MECHANICAL ENGINEERING TECHNOLOGY

DOI: 10.15587/2706-5448.2025.327212

DEVELOPMENT OF A METHODOLOGY FOR CALCULATING THE WORKING PROCESS OF THE ROTARY WORKING BODY OF MACHINES FOR EARTHWORKS AND ROAD WORKS

pages 6–12

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The object of this research is the working process of high-speed separation of soil mass elements by the cutting elements of a rotor. The existing problem is that soil cutting by the rotor occurs during the translational movement of the base machine. This creates a complex trajectory of the cutting edge and leads to continuous changes in chip thickness. Considering the trajectory of the cutting edges and the function of chip thickness variation allows for a more accurate assessment of the energy characteristics of the rotor drive.

Key parameters, such as the torque on the drive shaft, drive power, and energy consumption, were analyzed as functions of the working body's geometry, rotational speed, base machine velocity, and soil properties. The obtained mathematical models account for the actual trajectories of the cutting elements and changes in soil cutting thickness. Additionally, the interaction conditions with the surrounding environment and the physical and mechanical properties of the soil were considered. A methodology for engineering calculation and optimization of the rotary working body's parameters was developed. It considers the rotor's design, size, interaction conditions, and environmental factors. Analysis of the working process of a rotary working body with specified parameters and soil properties led to the following conclusions:

– The power consumption for the drive and the energy intensity of the process in direct and reverse soil cutting are practically equal. The differences do not exceed 5 %.

– In reverse operation, the average horizontal component of soil cutting resistance increases by 1.15–1.25 times compared to direct cutting. However, the resistance force vector is directed toward the working body's movement, reducing the required traction force of the base machine.

– The average value of the vertical component of cutting resistance in reverse operation is 2.0–2.5 times lower than in direct cutting. This reduces the effort required to deepen the working body or adjust the soil development depth.

This study will be useful for machine-building enterprises specializing in the design and manufacture of earthmoving and road construction machines, particularly those with an active rotary working body.

Keywords: rotary working body, cutting trajectory, cutting knives, cutting thickness, absolute speed, energy consumption.

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METALLURGICAL TECHNOLOGY

DOI: 10.15587/2706-5448.2025.325757

PERTURBATION OF THE FIRST FORM OF OSCILLATIONS OF LIQUID METALLURGICAL SLAG IN THE SLAG CAR BOWL IN TRANSIENT OPERATING MODES

pages 13–18

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The object of this research is the process of oscillation of liquid metallurgical slag in a slag bowl under the influence of acceleration. The work considers the oscillation processes in bowls used on railway and road slug cars, which differ in design and operating conditions. One of the key problems associated with the transportation of liquid slag is the dynamic instability of the melt, which leads to oscillations and splashing, which can pose a safety threat and reduce the efficiency of the transportation process. In this regard, the study of the dynamics of liquid slag in bowls of various designs is an urgent task aimed at optimizing transportation parameters and developing measures to reduce the risk of slag splashing.

Based on the results of numerical modeling, it was established that the nature of the oscillations of liquid slag in the bowl significantly depends on the magnitude of the acceleration, the type of slag and the design of the bowl. In particular, the acceleration ranges at which different oscillation modes are observed, from minor surface disturbances to intensive slag splashing, have been determined. At the same time, the differences in the nature of oscillations for different types of slag and bowl designs lie within the limits determined by their physicochemical properties and geometric parameters.

The results obtained allow to conclude that it is possible to develop measures for the operation of slag bowls, as well as their designs, in the direction of reducing the amplitude of liquid slag oscillations, which, in turn, contributes to increasing transportation safety and reducing dynamic loads on the bowl walls.

The obtained data can be used in the design of new bowl designs to optimize their shape and internal elements in order to minimize slag oscillations. In addition, the information provided can be useful for metallurgical enterprises to develop effective methods for controlling and monitoring slag stability during transportation.

Keywords: slag bowl, density, viscosity, transportation, acceleration, numerical modeling, liquid slag.

