\alpha)]^{2/3}$. The value of the pre-exponential factors is $8{,}617*10^{80}s^{-1}$.

22. E.Y. Sun, X.Z. Meng

Study on the effect of metallurgical waste on the water resistance of magnesium oxysulfate cement (MOS) coatings. In this paper, in order to achieve the resource utilization of metallurgical waste, this article studied the water resistance of magnesium oxysulfate cement coating using blast furnace slag powder and iron tailings powder as fillers, and characterized its hydration products using X-ray diffraction (XRD) and scanning electron microscopy (SEM). The results indicate that an appropriate amount of slag powder and iron tailings powder can make the internal structure of the coating more dense, effectively improve the softening coefficient, and enhance water resistance.

23. H. Wang, Š. Klarić, S. Havrlišan

Influence of activating fluxes on metallurgical characterizations in welding process for steels - a review. Activating fluxes can be used in welding processes like gas metal arc welding (GMAW) or tungsten inert gas welding (TIG) to improve the welding outcomes, as they can affect mechanical properties and microstructure as well as weld bead geometry, depth of penetration, shielding gas behavior, etc. The application of activating fluxes was researched on a wide range of welding materials like iron, magnesium, aluminum, or titanium alloys. This paper offers a summarized review of the effects of activating fluxes on the metallurgical properties of ferrous materials, presenting the influence of activating fluxes on the increase of ferrite content, phase transformation, and grain size.

24. D. O. Bannikov, O. Yu. Polozhechko, I. Mamuzić

Modern steels for building structures. Such steels include thermally hardened steels manufactured using a special controlled rolling technology with the addition of microalloying additives of chromium, niobium, vanadium and titanium, for example as 10G2FB or 10G2FBYu. As a result, steels have increased strength over 400 MPa, increased impact strength of 40–60 J/cm^2, and improved performance properties both at high and low temperatures. As the results of a theoretical analysis show, the use of such steels instead of traditional steels of ordinary strength makes it possible to reduce the mate-

rial consumption of a structure by an average of 30 % while maintaining its average cost, increasing the overall level of reliability and durability, and reducing exploitation costs.

25. O.A. Nosko, N.E. Pohrebna, A.V. Hrebenieva, T.A. Aiupova, O.A. Aiupov
34CrNi1Mo steel gear shaft destruction fractographic research. The fatigue nature of fracture is determined. It shows a high crack propagation rate and the low steel ductility. The fractographic surface is shiny, consists of cleavage facets with coarse scars, has a coarse-grained structure, typical for brittle fracture. By SEM the cleavage facets, microcracks, intergranular spall cells are detected. Non-metallic inclusions MnS have been revealed. Microhardness increase from 2500 to 4750HV after heating to 840–860°C with subsequent cooling in air was established.

26. K.O. Chornoivanenko, O.V. Movchan, I. Mamuzić
Features of steady-state α→γ recrystallization of ferritic iron alloys during carburization. The development of diffusion structures in multiphase, multicomponent alloys presents many features of metallurgical interest for study. One of these features is the morphology of interfaces between diffusion layers. The flat front of the α→γ polymorphic transformation (PI phase interface) becomes unstable under certain conditions of the carburization process. The flat PI stability was analyzed using the well known Mullins & Sekerka perturbation method. The analysis of single-phase cellular growth of the γ-phase layer during isothermal α→γ recrystallization of a carburized ferritic iron alloy was carried out. The resulting model can be used as a baseline for studying the growth of a in-situ austenite-carbide composite.

27. S. Volkova, V. Belozerov, I. Mamuzić
Tonlinear model with impulsive actions. Are constract the analytical model of a plane harmonic wave behaviour in a one-dimensional nonlinear optical medium with conductive nanofilms located periodically along wave propagation direction. Presents the modernized method of non-smooth transformation of the argument to eliminate the Dirac functions at the right hand of the non-linear inhomogeneous wave equation. The analytical model based on the nonsmooth argument transformation method is constructed, and the numerical calculations is performed to illustrate an application of the obtained model. The advantage of the proposed model is the possibility of its use in all cases where the wave theory of light is applicable.

28. I. Mamuzić, M. O. Sobolenko
Promising directions for comprehensive spheroidization of cementite in low-carbon steels for cold extrusion. Steels for cold extrusion should have a granular pearlite structure. Existing methods for spheroidizing cementite are time-consuming, making the reduction of the spheroidization process duration in low-carbon steels a relevant task. The main directions for comprehensive intensification of spheroidization annealing are considered: preparing the structural state of steel blanks before annealing, using temperature modes that provide proper cementite spheroidization, and utilizing internal heat transfer at all stages of the process.

29. I. Mamuzić, M. O. Sobolenko
The specifics of intensifying the process of spheroidization annealing in low-carbon steels. A systematic review of factors intensifying spheroidization in low-carbon steels and comparing data on the evolution of annealing time reduction allows distinguishing the primary factors that most significantly impact the intensification of the spheroidization process. The first factor is the thermal fragmentation of cementite through partial phase recrystallization. The second factor involves the prior preparation of the structure before spheroidization is carried out. The third factor is the transition from external heating to internal heating. The use of these factors in a specific systematic relationship leads to the intensification of spheroidization and significantly reduces the duration of the process.

30. M. O. Sobolenko
The study of the kinetics of the decomposition of undeformed austenite in boron-containing steels. Understanding the regularities in structure formation during rapid heating and cooling of boron-containing steels allows for the preparation of the structural state of steel blanks before annealing. The investigation of structural formation features was conducted using a differential-thermal analysis method. High-speed electrocontact heating of samples was employed on a laboratory setup equipped with water-air cooling devices and a control system for monitoring and regulating the heating and cooling process. The experiments provided experimental confirmation of the possibility of developing fast annealing regimes for low-carbon steels, resulting in a uniform distribution of cementite nodules within the ferrite matrix.

31. L.Kh. Ivanova, V.O. Terekhin, O.V. Yarovoi, I. Mamuzić
The effect of nickel content on the hardness of the working layer of two-layer rolling rolls. The working layer has the maximum hardness when the main part of the austenite turns into martensite. A further increase in the nickel content causes a decrease in the hardness of the working layer of the rolls due to the appearance of relatively soft austenite in their structure, an increase in the amount of annealing graphite and relatively soft austenite transformation products surrounding the graphite. Statistical processing of the data on changes in hardness depending on the nickel content showed a reliable correlation between these parameters: r = + 0.311; HSD = 51.3 + 5.9 Ni.

32. L.Kh. Ivanova, D.M. Nasonov, I.O. Osypenko
Dental cobalt-chromium alloys. Dental cobalt-chromium alloys used in prosthetics should not contain more than 29% chromium to prevent the appearance of a brittle alpha phase in the alloys and a sharp decrease in their casting properties. To increase strength, molybdenum and niobium are additionally introduced into these alloys, and silicon and manganese additives are also introduced into cobalt-chromium alloys to increase fluidity.

33. N. Lamla, P. Kwaśniewski, G. Kiesiewicz, M. Sadzikowski, K. Franczak
Research of the alloying additives content in high-silver solders on their susceptibility to soldering process. Brazing is a key technique for joining metals and their alloys. The essence of the brazing process consists in creating a suitable gap between the connected objects (with specially prepared surfaces), applying a suitable temperature gradient and utilizing the capillary effect of the brazing material at a temperature higher than its solidus. Copper and its alloys with steel, including stainless steel, are soldered using brazing materials Cu-Ag-Zn and Cu-Ag-Zn-Sn. They are used for making connections in heating, cooling and RES devices. The elements used in the above-mentioned alloys affect wettability, castability, corrosion resistance, impact resistance, plasticity, stress resistance and also lower the melting point of the solder. The article presents the impact of the percentage of alloying additives covered by the EN ISO 17672 standard on performance and susceptibility to soldering.

34. S. H. Wang, J. H. Ji, Y. P. Lou, M.Chen, C. C. Li, X. D. Yu
Study on the multiple dengrite growth of Al – Si binary alloy using phase – field method (PFM). Phase – field method offers the prospect of carrying out realistic numerical calculation on dendrite growth in metallic systems. The dendritic growth process of Al – 0,02mole % Si binary alloy was simulated by the coupling method of phase field and solute field. The effects of anisotropic parameters on the growth morphology of dendrite were studied. The results show that with the increase of the anisotropy magnitude, the secondary dendrite arms are more developed, and the dendrite tip is obvious oriented. For the multiple dendrite growth, the dendrites present the morphology from the tip splitting to the dendrite tip oriented. The multi dendritic branching and remelting states of Al – Si alloy were obtained and the directional solidification remelting and solute segregation were obtained under different anisotropic index conditions. And numerical simulations were conducted to investigate the growth of single and multiple dendrites under coupled conditions of phase field, solute field, and flow field.

35. A. Naizabekov, I. Stepankin, E. Pozdnyakov, S. Lezhnev, D. Kuis, E. Panin
Effect of surface modification of 5KHV2S steel on the mechanism and intensity of contact wear. The paper presents the experimental study of the contact wear of 5KHV2S steel after surface modification. It is shown that without hardening of the surface layer, 5KHV2S steel is capable of satisfactory operation when a pulsating contact stress of 970 MPa is applied. The most qualitative type of surface modification is the hardening of the surface layer by nitrocementation carried out before quenching and tempering. The proposed technology of volumetric-surface hardening, including forging in a new forging tool, chemical-thermal treatment, quenching and low-temperature tempering, provided the possibility of increasing the pulsating contact stress to 1 100 MPa, and the operation period during the first 13 000 loading cycles gives wear of the working surface no more than 0,1 mm.

36. V.F. Mazorchuk, M.A. Oleksiienko, I. Mamuzić

Study of drying conditions of shell mold layers on its properties. This pattern is explained by the fact that the application of each subsequent layer of refractory coating leads to the impregnation of the previously applied layers with the binder material. In this regard, the increase in the drying time of each subsequent layer is due to both an increase in the water saturation of the refractory coating as a whole and an increase in the length of the filtration channels in them, in the direction from the surface of the model to be melted to the surface of the coating.

37. A. Ivchenko, V. Pererva, O. Zuev, I. Mamuzić

Production of reinforcing steel from low-alloyed modified nitrogen steels. The actual task in the production of steel billets from low-alloyed steel grades is to increase the strength characteristics without increasing the production cost. The use of modification and micro-alloying schemes allows to increase the strength and performance characteristics of steel products. New technologies for modifying steel by separating nanodispersed excess phases under different conditions significantly increase the strength and plastic properties of steel billets. The increasing consumption of reinforcing rods with appropriate strength and ductility characteristics leads to high requirements for their production, which can be achieved by the technology of carbonitride hardening of steels containing vanadium and less often niobium.

38. D. L. Guo, C. D. Wu, C. J. Wang, Y. L. Wang, M. L. He, L. J. Zhang, H. C. Ji

Lifting method to analyze pipeline deformation. Lifting is to use lifting equipment to lift components and install them to the designated position. On the main structure, lifting equipment is used to transport the flue and transport the sectional flue to the designated position. Certain deformation will occur during the lifting operation of the flue due to its force condition, but it is not known whether it is elastic deformation or plastic deformation. Therefore, this paper analyzes the stress and strain of the flue during operation by finite element method, and observes and analyzes the influence of plastic deformation on the whole flue.

39. P. Huo, J. F. Chen, X. Li

2209 duplex stainless steel high temperature plastic deformation intrinsic modeling. The high temperature compression experiments of 2209 duplex stainless steel were carried out by using Gleeble3800 thermal simulator, the rate was 0,01~10 s^{-1}, and the deformation temperature was 950~1 100°C. The strain rate and deformation temperature were analyzed and the effect of strain rate and deformation temperature were analyzed. The high-temperature rheological behavior of 2209 duplex stainless steel was investigated, and the effects of strain rate and deformation temperature on the two-phase relationship of 2209 duplex stainless steel were analyzed, the strain rate compensation factor Z was introduced, and the Arrhenius eigenmodel equation was established. The results show that the theoretical value of peak stress calculated numerically by this constitutive model fits well with the experimental results, and the correlation is 97,3 %, which verifies the feasibility of the model.