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DOI: 10.15587/2706-5448.2025.325695

CONSTRUCTION OF A KINETIC EQUATION OF CARBON REMOVAL FOR CONTROLLING STEEL MELTING IN THE METALLURGICAL SYSTEM "CUPOLA FURNACE – SMALL CONVERTER"

pages 19–23

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The object of research in the paper is the process of steelmaking in a small converter, which works in tandem with a cupola furnace.

The existing problem is that the control of the process of obtaining steel in an oxygen converter is complicated by the need to determine in real time the current chemical composition of the melt, in particular carbon. This is due to the fact that the rate of carbon removal is too high, as a result of which the process of carbon removal is transient. Therefore, it is too difficult to implement regulation based on feedback on continuous measurement.

The presence of the specified problem requires solutions related to the possibilities of developing or improving software control of the process.

It is shown that in certain sections of the process within each time section of oxygen purging of the melt in the converter, the kinetic curve has a linear form with a constant coefficient value in front of the inlet mine. But the value of the initial coefficient for each equation that describes the process within its limits changes. This allows to state that in case of a change in the initial condition, the kinetic curves shift relative to each other in parallel. On this basis, a system of equations has been constructed that describes the process of carbon removal in a small oxygen converter that receives liquid iron from a cupola furnace.

It has been shown that to use the obtained system of equations, it is necessary to know the initial carbon content in the melt discharged from the cupola furnace, and it depends on the method of oxygen supply to the cupola furnace. Based on the modeling of this process in two variants – using a "sharp blow" and supplying oxygen to the air blown into the tuyeres, a nomogram has been constructed. It allows to determine the initial carbon content for the practical use of the obtained system of equations.

Using the obtained system makes it possible to determine the time after which oxygen cutoff should be made. This will allow to decide to implement software control of the melt blowing process in the converter.

The presented study will be useful for machine-building enterprises that have foundry shops in their structure, where cast iron is smelted for the manufacture of castings.

Keywords: cupola melting, converter, oxygen blowing, sharp blast in a cupola furnace, kinetic equations.

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MATERIALS SCIENCE

DOI: 10.15587/2706-5448.2025.325343

STUDY OF PHYSICOCHEMICAL AND GEOCHEMICAL ASPECTS OF ENHANCED OIL RECOVERY AND CO_2 STORAGE IN OIL RESERVOIRS

pages 24–29

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The object of research is the processes of multiphase filtration in porous media. These processes occur when carbon dioxide (CO_2) is injected into oil reservoirs to increase oil recovery. The object is also the interphase phenomena, geochemical interactions and technological operations for well control associated with these processes.

One of the most problematic areas is the lack of understanding of complex relationships. These relationships exist between physicochemical processes at the micro level (interfacial tension, wettability, solubility, adsorption, geochemical reactions) and macroscopic characteristics of the reservoir (permeability, porosity, heterogeneity). Technological parameters of CO_2 injection (pressure, temperature, speed, volume) are also important. This leads to suboptimal selection of technologies for increasing oil recovery technologies, premature CO_2 breakthroughs, low oil recovery ratios, and also complicates the prediction of the behavior of the "reservoir – fluid – CO_2" system in the long term, in particular, from the point of view of CO_2 storage safety. Another problematic area is the limitation of existing empirical models describing the impact of CO_2 injection on well productivity, which do not fully take into account the heterogeneity of the reservoir and the complexity of physicochemical processes.

A comprehensive overview of the mechanisms of CO_2 interaction with reservoir fluids and rock has been obtained. The impact of supercritical CO_2 on interfacial tension, wettability, swelling and viscosity of oil has been analyzed. Geochemical reactions and their impact on permeability have been considered. CO_2 mobility control has been investigated. Mathematical relations for the calculation of throttling devices have been developed. An analysis of industrial data has been conducted, which revealed a nonlinear response of wells and allowed to refine regression models.