40. Y. Y. Shao, Z. W. Jia, Q. Guo

Effect of finishing rolling reduction on microstructures and textures of grain oriented silicon steel. The effect of finishing rolling reduction on microstructures and textures of grain oriented silicon steel was researched by optical microscopy, zeiss ultra 55 Scanning Electron Microscope (SEM) and Electron Backscatter Diffraction (EBSD) technique severally. The results show that the grain size of hot rolled sheets and decarburized strips decreases, while the center grain size of the normalized sheet increases with the increase of the finishing rolling reduction. The pearlite content increases with the increase of the finishing rolling reduction after normalization. Compare with the previous research, the effect of finishing rolling reduction on the grain size of primary recrystallization is greater than that of roughing rolling reduction, and large rolling reduction is beneficial to the formation of {110}<001> texture.

41. Akhyar, P. T. Iswanto, V. Malau, F. P. Putra, A. Farhan

Fatigue strength of Al-Cu cast alloy with different pouring temperature. This experiment aimed to evaluate how pouring temperature affects fatigue strength of Al-Cu cast alloy. Subsequently, commercial aluminum ingots, such as Al-2024 were remelted and then machined into samples for both tensile and fatigue testing. These samples were cast at three different temperature of 688, 738, and 788 °C while maintaining a constant mold temperature of 220 °C. The results showed that the highest tensile strength was 201,06 MPa at 738 °C. Additionally, the greatest fatigue strength was observed at 80,4 MPa at pouring temperature of 738 °C. It was observed that variations in pouring temperature can significantly impact fatigue strength of cast alloy. At the highest pouring temperature of 788°C, the presence of pores in the metal casting samples resulted in a decrease in both tensile and fatigue strength. Furthermore, when examining the surface fractography of casting sample, the presence of brittle cracks in alloy was observed.

42. I. A. Hasani, P. T. Iswanto

Improvement of mechanical properties and fatigue life of stainless steel 316L in 0,9 % NaCl environment by applying shot peening and plasma nitriding treatments. Among metallic biomaterials, AISI 316L has the cheapest price yet but the lowest mechanical properties and it is prone to corrosion. Bone plate failure is often triggered by dynamics load, crevice or pitting corrosion, or a combination of fatigue and crevice or pitting corrosion attack at the same time. Shot peening and plasma nitriding are surface treatments that enhance material properties. This work examined the shot peening duration effects and plasma nitriding on surface to the depth hardness, roughness, droplet contact angle, and fatigue life in environment containing rich chloride ions. The results revealed that shot peening and plasma nitriding improved both surface layer roughness and hardness. Furthermore, shot peening and plasma nitriding reduced droplet contact angle and enhanced the fatigue life of the material.

43. Y.S. Chen, X.D. Shu, Y.X. Xia, Z.X. Li, H.J. Xu, S. Zhang

Deformation law of aerospace thin-walled the rods with three-roll size reduction and end extrusion thickening. Aiming at the aerospace aircraft tie rod pipe fittings with indented riveted threaded bushing manufacturing, there are problems such as low connection strength, manufacturing cost and high weight, this paper innovates a new process of three-roll reduction and end extrusion thickening to form the aerospace thin-walled tie rods, and adopts the simufact finite element analysis software to numerically analyse the forming process of the thin-walled fittings of A6061 aluminium alloy and analyse the equivalent plastic strain distribution, the change rule of the force-energy parameter, as well as the uniformity of the wall thickness in the process of rolling and squeezing, so that we can get the principle of rolling and squeezing forming and deformation rules of the thin-walled tie rods, and the results of the research provide the theoretical foundation for the domestic forming of the thin-walled tie rod pipe fittings.

44. C. Yang, J.R. Zuo, Q.D. Zhang, J.J. You, A.M. Yin, X.D. Shu, B.Z. Mei, G.B. Wang

Effect of cryogenic and heat treatment on microstructure and mechanical properties of Al-7Si-1,5Cu-Mg. An Al-7Si-1.5Cu-Mg alloy was synthesized through the modification of a commercial A356 alloy with the inclusion of alloying elements. This alloy underwent a treatment regime comprising solid solution, cryogenic treatment, and ageing. The results indicate that cryogenic treatment increased nucleation rate of precipitates, which increases the number of precipitates and reduces their sizes, ultimately improving the mechanical properties and reduce secondary dendrite arm spacing of the alloy. Under the optimal treatment conditions (solid solution at 520 °C for 10 hours, followed by deep cooling for 48 hours, and ageing at 160 °C for 10 hours), the secondary dendrite arm spacing of the alloy was reduced by approximately 37,5 %, exhibiting hardness of 102,8 HV and plasticity of 4,2 %.

45. J.B. Liu, J. Wang

Study on crystal structure of $PbTiO_3$ nanowires by X-ray researches. $PbTiO_3$ nanowires is produced by stainless steel reaction kettle with Teflon lined. The crystal structure of nanowire was analyzed by electron backscatter diffraction (EBSD). At present, EBSD is seldom used to analyze these powder materials with fine crystalline grain and nanosized materials. An attempt is carried out to analyze the powder materials with fine crystalline grain by EBSD. $PbTiO_3$ nanowires is investigated by EBSD, and then analyzed by X-ray diffraction and Scanning Electron Microscopy (SEM). The crystal structure of $PbTiO_3$ is P4mm(99), and the cell parameter is cell = 3,905 × 4,156 Å. Experimental results of EBSD are accordant with that of XRD, which illuminates that surface EBSD analysis technique is feasible to determine crystal structure and orientation of powder material with new structure.

Process Metallurgy – Section „B"

1. X.Y. Liu, Y. Y. Wang, H. Jin

Study on the mechanism of cobalt recovery from waste lithium cobaltate batteries in citric acid system. The waste lithium cobalt acid batteries were utilized as raw materials to separate out $LiCoO_2$ cathode material. Citric acid was used to leach cathode material, and $LiCoO_2$ leaching solution was electrodeposited to obtain cobalt plating, in the meantime the Li^{2+} ions were enriched. The optimized conditions of leaching process are 1,2 mol/L citric concentration and 0,35 mol/L sodium thiosulfate concertation, the leaching efficiency of cobalt and lithium is 97,5 % and 97,0 % respectively. At pH 4, the smooth cobalt coating with fine grains can be obtained on the surface of the stainless-steel cathode.

2. Y.Q. Cai, S.Y. Chen, S.Cai

Thermal analysis of rare earth electrolytic robots under high temperature environment. Based on ANSYS software and APDL language, the thermal-structural coupling simulation analysis of the rare earth electrolysis robot is carried out to construct the temperature distribution and thermal deformation model of the robot, and the thermal deformation error and connecting rod machining error are considered comprehensively to obtain the linkage length dimension error model, which provides some theoretical basis for the robot error compensation to improve the accuracy.

3. R. Wang, D. X. Gao, Y. J. Zhang

Finite time command filtered adaptive fuzzy control for a twin roll inclined casting system. This paper, the adaptive fuzzy control problem for finite-time command filtering is studied at the twin roll inclined casting system. An explosion of complexity caused by a differential surge can be avoided by constructing adaptive fuzzy controller combined with command filtering and backstepping schemes. The designed adaptive fuzzy controller ensures simultaneously the stability and tracking performance of the closed-loop system in a limited time, and the tracking error converges in a small neighborhood of the origin. Eventually, a simulation example is given to verify the effectiveness of the proposed scheme.

4. X.X. Lu, X.D. Shu, C.Q. Dong, B.S. Sun, G.H. Li

Numerical simulation and optimization of die casting for automotive shift tower cover. The structural characteristics of the car shift tower cover were analyzed, and the pouring system and overflow system were designed according to the empirical formula.The numerical simulation based on Anycasting software shows that the metal liquid flow and solidification rate of the initial process are not smooth.According to the simulation results, the shape of the runner and the number of the gate were modified, and the point cold water pipe was set at the position where the defects might occur to optimize the process.The numerical simulation of the optimized process scheme shows that the filling process is stable and there is no liquid spatter, and good quality die casting is obtained through actual production.

5. M. Yaholnyk, M. Boiko, I. Mamuzić, A. Kruhlov, S. Zhuravlova, N. Poliakova

Improving the structure of the sinter layer to improve product quality. To achieve a rational structure of the agglomerated layer, it is important to determine the influence of the composition and properties of the raw materials on the mixing and palletization of the charge; the question of rational moistening of the materials during the palletization in order to achieve the required particle size distribution of the pelletized charge; the evaluation of the components ratio of the sintered charge, taking into account their particle size distribution, on the palletization at different moisture consumption; the determination of the moisture consumption interval for palletization.

6. V. Yefymenko, M. Boiko, M. Fursov, M. Yaholnyk, I. Mamuzić

Optimization of biochar integration in coking and sintering: quality and emission implications. Biochar, compared to coke, has a reduced fixed carbon content and calorific value. However, it's cleaner with fewer impurities like ash and sulfur. When blended with coal, its inert properties can compromise the strength of coke connections. To ensure high-quality coking products, it's advisable to keep biochar additions below 2%. The coke's strength and reactivity decline with diminishing biochar particle size. For biochar sourced from hardwood, a size range of 2.4–3.4 mm is optimal. In the sintering process, substituting coke breeze with up to 60% biochar can drastically reduce COx, SOx, and NOx emissions.

7. X. L. Dong, Q. K. Tu, Y. Q. Cai

Flexible constant force grinding of rare earth metal ingot. The rare earth metal ingots obtained by molten salt electrolysis method have oxide layers, salt layers, and other impurities on the surface, which require polishing processing. However, currently, manual polishing processing has problems such as low processing efficiency and resource waste. By designing a flexible end effector and adopting a parallel fuzzy Proportion Integration Differentiation (PID) control strategy for constant force control of the end effector, automation and high efficiency of rare earth metal ingot grinding are achieved.

8. Y.F. Wang, L.Y. Wang, Y.Q. Cai

Optimization of flow field and numerical simulation of slag entrapment behavior in slab crystallizer. The results show that an increase in casting speed intensifies the fluctuation of the steel slag interface, and as the immersion depth of the nozzle increases, the fluctuation of the steel slag interface gradually stabilizes. Section 950 mm × 230 mm crystallizer with a submerged depth of 120 mm at the nozzle and a casting speed of 1,1 m/min can avoid slag entrapment.

9. X. Zhen, Y. Q. Cai, X. L Dong, Q.K. Tu

Research on automatic grinding platform for rare earth ingot casting. Aiming at the problems of low grinding efficiency and difficulty in ensuring grinding uniformity of rare earth metal ingots, a rare earth metal ingot grinding system was designed. Based on Creo software and ANSYS/Workbench software, the kinematics analysis, modal analysis and transient dynamics analysis were carried out on the walking mechanism and flipping mechanism of automatic displacement platform of grinding system. The results show that the rare earth metal ingot grinding system has good stability and is beneficial to improving the grinding quality.

10. J. H. Peng, X. W. Cheng, J. Wang, L. C. Xiao

Analysis of temperature field and thermal stress of molten iron slagging-off robot arm. In this paper, the transient temperature field and thermal stress of the slagging-off robot arm were analyzed by finite element method. The results show that the temperature of the equipment in the slagging-off process can reach 206 °C, and the heat can be transferred to the position of 200mm, which will not affect the key parts in the manipulator. Due to the direct contact with molten iron, the heat stress and deformation of the slag-scraping plate are large, which may result in the high melt loss rate of the slag-scraping plate.

11. X.B. Lu, X.D. Shu, S.Y. Chen, Z.Y. Zheng, Z.X. Li, H.J. Xu

Feasibility study of SiCp reinforced TC11 titanium alloy under selective laser melting. SiCp/TC11 composites were prepared by selective laser melting (SLM) technology. The results show that the milling speed, time and SiC content have an effect on the morphology, size and distribution of the composite powder. Compared with TC11, the hardness of the composite prepared by SLM process is 426,723 HV, which is increased by 15,10 %, and the enhancement effect of SiCp is successfully realized.The research results provide a theoretical basis for obtaining high-quality aerospace titanium alloy parts.

12. H. Z. Yang, Z. C. Liu

Study on the strength of iron and steel smelting waste blast furnace slag. The waste blast furnace slag generated during the steelmaking process is used as the basic material, and an appropriate amount of fly ash is added to conduct shear tests to obtain the shear mechanical indicators of the fly ash blast furnace slag mixture, thereby obtaining the strength mechanical properties of the mixture. The test results show that there are few fine particles in the mixture, which is not enough to affect its shear mechanical properties, so the water content has little effect on the shear strength of the mixture, and the mixture has good water stability; In the shear test, it can be found that the greater the normal stress, the greater the initial shear shrinkage, and the smaller the later shear expansion. After the normal stress exceeds 150 kPa, the shear expansion significantly decreases.

13. J. R. Zhou, Y. Q. Cai, X. Liu
Kinematics simulation of temperature measuring robot for steelmaking furnace. Aiming at the temperature measurement in the refining process, a temperature measurement robot that can go deep into the furnace for temperature measurement is designed. Based on the D-H parameter modeling method, the kinematics of the manipulator is modeled, and the forward and inverse kinematics of the manipulator are solved. The workspace of the manipulator is simulated by Monte Carlo method on MATLAB, and the joint trajectory of the manipulator is planned by using Robotics Toolbox. The angular displacement, angular velocity and angular acceleration curves of each joint are obtained through simulation. The simulation results show that the manipulator runs smoothly and continuously, meeting the requirements of kinematics.

14. Y. F. Wang, Q. Q. Yin, Y. Q. Cai
Research on force control system of lead cathode leveler. The flatness of the lead cathode plate affects the electrolytic efficiency of lead and the production efficiency of the whole lead electrolytic industry. However, the dynamic response of the force control system of the leveler is slow, and the anti-interference and robustness are poor. By comparing proportion integration differentiation (PID) control and feedback linearized synovial control two control strategies, MATLAB software was used for modeling and simulation analysis. The results show that the system with feedback linearized sliding mode control has faster response, higher precision and better robustness.

15. W.C. Pei, Y. Hu, G.F. Cui, H. C.Ji
Numerical simulation of welding of intersecting line joints of 6061-T6 aluminum alloy bicycle frame. The joints of aluminum alloy frames are usually welded by manual TIG welding. In order to study the distribution law of welding stress level and welding temperature field of intersecting joints of 6061-T6 aluminum alloy bicycle frames, a intersecting joints model of welding parts was established by Finite Element Model (FEM), Software. Based on ABAQUS software, the welding temperature field and welding stress field were studied and analyzed by using direct thermal coupling method. The accuracy of welding simulation is fully verified, which can meet the simulation requirements required for the subsequent optimization process design, and achieve the purpose of shortening the time required for the accumulation of practical inspection.

16. D.A. Issagulova, Sv.S. Kvon, A.E. Omarova, T.V. Kovaleva, V.Yu. Kulikov, A.A. Alina
Studying the binder effect on the properties of briquettes of ferroalloy production waste. The paper shows the results of studies in searching for a binder for briquetting finely dispersed dust (FDD) of ferroalloy production of the Kazakhstan content. The fractional composition and shape of FDD particles were studied. Liquid glass and caustic soda were used as a binder. The research results showed the possibility of using liquid glass as a binder. Experimental briquettes have sufficiently high compressive strength and drop strength, which implies the possibility of their transportation and loading.

17. Ye. Tastanov, N. Sadykov, M. Dossekenov
Melting of calcined pellets with production of high-carbon ferrochrome. The use of composite calcined pellets obtained according to a sequential scheme of chemical and gravitational beneficiation of dump sludge tailings of the Dubersay tailing dump as a part of a charge with factory chromium concentrate enabled to obtain high-carbon ferrochrome FeCr70C90Si4LP China Standard where the low phosphorus content is not more than 0,03 % and that of sulfur is not more than 0,1 %. The obtained samples of high-carbon ferrochrome and slag were studied. The maximum chromium content was 57,14 % at 1 750 °C, the charge sample included 50 % of experimental pellets and 50 % of factory concentrate and reducing agent 17 %, chromium recovery into the alloy was 80 %.

18. I.A. Solovyova, Yu.M. Nykolayenko, V.F. Balakin, I. Mamuzić
Forecasting the accuracy of pipes in mandrelless drawing. Technological routes for the production of pipes from stainless and carbon steels were investigated. Following the developed routes batches of pipes were stretched and wall thickness measurements were taken at equidistant points of the cross-cut of the pipes. A correlation-regression analysis was conducted, regression models were built, and it was established that the intensity of the correction largely depends on the cross-wall heterogeneity of the initial workpiece, the compression coefficient along the diameter and the degree of thin-walled pipe. The research results were introduced into route calculations in order to predict the difference in thickness of finished pipes during drawing and introduce a reduction in metal consumption in production.

19. V. I. Musiyko, O. M. Stoyanov, Ye. V. Synehin
Production of steel with a low content of harmful impurities. Recent studies have shown that large reserves for improving the quality of finished steel and enhancing its mechanical properties lie in the area of achieving a low content of harmful impurities such as S, P, N, O, Cu and other non-ferrous metals. The theoretically desirable maximum content of impurities in solid iron should not exceed the solubility limit. The authors propose an approach to the producing "clean" steel, starting with out-of-blast furnace iron treatment, low-slag converter smelting and out-of-furnace steel treatment processes at CCM and vacuum units.

20. V. O. Ruban, O. M. Stoyanov, Ye. V. Synehin, I. Mamuzić
Review of out-of-furnace steel treatment technologies at the ladle-furnace using hollow electrodes. A review of existing technologies for out-of-furnace steel treatment at a ladle-furnace has been carried out. Since the process of high-temperature heating of a conventional electrode causes its physical and chemical destruction, the feasibility of using a graphitized hollow electrode with gas supply through its channel was considered. It is noted that the presence of a channel in the electrode provides a positive effect on the formation and existence of an electric arc, improvement of metal desulfurization conditions, decrease of processing time, and reduction of electrode consumption.

21. K. H. Niziaiev, O. M. Stoianov, T. A. Shashkin
Recycling of steelmaking slag in metallurgical production. Solution of the problem of rational use of material resources in metallurgical production allows increasing the product competitiveness and, simultaneously, improving the environmental situation in the region. Using the results of high-temperature studies the substitution coefficients of fluxes and sinter in blast furnace melting with stabilized BOF slag (SBS) have been calculated. The use of SBS in the blast furnace charge allows sinter to be replaced with a coefficient of 0.5 and limestone to be completely eliminated. In addition, it allows the replacement of fluxed sinter in the blast furnace charge.

22. K. H. Niziaiev, O. M. Stoianov, Ye. V. Synehin, A.V. Skrypnyk
Interaction of firebricks oxides with carbon. The reaction between carbon and oxide in the presence of oxygen has great significance for refractories in the oxide-carbon system (MeO-C). Typically, this system can be represented by a triple M–O–S. As temperature rises during the process, the rate of oxygen penetration into the refractory significantly increases, which heightens the probability of MgO recovery as the amount of oxidized carbon in the refractory increases.

23. Ye. V. Synehin, K. H. Niziaiev, S. V. Zhuravlova, R. Ye. Ostrianin, M. O. Dei, M. O. Ekongo
Methods of electromagnetic stirring of metal in the CCM mould. A review is carried out of the methods of electromagnetic stirring of metal in the liquid core of a billet during steel casting in a CCM. The scope of their application, advantages and disadvantages are considered in line with the recognized classification of these methods. Further, the potential of using electromagnetic stirring in roll casting of steel is discussed.

24. S. Zhuravlova, R. Dutnii, M. Boiko, I. Zhuravlova, I. Mamuzić
Disposal of aluminum-containing waste in out-of-furnace steel processing. One of the technological methods of steel treatment is the use of synthetic slags. This approach ensures optimal contact between the slag and metal phases and enables the conditions for subsequent slag separation. The production of non-ferrous metals and alloys generates aluminum slag. The mixture consists of aluminum, its oxides and alkali metal compounds. Prolonged storage of aluminum slag is hazardous to the environment, as large accumulations pose a significant threat of air, surface and groundwater pollution. It is therefore crucial to recycle it in out-of-furnace metal processing.

25. S. Zhuravlova, A. Marko, M. Boiko, O. Tanchev, V. Mameshyn
The use of agricultural waste in steel production. The growing proportion of advanced high-strength steels in overall steel production, typically containing higher carbon levels than conventional low-carbon steels, demands the application of carburizers. The utilization of sunflower husks, sunflower stalks, corn, and straw displays potential. However, the effective utilization of these biomaterials requires specific preparation technologies for carburizing steel. The paper examines the characteristics of carburizing materials obtained from bio-based resources and their influence on the steel carburizing technique, the chemical composition of steel and its uniformity.

26. M. Boiko, V. Treshchov, S. Zhuravlova, N. Poliakova
Use of plant-based carbon materials for metallization of iron ore pellets. Efficiently utilizing even small quantities of plant-based feedstocks from recycled materials in metallurgy allows us to save traditional fossil fuels and gain valuable experience using alternative fuel technologies in metallurgical production. We are considering the issue of replacing fossil fuels in the metallurgy of iron ore raw materials, thereby solving a whole group of problems: reducing the use of fossil fuels, simplifying steelmaking technology and the possible economic benefits of replacing natural gas with biomaterials. Biomaterials act as not just fuels, but also reducing agents in these operations.

27. V. Yefymenko, M. Boiko, M. Fursov, M. Yaholnyk
Green transitions in energy and metallurgy: exploring bio-based alternatives. Pyrolysis technology, drawing from diverse raw materials like garden and food waste, produces biochar is a sustainable alternative to coal, boasting porosity and stability. Similarly, vegetable oils such as soybean, palm and rapeseed present robust alternatives to fossil fuels. Krakow's Technical University in Poland has innovated a unique blend: 70-80% coal sludge with 20-30% plant waste, yielding solid fuel granules. Elsewhere, Poltava Mining, under Ferrexpo, utilizes sunflower husks as fuel, conserving 5 million cubic meters monthly. Integrating biomaterials in metallurgy can reduce flux costs. Direct iron production further sidesteps the polluting blast furnace stage, streamlining metallurgy.

28. V.V. Bochka, M.V. Yaholnyk, K.V. Shmat, A.V. Sova, M.O. Fursov
Evaluation of sinter stabilization efficiency during machining. The essential criteria for proficient stabilization of the sinter concerning particle size distribution and strength during machining are follows: the combined effect of impact, abrasion and splitting forces; lowering the loading energy during machining from 100 to 30-40 J/kg by reducing the size of the pieces themselves. By modelling various structural and technological factors that impact the destruction of lumps in a drum, the research was able to determine the nature and extent of their influence on the type and magnitude of load energy on the sinter.

29. I.Y. Vodin, I. Mamuzić
Theoretical substantiation and development of technology for the carbon-thermal process of ferrosilicoaluminum smelting. The work performed a thermodynamic analysis of the Al-O-C and Si-O-C systems using new and refined thermodynamic data. Phase equilibrium diagrams of the systems were constructed in the coordinates $\log(P_{SiO}/P_{CO}) - 1/T$, $\log(P_{Al2O}/P_{CO}) - 1/T$. Based on thermodynamic analysis, the calculation of the material, thermal and energy balances of the carbon-thermal process of producing the Si45Al20Fe alloy (ferrosilicoaluminum) was carried out in relation to ore thermal smelting in the RKO-5.0 furnace. The data obtained were used in the development of technology for the carbon-thermal process of smelting ferrosilicon aluminum in relation to the conditions of existing ferroalloy plants in Ukraine (Zaporozhye and Nikopol ferroalloy plants).

30. V.F. Balakin, S.A. Sviridov, S.V. Savkin, Yu.M. Nykolayenko, T.V. Balakhanova
Modeling the influence of the texture of cold-rolled sheet on deformation behavior during high-speed deformation. The issues related to steel armor plates for Class 4-5 body armor with minimal weight are highly relevant. Traditional metallurgical and materials science approaches to producing homogeneous hot-rolled plates from armor steels have largely exhausted their capabilities. Multilayer plates made of cold-rolled carbon steel 08 KP with a thickness of 1 mm were used as samples for impact testing. The influence of the deformation texture orientation between the plates was simulated using ANSYS. Numerical modeling led to the conclusion of the necessity for further research.

31. S.A. Sviridov, S.V. Savkin, T.V. Balakhanova, I.A. Solovyova, V.F. Balakin
Enhancing the durability of armor plates using vibration. The application of physical methods in conjunction with the best examples of domestic steel armor will enable the production of lightweight, cost-effective Class 4-5 body armor. Low-frequency vibration, combined with various amplitudes, was employed as the dynamic impact on the armor plate. Tests were conducted on 30HN2MA and 30HGSA steels with a thickness of 6.7 mm. The results of bullet penetration tests (7.62 PS cartridge with a steel heat-treated core) demonstrated 100% protection when vibration was applied, whereas without vibration, the same plate experienced complete penetration.