This provides the possibility of obtaining increased oil recovery rates and long-term CO_2 binding. Compared with similar known methods, CO_2 provides a decrease in interfacial tension, a decrease in oil viscosity, dissolution of residual oil and a potential reduction in greenhouse gas emissions. Refined regression models allow for a more accurate prediction of well productivity. The developed mathematical relationships provide effective well management. The results obtained can be used in practice to optimize oil field development processes using CO_2 injection technologies, as well as to assess and ensure the safety of long-term CO_2 storage in geological formations.

Keywords: carbon dioxide, oil recovery, multiphase filtration, permeability, geochemical interactions, wettability, fittings.

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DOI: 10.15587/2706-5448.2025.325362

DETERMINATION OF THE DEPENDENCE OF THE FILTRATION PROPERTIES OF A BIOPOLYMER SYSTEM ON PRESSURE, TEMPERATURE AND CONCENTRATION OF COMPONENTS

pages 30–34

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The object of study is the biopolymer system "X", which is used as a clay-free drilling fluid for development of productive horizons. Biopolymer system "X" is a clay-free drilling fluid for drilling directional and horizontal wells, development of productive horizons under high pressures and temperatures.

A distinctive feature of the biopolymer system is a high level of mineralization, increased heat resistance and high density, which significantly expands the scope of clay-free muds.

At the same time, this system has a number of significant advantages:

– high level of mineralization;

– increased heat resistance (operable up to 150 °C);

– high density, which expands the scope of application;

– provides a higher coefficient of recovery of reservoir permeability compared to traditional weighted solutions;

– low content of colloidal particles, which reduces the risk of deterioration of reservoir performance;

– ability to control filtration properties at high temperatures and pressures.

The following disadvantages can be identified based on the research:

1. Significant increase in the filtration rate with increasing temperature (nonlinear dependence with a correlation coefficient of 0.773).

2. The need to maintain a constant concentration of potassium chloride (~3 %) to ensure the development quality of productive formations.

3. Difficulty in controlling the properties due to the need to accurately select the concentrations of various components (sodium chloride and organomineral colmatant).

The optimal ratio of components to ensure the stability of the system at temperatures up to 150 °C was obtained: sodium chloride concentration 15–20 %, stabilizer 0.75–1 %. This is due to the fact that the proposed composition has a number of features of synergistic interaction of the components, in particular the formation of stable complexes between biopolymers and sodium ions, which prevents the thermal destruction of polymer chains at high temperatures. At the same time, the stabilizer forms an additional protective layer around the polymer molecules, ensuring their resistance to oxidation and hydrolysis under high pressure of up to 7 MPa.

The obtained research results indicate the possibility of effective use of the biopolymer system at high temperatures and pressures due to the thermostabilizing effect of sodium chloride and organo-mineral colmatant.

Keywords: biopolymer system, rheological properties, biopolymer stability, formulation optimization, high-temperature stability.

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ELECTRICAL ENGINEERING AND INDUSTRIAL ELECTRONICS

DOI: 10.15587/2706-5448.2025.325777

DIAGNOSTICS OF THE TECHNICAL STATE OF HIGH-VOLTAGE EQUIPMENT UNDER OPERATING VOLTAGE

pages 35–44

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The object of research is systems for online monitoring of the technical condition of oil-filled high-voltage electrical equipment during operation, which are used for automated diagnostics of the technical condition of equipment, resource forecasting and reducing of accidents.

The work is devoted to finding opportunities to reduce the cost of online monitoring systems, taking into account the military situation in Ukraine. The problem is caused by the need to use such systems to increase personnel safety and reliability of power grids, reduce the risk of failures due to deterioration of the technical condition of equipment due to unforeseen resource depletion or accelerated development of hidden defects due to military actions (excessive short-circuit currents, overvoltage). But taking into account the fact that the restoration of the power structure of Ukraine takes place in conditions of limited financial resources, one of the important tasks is to use online monitoring systems with an optimal price/diagnostic capabilities ratio to ensure the required level of diagnostics with a reduction in material costs for such systems.