32. T.A. Fonarova, I. Mamuzić
The concept of optimizing business processes within the framework of the compliance program of metallurgical production. This concept consists of the following phases: 1 – organization of business process improvement; 2 – documentation and development of a set of documentation techniques; 3 – analysis of opportunities for improvement; 4 – design of a new business process; 6 – implementation of solutions aimed at the future; 7 – management of administrative business processes for continuous improvement. It is advisable to design and manage all business processes within the framework of the metallurgical production compliance program, built on risk assessment and included in the enterprise information system using a decision support system.

33. T.A. Fonarova
Facilitation as a new direction in personnel management of metallurgical companies. Facilitation in the management of metallurgical enterprises ensures: 1) constructive collective interaction and cooperation in achieving the goal; 2) partnerships between the manager and employees create opportunities for solving problems and overcoming difficulties; 3) the effectiveness of training and advanced training of personnel at trainings, seminars, etc. The absence of a commanding and directive tone in relationships creates powerful motivational conditions for transforming intellectual potential into real human capital of an enterprise. Facilitation, as a modern personnel management tool, fully complies with the concept of value-based management and helps to increase the goodwill of a metallurgical enterprise.

34. I. Mamuzić, O. Dmitrieva, M. Lefterov, V. Huskova
Simulation of solid-particle interaction. To implement the simulation process, mathematical models of solid particle interaction were developed and justified, algorithms for processing elastic and inelastic collisions, motion, interaction were implemented, and relations for calculating numerical indices of forces were obtained. On the basis of motion and interaction models the known algorithms of numerical integration were modified. Taking into account the large volume of calculations, the application of parallel block methods for numerical solution of ordinary differential equations and their systems used to describe dynamic processes was proposed. The program system was developed using the principles of object-oriented programming and design patterns.

35. L.I. Solonenko, O.P. Bilyi, A.A. Taranov
Production of ceramic shell forms using man-made raw materials. The production of ceramic shell forms using man-made raw materials is an innovative approach to the creation of high-quality shell structures. It is necessary to select appropriate man-made raw materials, such as slag or dust. All materials are subject to appropriate processing and preparation. Casting of ready-made forms takes place according to the volumetric casting technology. This approach to the production of ceramic shell molds helps to conserve resources and helps to reduce the negative impact on the environment.

36. R.V. Usenko, O.V. Meniailo, V.Yu. Shemet
Rational designs of high-strength cast iron molds with a cast gauge profile for rolling rolls. Rational designs of high-strength cast iron molds with a cast gauge profile for rolling rolls contribute to improving the efficiency of the production of metal products. The cast profile of the gauge ensures the exact geometry of the rolls and increases their service life, which is important for the quality of metal processing.

37. O.P. Bilyi, I.O. Osypenko, V.F. Mazorchuk
Designing technological departments of shops. The design of foundry departments involves optimizing the flow of materials and processes, which helps to reduce production time and reduce costs. In addition, it takes into account the introduction of advanced technologies and provides convenient

access to equipment for maintenance and repair. Professional design of technological departments of shops helps to increase the competitiveness of the enterprise and achieve high standards of production quality.

38. V. Pinchuk, T. Sharabura, S. Pinchuk, I. Mamuzić

The study of coal thermal activation at different stages of metamorphism. The study of physical and chemical transformations patterns in coal thermal activation process allows to establish rational parameters of heat treatment. This leads to changes in fuel structure and properties, increasing its combustion efficiency. To establish the temperature and time limits of the previous thermal exposure, experimental studies were conducted during which coal samples from the metamorphism series were heated to certain temperatures in the air atmosphere for a certain time. It has been established that during the coal thermal activation, intermediate compounds are formed that significantly change the ignition reaction mechanism, and thermally prepared coal has twice the reactivity of unprepared coal.

39. O. Yu. Gusev, V. V. Sidanchenko, I. Mamuzić

Fractal analysis in the problem of predicting the chemical composition of cast iron. Until recently, it was believed that time series of data on the chemical composition of cast iron at the output of a blast furnace obey a normal distribution law. We have found that these series have the property of time scale invariance (self-similarity). Phenomena of nonlinear dynamic self-organization were discovered in the system, confirmed by RS-analysis. It has been demonstrated that the series have long-term memory and a strange attractor with one attraction zone. Therefore, for adequate modeling and forecasting of such series, it is necessary to use stochastic processes that have self-similar and fractal properties.

40. T. Merder, S. Kozłowski, J. Pieprzyca

Modelling of hydrodynamic phenomena occurring in refining ladles for high-carbon Fe-Si alloys. This paper presents the results of research conducted with the use of water physical model of refining ladle for production of high-carbon FeSi alloys. The purpose of the research was to determine the possibilities to enhance the efficiency of the production process by using combined gas injection into the bath. The research involved analysis of four variants of the experiment. Those variants varied in terms of the location of a purging plug fitted in the model bottom and the application of immersion lance to support the process. The research involved the analysis of changes in the hydrodynamic effects in the ladle model occurring as a result of the gas injection. The tests consisted in a qualitative analysis (process visualisation) in order to identify the movement of the modelling liquid and the mechanism of gas bubbles behaviour in the liquid.

41. A. Proydak, M. Yashyn, I. Mamuzić

Results of Research on Mineral Varieties of Phosphorite Ore. Comprehensive studies of the mineral varieties of phosphorite determined that the phosphorus-containing mineral substance in the "Peremoha" deposit (Kharkiv region) is represented by a mass cementing non-metallic minerals such as quartz, glauconite, calcite, and plagioclase. The presence of fluorine in the phosphate substance composition confirms its affiliation with francolite, with a mineral formula of $Ca_5[F, OH \mid (PO_4)_3]$. It has been established that the francolitic cement of phosphorite ore is represented by a cryptocrystalline mass (aggregates), the individual entities of which are not distinguishable under an optical microscope. The mineral has a hardness of 5 on the Mohs scale and a density of 3.18 g/cm^3.

42. L.V. Kamkina, Yu.S. Proydak, Ya.V Mianovska., O.O. Zhadan, I. Mamuzić

Experimental determination of effective conditions for zinc and lead removal from electric steelmaking dust. Chipboard dust was thermally treated under reducing conditions using anthracite in an argon flow (consumption 7.5 l/h) in a closed aluminum oxide crucible. The temperature of isothermal holdings was 9000C, 10000C, 11000C. The exposure time is 2.5 hours. At temperatures of the order of 1000...1100°C, the content of Zn in iron-containing dust and sludge decreases, and the original finely dispersed materials are sintered. Effective removal of zinc from chipboard dust is already possible at moderate temperatures of 1000...1100°C. To obtain a liquid product, it is necessary to provide an excess amount of carbon to lower the temperature of the melt.

43. L.V. Kamkina, Yu.S. Proydak, Ya.V. Mianovska, V. Khodak

Determination of the chemical and mineralogical composition of dust from electric steelmaking production. The main mineralogical components of the dust are zinc ferrite, magnetite, zincite and lime, while lead is present in relatively small amounts as an oxide. The chemical and structural characteristics of chipboard dust with different Zn content are given. The following phases were detected: ZnFe2O4, Fe3O4, MgFe2O4, FeCr2O4, Ca0.15Fe2.85O4, MgO, Mn3O4, SiO2, ZnO. Phases identified by Mössbauer spectroscopy: ZnFe2O4, Fe3O4 and FeCr2O4. At the same time, X-ray structural analysis revealed the presence of other metal-containing complex compounds, such as ZnFe2O4, ZnMnFeO4, ZnO, graphite, and other chemical compounds with zinc, iron, and aluminum. , magnesium, copper and manganese.

44. Yu.S. Proydak, V.Yu. Kamkin., O.H. Bezshkurenko, O. Remez

Electric steelmaking production of ultra-low carbon steels. Production of electric steel smelting production from ultra-low carbon steels. Ultra-low carbon steel grades 01ЮТ, 01ЮТА are used for the production of thin sheet with an increased complex of mechanical properties. Smelting of ultra-low-carbon (0.002-0.005% carbon), microalloyed aluminum steel with a minimum content of harmful impurities (P < 0.010%; S < 0.005%; N< 50ppm; O< 30ppm; H< 2ppm) was carried out. Rolling was carried out on a continuous broadband condition. Before rolling, the metal was heated in an electric furnace. Rolling was carried out on a laboratory single-cell condition for two passes in the austenitic and ferritic temperature ranges.

45. O. Gryshyn, A. Nadtochiy, R. Guba

Thermodynamic regulations of gas-oxygen conversion of methane ne. There is a permissible amount of residual methane for converted gas. At a constant H2O/CH4 ratio, the growth of the oxidant excess is achieved due to an increase in the amount of introduced oxygen by only 0.1 molar volume (from 0.6 to 0.7), an increase in the amount of heat released by almost 1.5 times (from 103.86 to 158.27 kJ). In conditions of an excess of oxidants, the additional introduction of oxygen (up to 5-7% of the initial mixture rich in reducing agents) allows you to fully compensate for the energy costs for carrying out endothermic reactions of steam and carbon dioxide conversion of methane.

46. O. Gryshyn, A. Nadtochiy, L. Mamonova, I. Mamuzić

Kinetic regulations of gas-oxygen conversion of methane. The process of steam-carbon dioxide and gas-acid conversion of natural gas on sponge iron was experimentally investigated. Replacing half of (H2O+CO2) with an equivalent amount of oxygen allows you to increase the degree of conversion at 1033 K by 1.25 times and raise the concentration of (H2+CO) in gaseous products to 97%. The conversion largely depends on the contact time of the gas mixture with the catalyst. An increase in doubling time due to the height of the layer of freshly reduced iron provided an increase of 1.2-1.25 times, and due to a decrease in the gas flow rate ~ 1.13 times.

47. O. Gryshyn, A. Nadtochiy, A. Gritsenko

Velocity of gas flows during complex recovery of coal pellets. The optimal parameters for the complex extraction of coal pellets in the absence of liquid phases were determined. The influence of the size of the granule, the proportion of gasified carbon, the temperature and the depth of penetration of hydrogen into the granule on the position of the border dividing the volume of the granule into two parts was determined. Carbon-thermal recovery takes place in the inner sphere. Complex recovery (C + H2) is implemented in the external sphere. An equation was obtained to describe the influence of the considered process parameters on the values of gas flows.

48. A.G. Velichko, A.S. Grek, I. Mamuzić

Application of an induction furnace for solid-phase reduction of iron oxides. For the solid-phase reduction of iron oxides and melting of steel in an induction furnace, briquettes from a mixture of ore-coal component and iron-containing material were used. The high efficiency of solid-phase recovery and melting of steel is shown. The optimal option was the use of pellets (briquettes), which include metallized sponge, coal and iron ore concentrate. A frontal recovery mechanism is implemented in iron coal briquettes: the coolant and reductant are inside the briquette, there are no temperature and concentration gradients, and the determining parameter is the process temperature

49. E.L. Sorokin, V.Yu. Kamkin, N.O. Kashirna, K.V. Baikina
Expansion of the raw material base of coking by involving energy low-firing coal. The problem of coke chemical enterprises is the unstable raw material base of coking, in particular, the shortage of high-sintering coal. It is proposed to expand the raw material base of coking to use an understanding of the molecular and supramolecular structure of coal of various brands, which will allow the use of low-sintering thermal coal in industry and obtain a final product with the necessary set of specified properties. Regularities between the structural organization of the component composition of coal macromolecules and its physicochemical properties have been established.

50. I.V. Derevyanko, O.V. Zhadanos, Y.V. Yaroshenko, I. Mamuzić
Research on silicon carbide product obtained from technogenic materials. The chemical composition of the studied material after deducting free carbon is as follows, wt.%: 76.36 SiC, 6.3 SiO_2, 5.6 Al_2O_3, 2.9 Fe_2O_3, the rest are impurities. The X-ray pattern shows that the reduced product is characterized by SiO_2 – β-tridymite lines, SiC is represented mainly by β-SiC and α-SiC 4H. Polytypes 6H, 15R and 51R are present in the product in small quantities. Conclusions: the obtained product does not meet the requirements for abrasive silicon carbide according to its polytype composition, but it can be successfully used for the production of refractories.