The paper presents the results of an analytical study of the operation of online monitoring systems operated at various facilities over the past 20 years. The approach to diagnostics under operating voltage proposed in this study is aimed, first of all, at preventing emergency situations caused by the most frequent causes of accidents associated with: partial breakdown of capacitor insulation, increase in relative moisture saturation of transformer oil, appearance of dissolved gases in oil. The use of such an approach will increase the reliability of the power infrastructure and improve fault detection and preventive maintenance strategies while reducing the costs of organizing automated diagnostics in relation to "full-range" online monitoring systems of high-voltage equipment, which have been actively installed in Ukraine in recent years.

Keywords: online monitoring systems, transformer oil, accident prevention, dissolved gas analysis, partial insulation breakdown.

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TECHNOLOGY AND SYSTEM OF POWER SUPPLY

DOI: 10.15587/2706-5448.2025.326080

DETERMINATION ON ENERGY EFFICIENCY IN CORN GRAIN DRYING

pages 45–49

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The object of research is the technological processes of corn grain drying, energy plants. One of the most problematic areas for agricultural producers is providing energy for technological processes of bringing grain material to the indicators of product sales. And during the war and post-war period in Ukraine, this requires non-standard approaches and ways of implementation. Therefore, for operation in autonomous mode, the technology involves the use of biomass, electricity from solar panels and/or a diesel generator to supply the coolant to the grain drying zone. The availability of biomass is ensured by cleaning grain material after harvesting and crop residues.

The study examined the technology of corn grain drying in "Agrotechservice" LLC of the Poltava district of the Poltava region (Ukraine) using the Saphir 2134 modular grain dryer with an improved biomass boiler.

The results of studies of the operation of a grain dryer using different types of fuel (gas, diesel fuel, alternative fuel) showed that the energy consumption for reducing humidity by 1 ton-percent was: for gas – 1.5 m^3; for diesel fuel – 1.8 l; for biomass – 3.4 kg. The total cost of drying on a Saphir 2134 grain dryer was obtained, which is 0.205 USD, which is 3.7 times less than when using natural gas and 9.2 times less than when using diesel fuel. This is due to the fact that the proposed technology involves the use of an improved biomass boiler and alternative energy sources. This provides the possibility of obtaining average daily savings using a grain dryer of this model with an improved biomass boiler, which will be about 1.1 thousand USD. Compared to similar corn grain drying processes, these studies have shown the economic feasibility of using biomass as an energy material for the production of thermal energy in the corn grain drying process.

Keywords: corn grain drying, biomass, grain dryer, energy efficiency, biofuel boiler, alternative energy sources.

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DOI: 10.15587/2706-5448.2025.326476

ESTIMATION OF FUEL CONSUMPTION IN STANDARD DRIVING CYCLES AND IN REAL BUS OPERATION

pages 50–56

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The object of research is the basic fuel consumption of a bus in standard urban cycles and identical conditions in real operation.

Standard driving cycles are used to estimate fuel consumption. This allows consumers to compare buses and choose the best one, and manufacturers in the process of improving buses also allow them to estimate fuel consumption. However, sometimes standards may not correspond to reality. Therefore, specific routes are developed for some cities, which requires significant development costs. This problem is solved by collecting reliable information on average fuel consumption with an operating period of 1 year and bus mileage of 40–90 thousand km. As a rule, operating organizations do not provide such information. The development of electronic control systems allows to obtain information from "black boxes" additionally installed by the manufacturer, which record information throughout the entire service life of the bus. This approach is implemented in this work.

Existing standards for determining fuel consumption in urban driving cycles are presented. The results of modeling and real tests are presented. Information

ISSN-L 2664-9969; E-ISSN 2706-5448

was collected from the "black boxes" on fuel consumption on 12 buses for 1 year of operation with mileage from 40 to 90 thousand km on Ataman A092N6 buses. Fuel consumption was 16.4–21.2 l/100 km when operating buses in one city (the manufacturer claims up to 23 l/100 km). This makes it possible to solve the problem of collecting reliable information on fuel consumption based on year-round operation of buses, which has not been carried out in this format before.

The results of this study will allow operating organizations to see the real fuel consumption on Ataman A092N6 buses in the city. Implementation of this approach on other buses will allow obtaining data for interested organizations in a similar way. This will allow estimating fuel consumption without additional tests, which will reduce research costs.