51. I.V. Derevyanko, O.V. Zhadanos, O.G. Ageev
The search for new ecological binders for the production of carbon graphite products. The development of electrothermal production, in particular the production of carbon graphite products, consists in reducing the environmental burden on production. One of the areas of innovative development of technologies for the production of carbon graphite products is the involvement of alternative filler materials, in particular binders with a low content of carcinogenic substances. The conducted patent search confirms that one of the directions for solving the issues of reducing the environmental burden on the production of carbon graphite products is the involvement in the technology of lignosulfonates.

52. A.V. Ruban, O.O. Riabtsev, I. Mamuzić
Peculiarities of manganese recovery during the smelting of medium-carbon ferromanganese. Medium-carbon ferromanganese has increased requirements for the content of carbon, silicon and harmful impurities (phosphorus, sulfur). It is expedient to use the silicothermal method of melting the alloy. The process is two-stage: in the first stage, a reducing agent (ferrosilicomanganese with a content of 25-35% silicon) is obtained, and in the second - medium-carbon ferromanganese. In order to reduce the concentration of silicon, the alloy is subjected to bottom blowing, which partially leads to the oxidation of manganese. The paper researches ways to improve silicothermal recovery and substantiates the equilibrium state of the "metal-oxide phase" system.

53. V.A. Gladkikh, O.V. Anosov
The compromise solutions for the selection of the optimal composition of raw material for smelting of ferrosilicomanganese. During the smelting in the ore reduction furnaces the level of the manganese recovery is determined by the technology and located in the range 76-86%, but iron and phosphorus almost fully transfer to the metal. The article considers a possibility of costs minimizing (Y0) for smelting of the given quality of ferrosilicomanganese due to the optimal selection of the main components of charge: Y0=Y1+Y2+Y3+Y4+Y5 (1) where Y1, Y2, Y3, Y4, Y5 – appropriate costs of manganese, iron-containing raw materials, electricity, reductant and flux. Y1=C1X1+C2X2+C3X3+…. CnXn (2) where C1, C2, C3…Cn – raw material price, X1, X2, X3,… Xn – quantity of raw material.

54. V.A. Gladkikh, V.P. Kravchenko, I. Mamuzić
Improvement of high-percentage ferrosilicon smelting. Ferrosilicon is one of the most widely used ferroalloys, since almost all steels contain silicon. Ferrosilicon is smelted using a carbon-thermal method using different types of carbon reducing agents. Much attention is paid to the qualities of the reducing agent, mainly in terms of sulfur content, its reactivity, electrical resistance, it must have a suitable fraction. The search for effective compositions of several types of carbon reducing agents is a constant task in the implementation of ferrosilicon smelting technology with a Si content of 65-75%.

55. Y. K. Wang, C. Y. Shi, Z. H. Bao
Prediction of the outlet temperature of the converter dry-type dust removal evaporative cooler based on LAOA-SCN. This study utilized improved Arithmetic Optimization Algorithm for Optimizing Stochastic Configuration Networks. This resulted in the establishment of the outlet temperature prediction model, LAOA-SCN, for the converter dry-type dust removal evaporative cooler. To assess the predictive performance of model, a comparative analysis was conducted with algorithms such as Back Propagation, Radial Basis Function, and Twin Support Vector Regression. Finally, the model was applied to practical production verification, confirming its high prediction accuracy. This underscores its potential to provide theoretical guidance for the control of outlet temperature in converter dry-type dust removal evaporative coolers.

56. Z.C. Ma, L. Zhang, C. Y. Shi, X. Wang, Y.K. Wang, P.L. Tao, P. Sun
Prediction of oxygen consumption in steelmaking based on LAOA-TSVR. To solve the issue of oxygen consumption forecasting, the researchers suggested a twin support vector machine for regression (LAOA-TSVR) prediction model based on an improved arithmetic optimization algorithm. The model has beneficial generalization, high prediction accuracy, and the ability to jump out of the local optimum and other characteristics. The group used the method of mechanism analysis to determine the main influencing factors of oxygen consumption. To confirm the model's prediction effect, it is compared to the Back Propagation, Radial Basis Function, and Twin Support Vector Regression prediction models. The LAOA-TSVR oxygen consumption forecasting prediction model was then tested on actual steel mill production. The test phase consisted of 200 production cycles, and the results revealed that the LAOA-TSVR model had an 85,1 % hit rate for oxygen consumption within 5 m^3/t. The model can suit the actual needs of predicting oxygen consumption in steel.

57. Kh.B. Omarov, Zh.T. Nurtai, N.U. Nurgaliyev, Y.Y. Zhatkanbayev, E.B. Zhunusova, A. K. Zhumabekova
Rational extraction of arsenic from copper production waste. Practically and theoretically important are studies aimed at creating new methods for purifying copper electrolyte with the removal of such a dangerous impurity as arsenic in a form suitable for the intended use. Using probabilistic-deterministic planning of the experiment, the course of chemical reactions in manganese- and arsenic-containing systems, the directions of reactions and the stability of their constituent phases were studied. Based on experimental data and thermodynamic analysis, the probable behavior of chemical elements and their compounds, the limits of potential and pH, within which a given compound of an element must be stable, are determined. X-ray diffraction identified the formation of manganese arsenate ($Mn_3(AsO_4)_2 \cdot 4H_2O$) in deposits formed during the extraction of arsenic from a copper electrolyte with manganese (IV) oxide.

58. J. K. Huang, X. Li, S. X. Hong, T. J. Gu, Y. B. Huang, H. R. Wang
Density functional theory (DFT) study on the reaction mechanism of in-situ no reduction in hydrogen rich blast furnace. Based on density functional theory and classical transition state theory, the reaction mechanism of NO reduction by H_2 catalyzed by coke in hydrogen rich blast furnace was investigated. The results showed that the presence of active sites on the coke surface promoted the NO reduction reaction. Reactive oxygen species remaining on the coke edge inhibited the NO reaction after NO reduction. Both coke and H_2 can release edge sites by reducing reactive oxygen species, but reactive oxygen species reduction by H_2 requires a high barrier value of 634,3 kJ/mol, which is higher than that by coke.

59. C.X. Li, Y. Zhang, Y.K. Xue, D.G. Zhao, S.H. Wang, K.X. Zhang, X. Meng, H.J. Shen
The thermal decomposition mechanism of small particle limestone under high CO_2 partial pressure. Converter blown limestone powder steelmaking process has the advantages of energy saving and high efficiency to meet the needs of low carbon metallurgy. Based on a thermogravimetric-differential thermal analyzer, the effect of high CO_2 partial pressure on the pyrolysis behavior of limestone at steelmaking temperatures was investigated at 20 °C/min, 30 °C/min, and 40 °C/min, the kinetic parameters of limestone pyrolysis were calculated by the improved double extrapolation method.

60. O.P. Bilyi, V.Ye. Khrychykov, I. Mamuzić, V.O. Zakharov,
The use of controlled heat exchange in the production of castings. Controlled heat exchange is widely used in the production of castings. The use of controlled heat exchange in the process of manufacturing castings helps to achieve high quality and accuracy of products by regulating the metal cooling temperature, which allows to avoid defects and increase productivity.

61. R.V. Usenko, V.F. Mazorchuk, R.R. Barkar, I. Mamuzić

Justification of the technology of melt processing in foundry ladles. Treatment of melts in ladles is an important technological operation that has several valid advantages. First, this technology allows accurate dosing of materials and melts, ensuring high quality products. Secondly, processing in ladles allows you to control the temperature, composition, which affects the structure and properties of the material. The treatment of melts in ladles is essential to support the production of high-quality parts and contributes to the productivity and efficiency of the casting process.

62. L.I. Solonenko, D.Yu. Yakymenko, O.P. Bilyi, I. Mamuzić

Cladding sand structuring in the manufacture of foundry molds based on frozen models. Clad sand structuring plays an important role in the production of casting molds from frozen models. This process helps ensure casting accuracy and quality. The sand is compressed around the model, forming a shape. The relief surface of the model is transferred to the mold, and this is critical for the production of parts with the necessary configurations. It is important that the structure is uniform and strong to ensure successful casting and product quality.

63. Z. Cui, H. Y. Long, R. Q. Gong, F. Y. Zhu, W. Z. Yan

Structure optimization of ladle rotary table mounting device. As a widely used equipment in continuous casting process, the installation process of ladle rotary table is complicated and requires many installation equipment.According to the practical engineering application, this paper takes the installation device as the research object, and optimizes the original structure of the installation device.SolidWorks software was used to model the overall structure of the installation device, and the established model was imported into Hypermesh for mesh division, and finally into ANSYS for finite element analysis to compare the stress and deformation of the structure before and after optimization.The results show that the stress of the optimized structure is reduced to some extent, and the practical application requirements are met.

64. P. Huo, Y. J. He, J. F. Chen

High temperature deformation constitutive model of GGG70L duction iron. In order to accurately describe the high temperature deformation behavior of GGG70L ductile iron, the thermal simulation experiments with deformation rate of 0,01~10 s^{-1} were carried out at 800~1 100 °C by Gleeble-1500D thermal simulation machine. The deformation behavior of GGG70L ductile iron was studied. The temperature compensated strain rate Zener-Hollomon parameter was introduced, and the constitutive model of GGG70L ductile iron was established based on the strain compensated Arrhenius model. The results show that the theoretical value of peak stress calculated by the constitutive model is in good agreement with the experimental results, and the correlation is 97,8 %, which can accurately describe the high temperature deformation behavior of GGG70L ductile iron.

65. V.M. Shevko, R.A. Uteyeva, A.D. Badikova

Electrothermal co-production of ferrosilicon, calcium carbide and gaseous phosphorus from the chilisay phosphorite. The article presents the results of studies on the use of the high-silicon phosphorites (51,8 % of $Ca_3(PO_4)_2$, 25,6 % of SiO_2) for the co-production of ferrosilicon, calcium carbide and gaseous phosphorus. The studies included the electric smelting a charge in an arc furnace and using the second-order rotatable designs. The conditions of producing FeSi45 ferrosilicon (51,2-54,2 % of coke, 12,5-18,4 % of steel shavings) and FeSi25 ferrosilicon (53-58 % of coke, 39,7-40 % of steel shavings) with extraction of 65-67,8 % of silicon into the alloy were determined. The second product of the process is technical calcium carbide with a capacity of 129-167 l/kg, in which from 44,8 to 64,1 % of calcium is extracted. At least 99,3 % of phosphorus during the electric smelting is sublimated.

66. M. J. Mvita, N.G. Zulu, B. Thethwayo, S. Makhamisa

Thermodynamic effects of temperature during roasting of chromite for sodium chromate salts formation. This paper aims to assess the potential effects of roasting temperature on the formation of sodium chromate (Na_2CrO_4). To perform this task, chromite samples were complexed with NaCl at temperatures ranging from 900 °C to 1 200 °C in the presence of excess oxygen. These experimental conditions were set and assessed based on the predicted phase transformations using Facstage as a prediction tool. The scanning electron microscopy and energy dispersive spectroscopy (SEM-EDS) have revealed the roasting behaviour of chromite to be governed by a fully reacted outside layer and an unreacted core. As per the x-ray diffraction (XRD) results, at lower temperature settings, mineral phases such as hematite and chromium oxide reported as an indication of predicted oxidation of chromite. The key results indicate that the addition of NaCl reduces the equilibrium temperature, thereby fully decomposing the stable and refractory spinel structure of chromite at 1 200 °C.

67. M. Walkowicz, P. Osuch

The role of surface wettability of copper and its alloys CuSn6, CuZn37 in antimicrobial efficacy standardized tests. The spread of bacterial infections often occurs through indirect contact with infected individuals. Thus, surfaces with antimicrobial properties have gained prominence in healthcare and public spaces. Testing standards exist for assessing the antibacterial effectiveness of these materials, but they do not consider surface properties, particularly surface wettability during microbiological tests. An experiment was conducted to modify copper and its alloys' surfaces through chemical treatment, altering contact angles. The results revealed that contact angles significantly influence the contact area between droplets and test surfaces, as well as the evaporation time of droplets. These factors can ultimately impact the results of antimicrobial efficacy tests.

68. W.L. Fu, L.W. You

Influence of additional stress caused by mining subsidence on blast furnace in metallurgical mining area. Underground goaf in metallurgical mining area leads to surface subsidence and has destructive effect on blast furnace. This paper studies the influence of underground goaf on blast furnace. The overlying strata and surface subsidence due to the formed gob area after the underground mining led to a different degree of destruction to blast furnace. Hence, blast furnace was modeled to theoretically analyze the additional stress applied to blast furnace body and foundation when withstanding the surface deformation. On this basis, the anti-deformation structure was designed to analyze the influences of Class I - IN surface deformation on the setting of Blast furnace body unit

69. K. Akishev, K. Aryngazin, A. Tulegulov, M. Bayzharikova, Zh. Nurtai

Evaluation of the efficiency of the technological process for the production of building products with fillers from metallurgical slag. The article presents studies related to the practical use of metallurgical slags by Limited Liability Partnership "Casting", Limited Liability Partnership "Kazakhstan Steel Production-steel" in the production of building products. The process of preparation and experiments to determine the strength of control samples, full-scale tests of building products are shown. The relevance of the study lies in the fact that the technological process of production of building products involves technogenic waste that cannot be used in the process of metal production, which makes it possible to improve the ecological background in the region, as well as promising opportunities for obtaining raw materials used as ingredients of concrete mixtures. The presented practical implementation of the automation of the process of adding fillers (technogenic raw materials) in the preparation of a concrete mix allows increasing the efficiency and productivity of the production of building products. The article will be useful to everyone who conducts research in the field of recycling of industrial waste from metallurgy, as well as commercial use.

70. L. X. Sun, L. L. Li

Mathematical modeling and intelligent optimization solution of gas allocation problem in iron and steel production. This paper studies gas allocation problem in the iron and steel production. Gas allocation problem is a multi-objective optimization problem with complex constraints. A gas allocation problem is mathematically modeled with high dimension, non-linear and complex constraint features. The intelligent optimization algorithms have certain advantages in solving such model. An improved Differential Evolution algorithm based on individual quality evaluation is proposed to solve the above model. The results show multiple gas allocation schemes are provided when all constraints are met, and all optimization objectives of some schemes are better than then manual gas allocation scheme.

Plastic Processing – Section „C"

1. Z. H. Wei, Y. J. Zhang, X. J. Wang, J. T. Zhou, F. Q. Dou, Y. H. Xia

A YOLOV8-based approach for steel plate surface defect detection. Hot-rolled steel strips are a commonly used product in both production and daily life. However, the manufacturing process inevitably leads to the occurrence of surface defects. To solve this problem, Our method uses YOLOV8 and squeeze-and-excitation (SE) attention mechanism to detect surface defects in hot-rolled steel strips. Our method balances accuracy and real-time performance, while detecting four common surface defects. The method has an average accuracy of 90,9 % and a maximum accuracy of 98,5 % for detecting a single category of surface defects. Experimental results confirm good performance of our proposed method in classifying and localizing surface defects in hot-rolled steel strips, and has the potential for broad application and promotion.

2. P. Huo, F. L. Zhang, X. Li

High temperature plastic deformation constitutive model of Mg-Zn-Zr-Y alloy. In order to accurately predict the flow stress of Mg-Zn-Zr-Y alloy at high temperature, the hot compression test of Mg-Zn-Zr-Y alloy was carried out on Gleeble-1500 thermal / mechanical simulator. The deformation temperature was 523 K, 573 K, 623 K, and the strain rate was 0,01 ~ 1 s^{-1}. By obtaining the true stress-strain curve, the strain compensation factor Z parameter was introduced into the Arrhenius equation to establish a more accurate strain coupling constitutive model. The results show that the theoretical value of the peak stress calculated by the constitutive model is in good agreement with the experimental results, and the average relative error is 5,67 %, which verifies the feasibility of the model.

3. Y. M. Li, X. D. Shu, Q. Chen, Z. X. Li, H. J. Xu, Y. M. Deng

Feasibility analysis of short process flexible precision forming of aluminum alloy automobile hollow shaft. Aiming at the large weight of automobile steel solid shaft, this paper innovates aluminum alloy hollow shaft. The rolling process of automobile hollow shaft was simulated by using the short process flexible precision forming process and the Finite Element Method (FEM). The variation of the shape and inner hole of the rolled piece, the roundness of the outer surface and the wall thickness during the rolling process were analyzed. The numerical results verify the feasibility of rolling aluminum alloy automobile hollow shaft by this process, and provide a theoretical basis for forming aluminum alloy automobile hollow shaft in China.

4. J. Lulkiewicz, B. Pachutko, A. Kawałek, T. Bajor, S. Szkudelski, Sz. Kajpust

Ewaluation and analysis of the large-size forged and rolled EN AW – 7057 alumminum alloy ring structure. The article presents the results of tests on the structure and hardness of a large-size ring made of EN AW - 7075 aluminium alloy produced under industrial conditions at the Zarmen FPA forge according to the developed technology - a combined forging and rolling method. Studies of the ring were carried out in order to assess its structure and hardness after the forming processes. The scope of the study included microscopic observations (microstructure and EDS), X-ray phase analysis and hardness distribution measurements.

5. X.L. Dong, J.W. Wang, Y.Q. Cai

Study on the effect of work roll bearing fit clearance and speed on the vibration of leveling mill. The vibration of the leveling mill is common in metallurgical enterprises, which causes vibration marks on the surface of the support rolls and affects the surface quality of the strip. This paper establishes a bearing-rotor system model for a leveling mill, and finds that reducing the bearing clearance helps to improve the stability of the mill. The study of different speeds under the amplitude of the change, the work of the roll system gap changes on the vibration of the mill. Finally, the results of the study can provide reference for the theory of vibration suppression of rolling mills.

6. Q.D. Zhang, J.R. Zuo, C. Y. Xie, X. D. Shu, C. Yang, J. J. You, Y. M. Deng

Simulation of microstructure evolution during extrusion of large depth-to-diameter ratio variable cross-section hollow shafts of 6061 aluminum alloy. The hollow slender shaft is characterized by intricate component features such as a significant depth-to-diameter ratio, variable cross-sections, and non-uniform thin walls. Uneven deformation of the hollow slender shaft during deformation results in degradation of service performance. In this study, the deformation uniformity is explored from a microscopic point of view, the numerical simulation model of dynamic recrystallization of 6061 aluminum alloy is established with the DEFORM-3D software. And grain evolution during the aluminum alloy extrusion process was theoretically analyzed using the cellular automata.

7. A.V. Ivchenko, O.V. Zuev, I. Mamuzić, Yu.A. Bublikov, G. I. Perchun

Production of reinforcing bars with a strength class of 500–600 MPa with increased performance properties. For construction in seismically active regions reinforcement with a set of high performance properties should be used: strength, ductility, endurance, fire resistance, fire safety. The latter is possible due to carbonitride strengthening by microalloying steel with the "N - Ti - Al" system with a high N at the ratio of components, wt., %: C - 0.14...0.28; Si - 0.05…0.90; Mn - 0.50…1.60; Al - 0.025…0.060; Ti - 0.020…0.035; N - 0.012…0.028. Thus, the level of reinforcement properties is achieved: $\sigma_т \geq 500...600$ N/mm^2; $\sigma_в/\sigma_т \geq 1.15$; $\delta_р \geq 5.0\%$; impact strength KCV$^{60} \geq 30$ J/cm^2; fire resistance and fire safety threshold 500 °C.

8. M.A. Myronenko, L.V. Opryshko, T.V. Golovnyak, R.M. Korol, V.O. Zaleshchenko

Requirements for the quality of pipe shells for boiler tubes. In order to obtain boiler tubes with high operational reliability, it is necessary to use high-quality pipe shells with a set of properties in full compliance with the current regulatory documentation. The DSTU 8966 standard does not provide full and reliable control of contamination of undeformed continuously cast boiler pipe shells by non-metallic inclusions. It is necessary to develop a modern method of control with the selection of samples over the entire cross-section of the ingot, with scales of various types of non-metallic inclusions and standards for contamination of boiler ingots by all types of non-metallic inclusions and introduce them into the current regulatory documentation for seamless boiler pipe shells.

9. M.A. Myronenko, V.L. Galatska, I. Mamuzić, O.A. Kolisnyk, T.I. Lysenko, V.R. Berkunov

Analysis of trends in the development of pipe and agricultural enterprises of Ukraine based on the results of 2022 and the forecast for 2023. The agriculture of Ukraine slowed down its development in conditions of full-scale aggression according to the results of 2022. The dynamics of the change in the volume of the agricultural export volume is identical to the change in the volume of the production of pipe products in Ukraine in 2022. It is worth noting that overcoming permanent crisis phenomena and striving for improvement are the keys to further progress, even in the conditions of martial law. The given examples of the development of agricultural and mining-metallurgical complexes of Ukraine clearly testify to this.

10. I. Mamuzić, G.G. Shvachych, P.O. Shcherbyna

Peculiarities of controlling temperature characteristics of heat treatment of metal using high-temperature infrared pyrometers. For the application of information and industrial solutions in metallurgy, the task of analyzing and managing metal heat treatment modes in on-line mode is relevant. The use of modern pyrometers gives the parameters of the metal processing process a multi-point appearance. Analyzing the existing methods of heat treatment of drawing samples, it is desirable to install control devices in a semi-radial form, obtaining data both on the cross-sectional plane of the sample and on its length. In this way, measurement errors are almost completely eliminated and the speed of decision-making increases significantly, which is extremely important for controlling the metal processing process.

11. Y. Proydak, M. Nytkin

Evaluation of the Manufacturing Technology for Railway Axle Billets. A technological audit of the current continuous technology for producing forged profile billets from EA1N (35Г) steel for railway axles was conducted, with a focus on the feasibility of obtaining axles that can consistently meet the requirements (standards) of the International Union of Railways standards UIC 811-1 OR and EN 13261. The required tensile strength of rough forged axles made from EA1N (35 Г) steel was achieved through regulated carbon and manganese content, as well as adherence to developed heat treatment regimes. The conducted research indicated potential prospects for further exploration of technological solutions for manufacturing rough forged railway axles from continuously-cast vacuum-treated steel billets.

Metallurgy and Related Topics – Section „D“

1. P. Huo, J. S. Liu

Equilibrium moisture model of ceramic green body during drying. The drying stage of ceramic green body is crucial in the production process, and the equilibrium moisture content achieved by green body drying is very important for the green body firing stage. Based on the modified Oswin equilibrium moisture model, the influence of hot air temperature and relative humidity on the equilibrium moisture content of SiO_2 and Al_2O_3 ceramic composite green body drying was studied through hot air drying experiments, and according to the experimental data, the equilibrium moisture content data was fitted by the least squares method to determine the equilibrium moisture content model.

2. D. Wang, C. Song, Y. Gui, G. Ni, J Liu, S. Wang

Theoretical calculation and simulation analysis of the enhanced crushing process of high nitrogen steel molten droplet. High nitrogen steel has been widely explored and developed due to their unique properties. At present, most of the references on high nitrogen steel powders prepared via gas atomization mainly focus on their initial and secondary crushing. The research on the enhanced crushing process caused by the "nitrogen escape" inside the high nitrogen molten steel is rare. In this paper, the enhanced crushing process of high nitrogen steel molten droplet is investigated based on the theoretical calculation and numerical simulation, which reveals the enhanced crushing mechanism of nitrogen-containing droplets in the process of preparing high nitrogen steel powders by atomization method.

3. Sz. Pawlak

The impact of lean manufacturing on the number of failures in a metal industry production plant – case study. The article presents the results of an analysis of the impact of selected Lean Manufacturing tools on the number of failures occurring on the example of a production plant from the metal industry, specializing in the production of welded pipes. Reducing the failure rate of individual devices on the production line is one of the key factors determining the efficiency of the production process and the quality of the manufactured product. In order to reduce unplanned machine downtime caused by failures, various techniques are introduced to reduce them, for example TPM (Total Productive Maintanance). The purpose of this article is to conduct a statistical analysis to assess the impact of TPM implementation on the number of reported failures on one of the production lines.

4. V. V. Bilotserkivets, O. O. Zavhorodnia, I. Mamuzić

Prospects for the development of digital technologies in the metallurgical industry. The COVID-19 epidemic was an important trigger for changes in the world economy as a whole and metallurgy as its industrial part. The study demonstrates the role of formal and informal restrictions of direct contacts along the chains of producer-producer, producer-consumer, consumer-consumer actors in strengthening the role of remote technologies in communication and production. The research reveals the features of the wide implementation of digital technologies in the world economy at the level of the metallurgical industry. The researchers have proven the labor-saving content of digital technologies in the metallurgical industry. The study showed the role of digital technologies in the implementation of consumer-oriented development of the metallurgical industry.