Keywords: fuel consumption by buses, driving cycles, road tests, passenger transportation, urban cycle.

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DOI: 10.15587/2706-5448.2025.326512

INFLUENCE OF CORROSION OF THE FIRST CIRCUIT ELEMENTS ON THE DISTRIBUTION OF SEDIMENTS IN THE CIRCULATION TRACT OF THE SMR 160 REACTOR

pages 57–62

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The object of research is the circulation path of a water-water small modular reactor. The work is aimed at assessing the influence of corrosion intensity on the formation of sediments on the surfaces of the first circuit of the SMR 160 reactor module. The analysis of the circuit structure was performed, the intensity of corrosion destruction and the intensity of sediments on the local sections of the circuit are evaluated. The circulation circuit of vertical architecture, the movement of the coolant in which excites thermal pressure, created by heating in the core and cooling in the steam generator.

The methodology is based on the principle of material balance of the transition of corrosion products into the coolant and their sediment on the circuit surface. To estimate the speed of corrosion the results of complex studies conducted at stations in normal operation and on the physical models of sections of the first circuit in the laboratory were used. Estimation of the speed of sediments is performed according to the ratios that take into account the impact of the concentration of the sedimented substance in the coolant, the thermal load of the site and the consumption of the coolant.

The calculations showed that the main source of iron oxides in the circuit is the surface of the steam generator, causing the average value of their concentration in the final areas, and zirconium oxides come from the surface of the core and retain the concentration close to the average along the entire tract.

The research results showed that the high corrosion stability of the structural materials of the circuit significantly limits the transition and accumulation of corrosion products in the coolant. In turn, low concentrations of corrosion products in the coolant restrain the formation of their sediments on the surfaces of the core and steam generator. The values of the surface density of sediments and their average thickness are estimated.

Analysis of corrosion processes of structural materials and the distribution of their sediments in the circuit allow to predict the level of radiation contamination and to plan the service life of the system.

The presented technique allows to evaluate the effectiveness of the water-chemical regime used.

Keywords: modular reactor, water-chemical regime, corrosion, sediment, austenitic steel, zirconium.

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DOI: 10.15587/2706-5448.2025.326746

MATHEMATICAL MODELLING OF MIXTURE FORMATION IN THE COMBUSTION CHAMBER OF A DIESEL ENGINE

pages 63–68

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The object of research is the process of fuel mixture formation in a vortex combustion chamber located in the piston of a diesel engine.

Ineffective mixture formation leads to increased specific fuel consumption and harmful emissions into the atmosphere. The research addresses determining the conditions under which complete evaporation of droplets is achieved and the required ratio of the amount of fuel vapor and the available amount of air depending on the piston radius.

A mathematical model was created to describe the behavior of fuel droplets under the influence of aerodynamic forces, heat transfer, and phase transition processes. The calculations determined the radial fuel vapor concentration and air-fuel ratio distribution. The study found that fuel droplets with sizes ranging to 90.7 μm are completely evaporated which contributes to volumetric mixture formation. The model also identified regions where the mixture reaches stoichiometric conditions necessary for autoignition, particularly at a radius of $r/R_c = 0.22$.

This is explained by the rapid evaporation of small droplets, the number of which, as a function of the diameter distribution, is the majority, and their high speeds of movement relative to air and high mass transfer coefficients in the initial spraying area.

The study demonstrates that despite non-uniform fuel vapor distribution, volumetric mixture formation is achieved. The interaction between fuel droplets and the swirling air motion ensures adequate mixing, facilitating complete and efficient fuel combustion.

The results can be applied to optimize diesel engine designs by improving combustion chamber geometry and fuel injection strategies. The model is particularly useful for engines with high-pressure fuel injection systems. The work results contribute to developing more efficient diesel engines that comply with stricter emission regulations.

Keywords: droplet movement, evaporation, mixture formation, spray dispersion, volumetric combustion, excess air, steam unevenness.

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