5. M.A. Myronenko, V.L. Galatska, V.V. Filipenko, B.P. Filipenko

Ukrainian metallurgical terminology: specificity of the translation strategy. Borrowings of metallurgical vocabulary from other languages are phonetically and morphologically adapted in the modern Ukrainian language. In most cases, the borrowed root of the word with the addition of Ukrainian language affixes has been preserved (for example *вальцювати, вальцювання, вальцевий, вальцювальник* (Germ. walzen) or *бесемер, бесемерівець, бесемерування*, *бесемерувати* (Eng., named after Sir Henry Bessemer, English engineer). In these examples, it is the suffixes that are the international codes of the terms. Noun, adjective and verb forms adequately express the rich word-forming possibilities of the Ukrainian language. This translation trend promotes the development of cross-cultural competences.

6. M.B. Bushuiev, V.O. Petrenko, I. Mamuzić

Formation of organizational capital of a metallurgical enterprise. One of the areas for improving the activities of a metallurgical enterprise is the formation of organizational capital Conditions and factors for increasing the organizational capital of an enterprise: 1) collective interaction; 2) priority of functions over structure; 3) elimination of dysfunctions in the operation of the enterprise; 4) regulation and optimization of production processes in space and time; 5) compatibility of professional and collective norms; 6) organizational management structures based on standardization l; 7) the possibility of transforming human intellectual potential into objects of intellectual property rights; 8) conditions for flexibility of functions in relation to structure; 9) formalization and regulation of procedures for the use of modern information IT technologies.

7. A. Dolzhanskiy, O. Bondarenko, I. Mamuzić

Algorithm for implementation of the method of complex qualimetric assessment of the object quality. A generalized algorithm for the quality qualitative assessment of a multiparameter stochastic object for any sphere of economic activity has been developed. The algorithm includes the information obtaining and analyzing of control parameters that can be used for the process influence to ensure the maximum value of the complex quality indicator. Analysis of the obtained data showed that reducing the number of single quality indicators taken into account reduces the complex indicator level, but increases the sensitivity on control parameters changes, which can be useful for real quality management of various facilities processes.

8. O. Bondarenko, V. Treshchov, I. Mamuzić

Improving the quality of waste transportation logistics taking into account european regulatory documents. An analysis of the regulatory and legal documentation of Ukraine regarding the transportation and management of solid household waste as a part of cities transport system was carried out. The main problems of the transport system of the Dnipro city have been identified; the conditions of formation of transportation routes by the carrier company in accordance with international and regional environmental standards were investigated. A general route optimization algorithm was developed to improve the logistics system of waste transportation for one of the city districts.

9. A. M. Dolzhanskiy, O. A. Bondarenko

The parameters normalization influence on the object complex quality indicator extremum. When evaluating objects using the convolution of their complex quality indicator, it is important to determine its extremum. To achieve their dimensionless form in the range from 0 to 1, normalization of functions relative to certain basic values is used. The corresponding theoretical analysis was performed by varying the types of a complex quality indicator convolution (weighted average: arithmetic, geometric, harmonic) and parameters functions (linear, power, indicate, exponential). The data obtained for the first time revealed differences in the dependences of the complex quality indicator extremum of the facility management tools levels for the various options considered.

10. T.A. Fonarova, I. Mamuzić

Compliance control at metallurgical enterprises. The purpose of compliance control is to increase the efficiency and resistance to risks of internal processes and system and includes three main elements: 1) control over compliance with legal norms, internal rules, instructions, regulations, etc.; 2) identification of risks, their assessment based on constant monitoring and control; 3) the communication component. The Ukrainian University of Science and Technology has opened an educational program for master's training in specialization "Compliance of metallurgical production", which will provide training of compliance controllers for metallurgical and other industrial enterprises.

11. I. Mamuzić, G.G. Shvachych, P.O. Shcherbyna, O.I. Syrotkina

The problem of managing extensive data under information constraints. For the applicationof information technology solutions in various branches of industry, the processing of big data in conditions of time and computational limitations is an urgent task. One of the most important problems is their computational visibility. As the amount of data processed increases, the number of operations grows exponentially, this phenomenon is called

"combinatorial explosion". The way to solve this problem is to use methods of reducing the space of analyzed states. The work reveals the peculiarities of the development of mathematical methods of space reduction, analyzed states for the structure of data organization of the "m-ary tuples of sets of arbitrary power" type.

12. B.I. Moroz, L.V. Kabak, I. Mamuzić, I.M. Udovyk

Estimating the time to obtain results when working with extensive data. Methods of working with data organization structures of the "m-ary tuples based on ordered sets of arbitrary power" type are considered. The approach allows you to obtain the results of operations on the elements of the data organization structure using a set of proposed functions depending on the location of the operands in the given structure. Compared to other methods, the fetch time estimate varies from cubic $O(n^3)$ to linear O(n). Which minimizes time and computing resources, to the scale of real time. Here are graphical illustrations of some combinations of operands when one of them is a subset of the other.

13. M.O. Aleksieiev, O.I. Syrotkina, I. Mamuzić, I.M. Udovyk

Development of mathematical models for reducing the space of analyzed states for processing big data. The task of minimizing computing resources when working with large data is considered. Mathematical models for reducing the space of analyzed states for the data organization structure (DOS) of the "m-ary tuples " type are proposed. The initial is an ordered structure that describes the logical expression of the template. Space reduction is performed using analytic functions between DOS elements, depending on the location of DOS elements in an ordered logical expression. The proposed approach consists in the need to develop mathematical methods for solving the desired system for any correct combination of its parameter values in order to minimize computing resources.

14. I. Mamuzić, G.G. Shvachych, B.I. Moroz, O.M. Aleksieiev

Mathematical methods for processing data from SCADA systems. Modern SCADA (Supervisory Control and Data Acquisition) systems are considered as systems designed to monitor industrial processes. Process management, as well as the collection, analysis and processing of "big data" are relevant for SCADA systems. The main characteristics of "big data" include its volume and speed of processing. In this regard, the problem of preserving the quantitative and qualitative characteristics of "big data" for their processing and analysis is considered. Mathematical methods of processing "big data" based on a system analysis of properties and their structural organization are proposed in order to optimize and increase the speed of processing large volumes while maintaining their relevance.

15. M.O. Aleksieiev, B.I. Moroz, Vol. V. Hnatushenko, I. Mamuzić

Mathematical processing of data organization structures. Mathematical methods of working with data organization structures of the "m-ary tuples" type are considered. Components of pairwise combinations of Boolean elements are defined as operands. Considered changes in the components of pairwise combinations of Boolean elements depending on the power of the basic set. Estimates of the execution time of the methods are calculated as functional dependences on the amount of data O(f(n)). The components of combinations of Boolean elements that implement the operation under study are determined, since the desired result is determined in the very property of the data organization structure. The proposed approach makes it possible to increase the speed of processing large volumes of data.

16. Vik. V. Hnatushenko, O.M. Aleksieiev, I. Mamuzić, A.L. Shyrin

Minimization of time and computing resources when processing «big data». A method of predicting the result of an operation on elements based on their location in the structure without performing a computational algorithm has been developed. The analytical dependence of the determination of the component number of Boolean elements of length m2, including the element represented by a tuple of shorter length m1, on the total number of Boolean elements of length m2 was obtained. The analytical dependence of the determination of the minimum extremum of the derived functional dependence was obtained. The results the research can be used to minimize time when processing "big data" that has an ordered structural organization of the " m-ary tuples" type.

17. M.O. Aleksieiev, Vol. V. Hnatushenko, I. Mamuzić, D.M. Moroz

Analysis of structured collections of big data. The problems of creating and applying mathematical models and methods of finding generalized solutions when working with structured collections of "big data" are investigated. A mathematical model is proposed that describes the ordered set of all subsets formed from a finite ordered base set. The set of functional possibilities of the dependence of five discrete input variables for working with the proposed mathematical model was investigated. Graphical dependences illustrate the rate of growth of the number of operations depending on the size of the original finite basis set. The conclusions emphasize the impact of mathematical methods of working with structured collections in order to minimize time and computation costs.

18. Vik. V. Hnatushenko, G.G. Shlomchak, I. Mamuzić, O.M. Aleksieiev

Analysis of regularities in structured collections of big data. Pattern analysis in structured big data collections is the process of extracting meaningful patterns, trends, and relationships to uncover valuable information for decision making. In the course of the research, mathematical models, methods and algorithms were obtained using the system analysis of properties. By analyzing the ordered set of subsets obtained from the final ordered base set of arbitrary power of various data types, it was possible to increase the efficiency of the data processing process. Such methods allow flexible grouping and classification of data. The given comparative evaluations confirm the advantages of using the developed mathematical methods, providing valuable information for effective data processing and resource optimization.

19. I. Mamuzić, G.G. Shvachych, P.O. Shcherbyna, D.M. Moroz

Features of modern technologies of network interface channel aggregation in multiprocessor computing systems. Modern HDR expansion technology allows the exchange of computing data between system nodes at a speed of about 200 Gbit/s. On the other hand, according to the manufacturer, HDR4 technology has a data transfer delay of 0.4-0.5 μs. Increasing the efficiency and speed of the multiprocessor system should be carried out at the expense of multidimensional aggregation of network interface channels. At the same time, using HDR4x2 technology, it becomes possible to increase the speed of computing data exchange from 200 Gbit/s to 400 Gbit/s. With reconfiguration of channels for symmetrical use of controllers, the delay can be reduced to 0.1 μs.

20. G.G. Shvachych, P.O. Shcherbyna, I. Mamuzić, D.M. Moroz

A promising technology for connecting channels of network interfaces of multiprocessor systems. The technology involves connecting network nodes to the switch via more than one channel. The approach is similar to the control mode of switches, thanks to which it is possible to increase the data transfer rate between two or more nodes. The application of the channel binding procedure allows you to achieve a balance between them in a multiprocessor system. The advantage of the proposed approach is the possibility of increasing the speed of exchange and increasing the reliability of the multiprocessor system. In case of failure of one adapter, the traffic is directed to the next working adapter and returned when the adapter is restored.

21. G.G. Shvachych, P.O. Shcherbyna, P.O. Ishchuk, I. Mamuzić

Multiprocessor complexes in the task of developing the latest technological processes. The use of multiprocessor complexes for the development of the latest technological processes is considered. The problem is quite urgent, since its solution allows to reduce the number of experimental studies, as well as their duration, allows to obtain the necessary information for the introduction of technological innovations. The studies recommend the use of multiprocessor systems in the installation of intensification of spheroidal annealing of steel products. Its use is aimed at reducing the duration of the technological process of spheroidal annealing of metal by non-isothermal exposure. This process of heat treatment of metal acquires undeniable advantages, including high productivity and a significant reduction in energy consumption.

22. I. Mamuzić, G.G. Shvachych, P.O. Ishchuk

Development of mathematical models of atmospheric dynamics. These models describe the complex interactions of the Earth's atmosphere, oceans, and the planet itself, represented as multi-dimensional nonlinear differential equations primarily driven by solar energy, constructed by applying the principles of mass, momentum, energy conservation, chemistry, and thermodynamics. These models rely on input parameters obtained from experi-

ments, which may have uncertainties. These parameters encompass equation coefficients, initial conditions, and domain characteristics for integration. In some cases, a range of permissible input parameters is established, allowing data analysis to estimate the system's initial state. In essence, solving these problems depends on both space-time coordinates and input parameters. Therefore, evaluating the solution's reliability involves examining its behavior within the range of allowable input parameter variations.

23. G.G. Shvachych, P.O. Ishchuk, I. Mamuzić

Analysis of Pollution Transport Models. Pollution transport models for industrial equipment involve various emission sources. Contaminant removal in indoor settings relies on exhaust systems, with optimal efficiency achieved when these systems are close to pollution sources. A straightforward approach for handling emissions during equipment operation replaces complex emission patterns with point sources. This approach constructs a precise physical model, representing pollutant emission as a system of specified point sources, each with defined locations, intensity, and operational characteristics. To ensure compliance with sanitation standards, the ventilation system's capacity can be determined through computational experiments. This task entails finding the ideal number and capacity of exhaust devices while adhering to emission constraints, ultimately maximizing the economic benefits of equipment operation.

24. G.G. Shvachych, P.O. Ishchuk, I. Mamuzić

Specifics of modeling the transport of harmful impurities against the background of atmospheric processes. Mathematical models for environmental mechanics rely on nonlinear differential equations involving spatial variables. These models describe natural environmental conditions using a vector of indicators, with air pollutant concentration being a crucial factor. When dealing with such topics, modeling the transport of pollutants within atmospheric processes is pivotal. Input parameters are characterized with certain probabilities, and the initial system state is estimated after processing measurement data. Thus, solutions depend not only on spatial and temporal factors but also on input parameters. To assess solution reliability, it's essential to study its sensitivity to input variations.

25. I. Mamuzić, G.G. Shvachych, P.O. Ishchuk

Features of data processing for atmospheric dynamics on parallel computing complexes. Modern personal computers, despite their substantial computing power, often encounter tasks that demand extended processing durations. Such challenges encompass atmospheric data processing. Employing multiprocessor computing complexes can substantially reduce the time needed to tackle these tasks. To harness these systems effectively, it's imperative to adapt algorithms for parallel processing, ensuring each processor's maximal utilization to minimize task completion time. Recently, modular multi-processor systems have gained prominence. These systems consist of interconnected standard computing nodes via high-speed communication channels. Their application spans a wide range of tasks, rivaling powerful supercomputers. They excel in handling diverse processes, including simulations.

26. L.I. Meshcheriakov, S.V. Shvachych, P.O. Ishchuk, I. Mamuzić

Analysis of modular multi-processor systems for processing atmospheric dynamics data. Today, it can be said that modular computing systems are successfully applied to all supercomputing tasks, from scientific and industrial computations to database management. For instance, in processing atmospheric dynamics data, grid methods traditionally divide the computation domain into regions, each handled by separate computation units. This approach is cost-effective, unlike most shared-memory server systems. Cluster solutions easily scale for higher performance, eliminating the need for new systems; standard computing nodes can be added to expand existing setups. Cluster solutions offer the best price-to-performance ratio today, significantly reducing total ownership costs. This is achieved through scalability and the use of cost-effective standard components with continually decreasing prices.

27. O. Dmitrieva, D. Nikulin, V. Huskova, A. Khalygov, I. Mamuzić

Investigation of the efficiency of distributed processing of transactional data. The processing of large volumes of structured data, depending on their nature and the type of task, can be performed by a significant variety of software tools, for example, using a relational database management system. However, for unstructured data, such as transactional data, there is a need to use unique distributed processing solutions, such as specialized distributed computing frameworks. The paper proposes scripts for deploying a Hadoop cluster in the Amazon AWS environment for real computing equipment, which is isolated from external factors affecting the representativeness of the results. Apriori and AIS linear algorithms and their distributed implementations for the Hadoop MapReduce and Apache Spark frameworks have been modified in order to adapt to the required distributed computing frameworks.

28. M. Chemerinskiy, V. Popova

Production of biomaterial to replace the plastics. The annual volume of plastic waste is about 9 billion tons, and this amount is constantly growing. Plastic pollution harms the ecosystem and has negative impact on the economy. Therefore, research has been conducted in order to create a recyclable substance that can partially replace similar plastic products. The base of this material is straw and a binder derived from sugar production waste. The conducted research allowed to obtain samples which can be used as disposable tableware in the future. Hence, the use of industrial waste can become a decent substitute for plastics, which will significantly improve the environment and reduce the impact of carbon effects.

29. V.I. Mieshkov, I. Mamuzić

Promising directions of computer network traffic monitoring for intrusion detection systems. Traffic monitoring plays a crucial role in protecting corporate information resources from potential threats. The relevance of using intelligent traffic monitoring systems is due to the growing complexity of attacks and the need for automatic detection of new or changed threats. The formation of an effective monitoring model requires an understanding of the characteristics of network traffic and machine learning methods. Promising areas of research include the development of deep learning algorithms for traffic analysis and integration with other security systems for a holistic approach to protection. Intelligent traffic monitoring is key to detecting and countering today's network threats, but its effectiveness depends on constant research.

30. V.I. Magro, V.I. Korniienko, I. Mamuzić

Improvements in antennas for vehicle location tracking technology. The use of automated guided vehicles (AGV) in enclosed spaces requires knowledge of information about the current location of such a mechanism. RTLS technology is used to track location AGV. This technology includes antennas that collect information from tags and transmit it to the server to calculate the coordinates of the tags. The work is devoted to mathematical modeling of an improved antenna design in the form of a finite linear antenna array. Improved antenna array performance is achieved by exploiting the coupling region between the radiating elements of the antenna array, which allows for significantly improved matching of the array to free space for all scanning angles.

31. V.I. Korniienko, O.V. Herasina, O.A. Zhukova, I. Mamuzić

Identification of self-similar traffic of information and communication networks for intrusion detection systems. The way to protect information and communication networks (ICN) from cyber attacks is the development and improvement of intrusion detection and prevention systems (IDS). The ICN self-similar traffic identification method is substantiated. Autoregressive, fractal and multifractal traffic models are considered, which allow to form an adequate reference model of «normal» traffic and use it to detect its anomalies in IDS. The simulation showed that the signals of the neural network and neural wavelets of adaptive filter-approximators, as well as multi-wavelet models are adequate to the experimental traffic and have the appropriate statistical regularities and characteristics.

32. V. N. Gorev, A. Yu. Gusev, V. I. Korniienko, Y. I. Shedlovska

On the polynomial solutions for the Kolmogorov–Wiener prediction of smoothed heavy-tail data.The telecommunication traffic is treated as a heavy-tail process, in simple models it is considered to be stationary. The Kolmogorov–Wiener filter may be applied to the prediction of smooth heavy-tail data, so it may be applied to traffic prediction in simple cases. The applicability of the truncated polynomial expansion method to the continuous Kolmogorov–Wiener prediction of smoothed heavy-tail data is investigated. The modeled data are generated as a smoothing of the fractional Gaussian noise process. The comparison of the solutions based on the polynomial expansion and on the Walsh function expansion is given.

33. V.I. Magro, V.I. Korniienko, O.A. Zhukova
Design of radiating element for MASSIVE MIMO technology. The implementation of the fifth generation of mobile communication requires the creation of efficient radiating elements for the MASSIVE MIMO technology. This work is devoted to the numerical study of a waveguide emitter designed for MASSIVE MIMO technology. Such a radiating element contains a metal-dielectric structure in the aperture. The complex effect of the dielectric coating and the metal wedge-shaped structure on the radiation characteristics was studied. The optimal dimensions of the metal diaphragm and its position relative to the aperture have been determined, which allow matching the radiating element with free space for most scanning angles.

34. V.I. Korniienko, O.V. Herasina, I. Mamuzić
Intelligent speech signal prediction in a confidential communication system over a network with dedicated channels. Use of dedicated channels for confidential network communication raises questions about the quality of communication with limited network bandwidth. A decrease in the quality of communication in the network occurs due to packet loss. To restore the speech signal (SS), there is a mechanism for predicting cells lost during transmission in the network. Through modeling, the prediction accuracy of the proposed intelligent filters was assessed and it was established that the use of the neurowavelet prediction algorithm increases the effectiveness of the confidential communication system over the network with dedicated channels by reducing the SS prediction error compared to linear prediction.

35. M. A. Miroshnyk, A. V. Shafranskiy
Diagnostic methods of reconfigured digital systems. The work is devoted to modern architectures of embedded systems. An overview of systems on a crystal, reconfigurable digital systems on a crystal is made. Examples of embedded systems based on FPGAs are given. The work does not provide an overview of modern methods of diagnosing digital systems, protection of digital projects and devices from unauthorized use and copying, and methods of authentication and identification of digital devices implemented on FPGAs. It is shown that the promising technology underlying the methods of hardware authentication and identification of digital devices is the hardware implementation of physically non-clonable functions.

36. O. S. Shkil, V. Korniienko
Technologies for designing networks and open architectures of software processors. The main architectures for reconfiguring FPGAs and software processors that can be used to develop solutions in the field of digital signal processing are considered. An analysis of a typical generalized SoC design process is presented. The study identified prospects for using the RISC-V software architecture for the purpose of expanding with custom IP blocks using the LiteX framework and its SDK. The features of application profiling and the availability of open projects for the development of SoCs for embedded devices based on the RISC-V architecture are determined. Advantages - rapid prototyping of blocks using Python and Migen with the ability to obtain quick results from project validation.

37. B.T. Sytnik, A.M. Miroshnyk
Structural-parametric index identification in adaptive control systems for moving objects. The adaptability of system identification improves their reliability and technical and economic indicators, and the immutability of the structure of the customized model, the time spent on calculations, and the non-simultaneity of calculations of static and dynamic parameters of the object model during the transition process are their disadvantages. The search and development of ways to improve the quality of operational characteristics of automatic control systems is relevant, which is associated with ensuring safety, equipment speed and slow response of operators due to human physical capabilities. The work is devoted to the creation and research of a new model for index identification of the structure and parameters of a complex object for the construction of adaptive control systems with correction of the current settings of regulators.

38. N. Vozna, I. Mamuzić
Theory of structuring multifunctional elements of complex information and measurement systems. This report clarifies with the problem of formalizing elements and binary relations multifunctional data. The concept of free and active element of a complex system and their classes relatively interaction with the environment resources and consumer information messages. The aim is to formalize elements and binary relations multifunctional data in complex systems. Proved the concept of free and active element of a complex system. Classified six attributes of binary relations elements such as: information, material, energy, optical, management. Outlined the fundamentals of the theory to solve the problem of structuring multifunctional data defined and the concept of an element of a complex system.

39. A. I. Segin, I. Mamuzić
Construction of correlation models of periodic processes in the polar coordinate system. A large number of investigated processes in nature and technology have a cyclic or rotational nature. When studying the mutual influence of such processes on the basis of correlation analysis, it is suggested to use a polar coordinate system. Since most periodic processes in the polar coordinate system have a much simpler mathematical description, it allows to significantly simplify calculations and provides a clearer graphical representation of the results. In addition, the construction of correlation models of such processes in the polar coordinate system allows one to take into account the cumulative effect of multiple repetitions of weak relationships, which in the end may have a significant value.

40. A.I. Segin, Y.I. Popyk
System of automatic translation of verbal audio streams in real time. With the development of information technologies, the exchange of information between people and organizations of different countries of the world has accelerated. However, the problem of fast, reliable, simultaneous translation of the speaker's speech in real time into several other languages remains. The proposed system of simultaneous automatic translation in real time allows to solve this problem when it is used in various international conferences and events. This system solves the task of dividing verbal flows into separate phrases, their automatic translation from one language to the selected languages of other participants using artificial intelligence with preservation of context and an acceptable time delay.

41. N. Vozna, O. Zastavnyy
Information and measurement system of microclimate control based on wireless sensor networks. With the development of automation systems and wireless technology, information and measurement systems are widely developing. In particular, the spread and development of wireless systems, which have better characteristics regarding the deployment and modification of the system, is gaining popularity. The work deals with wireless systems based on modern sensor networks and their features regarding energy consumption and deployment. The use of wireless systems makes it possible to change the system configuration. This is especially relevant in experimental systems and provides an opportunity to improve system performance with minimal costs.

42. I. Pitukh, A. Sydor, N. Vozna
Peculiarities of the influence of external dynamic factors on the functional characteristics of high-voltage electrical networks. The work investigated the characteristics of interactive information and measurement systems based on the criterion of emergency. A study of the dynamics of impacts on power grids was conducted. The probabilistic characteristics of the effects on the operation of working substations are given. It is shown that in order to determine the level of degradation of the energy system, it is advisable to use logical-statistical information models based on the calculation of the matrix of correlation-Hamming and Euclidean distances between technological and structural parameters of high-voltage networks under the conditions of the influence of external factors on the operation of the network.

43. W.P. Lv, W. Li
Dynamic characteristics analysis of rolling mill gear reducer using nutation face gear transmission. The nutation face gear transmission system has advantages such as high reduction ratio, high power density, compact structure, and smooth transmission, making it suitable for high-power transmission in metallurgical machinery, tunnel boring machines, and other applications. In this study, a 12-degree-of-freedom bending-torsion-axial coupling dynamic model of the transmission system is established. The impact of mesh stiffness amplitude on the dynamic characteristics of the novel rolling mill gear reducer is considered. The research indicates that an increase in gear pair mesh stiffness leads to an increase in torsional vibration amplitude.