

## Summaries

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ROGER ABANG, ALEXANDER FINDEISEN, HANS JOACHIM KRAUTZ

**Corrosion Behaviour of Selected Power Plant Materials under Oxyfuel Combustion Conditions** • Kwartalnik Górniczo i Geoinżynieria • z. 3/1, 2011

To reduce the production of anthropogenic CO<sub>2</sub> emissions, two lines of research are being investigated for fossil fuel-fired power plants, especially for those fired with lignite. One line concentrates on increasing efficiency in conventional power plant units (e.g. 700 °C technology, coal drying) while the other concentrates on the implementation of CO<sub>2</sub> — reducing technologies including pre-combustion, post-combustion and oxyfuel technology. The standard low Nox-producing operation of large and modern lignite-fired power plants as well as the altered process conditions that occur when oxyfuel technology is implemented results in combustion conditions that cause damage to system components. Therefore, the corrosion of plant components as a result of contact with flue gas plays a particularly significant role. Within the framework of a BMBF-funded project investigations focussing on the corrosion behaviour of selected plant materials under conventional air and oxyfuel combustion conditions are being evaluated. These investigations were carried out in a 500 kWth test facility over a timeframe of 110 hours and initial corrosion occurred. The corroded probes are then placed for a further 1.000 hours in a laboratory test rig at the BTU Cottbus, Chair of Power Plant Technology. The material probes investigated were: 16Mo3, 13CrMo4-5, 7CrVTiB10-10, 10CrMo9-10 and VM12SHC. Subsequently, the probes are analysed with the help of light and scanning electron microscopes. From the results of the investigations, conclusions on the corrosion behaviour of materials and altered process conditions can be reached, which also demonstrates the need for further investigations to be carried out in this area.

**Keywords:** *CCS technology; oxyfuel process; corrosion; materials; power plant*

JERZY ALENOWICZ, MAREK ONICHIMIUK, MARIAN WYGODA

**Assessment of Fatigue Life Resources of Load Carrying Structures in Opencast Mining Basic Machines** • Kwartalnik Górniczo i Geoinżynieria • z. 3/1, 2011

Specificity of operation and construction of opencast mining basic machines has been presented in the paper. Regulations of load carrying structures dimensioning and existing inconveniences have been discussed. Reasons of fatigue fracturing in these structures have been indicated. Previous assessment methods of fatigue life resources based on research have been presented. Description and operational scheme of a system of constant monitoring of load carrying structure effort of opencast mining basic machines has been placed. Advantages resulting from system implementation in current exploitation of machines have been given. Possibilities of system implementation in brown coal opencast mines have been discussed.

**Keywords:** *opencast mining, machines, load carrying structures, research, fatigue*

JÓZEF AUGUSTYNOWICZ, DIONIZY DUDEK, KRZYSZTOF DUDEK, ANDRZEJ FIGIEL

**Strategy of Maintenance of Long-Lasting Exploited Open Pit Mmines Mmachines** • Kwartalnik Górniczo i Geoinżynieria • z. 3/1, 2011

Achieving an appropriate quality of open pit mines basic machines after modernizations requires diagnostic estimations of their current degree of degradation and developing a detailed analytical and technological methodics for modernization.

It is also necessary to develop and carry out scientifically proved methodics and technology of creation, diagnosis and control of machines after modernization.

**Keywords:** *open pit mines machines, modernization and diagnosis*

*RYSZARD BŁAŻEJ, LESZEK JURDZIAK, RADOŚLAW ZIMROZ*

**The Need to Work out Own Diagnostic Devices for Automatic Assessment of Conveyor Belts Condition in Surface Mines** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

Review of available on the market conveyor belt inspection tools for assessment of their condition has shown lack of openness of ready solutions on cooperation with existing in mines belt databases and lack of possibility to create own applications based on source diagnostic signals with usage of additional information from these databases. This situation induce authors to create the machine vision device for belt cover inspection and process source signal from magnetic scanner of belt cord. The aim is to work out comprehensive set of devices and algorithm processing collected data and making integrating evaluations of belts condition in order to aid taking rational decisions about their replacements taking into consideration possibility of effective and economically profitable belt refurbishment. System will be not only used for assessment of belt and its core condition, but also will protect belt and conveyor before catastrophic event such us longitudinal rips. It will also create schedules of essential repair works. Due to close cooperation with future users the worked out system should very well fulfill their needs. They can be taken into account at the design stage and during defining its functionality. Authors of solutions have decided to put more attention on possibility of automation of carried out assessments and their recording in databases in order to minimize necessity of human interpretation and intervention everywhere it will be possible. Quality financial analysis has shown that it is possible to lower total transportation cost increasing expenditure on automatic diagnostics of conveyor belts.

**Keywords:** *Conveyor belt, NDT, machine vision system, magnetic system, diagnostics, belt condition*

*JERZY CZMOCHOWSKI, PAWEŁ KACZYŃSKI, PRZEMYSŁAW MOCZKO*

**Strength Analysis of Bucket Wheel of Excavator in Conditions of Assumed Performance** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

Assembly, which is particularly strained and vulnerable to failures is the mining system of multibucket excavators, especially the buckets and the bucket wheel. The paper presents a strength analysis of bucket wheel at the assumed, required performance. The analysis was conducted for the various categories of land, for a specified number of buckets, velocities and power of transmission system. This issue is particularly important at changing the mining conditions and possibilities of increasing efficiency while maintaining the required stability. An analysis of the forces encountered during excavation was conducted. The total resistance of the mining, cutting resistance torque and power at the assumed resistance of the mining efficiency were determined. These data are included in the carried out strength calculations according to PN-G-47000-2 standard, which allowed to assess the applicability of the assumed productivity.

**Keywords:** *brown coal mining machinery, multibucket wheel excavators, mining system, strength calculation, finite element method*

*RYSZARD FAJER, EUGENIUSZ IDZIAK, ZBIGNIEW KONIECZKA, ADAM MRÓWKA, LESZEK ORZECZOWSKI, TOMASZ SZCZEPANIAK*

**Optimization of Technical Solutions for Belt Conveyors in PGE GiEK Oddział KWB Belchatów** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

The article presents the scope of works taken up in PGE GiEK Oddział KWB Belchatów in order to optimize the technical solutions for belt conveyors. Seeking new solutions is determined by the necessity of working costs reduction with the use of best solutions within the scope of: construction of roller sets and their suspensions; selection of the belt conveyors; construction of dumpings; solutions for cleaning the belts and the seals; drives and operations; belts conveyors routes with their supporting mechanisms.

**Keywords:** *belt conveyor, roller, energy-saving*

KAZIMIERZ FURMANIK, STANISŁAW KAJZER, JAN MATYGA

**The Possibilities of Applications Polyurethane Materials into Conveyor Belts** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

The article suggests the possibility of application of modified polyurethane plastic friction linings driving drums and rollers in conveyor belts. Particular attention is paid here on the cooperation of these elements from the conveyor belt, their proper construction and buildings on the route in order to reduce resistance, which has a significant impact on energy consumption and durability of the conveyor.

**Keywords:** *conveyor belts, friction connections, polyurethane materials*

MONIKA HARDYGÓRA, HENRYK KOMANDER, MIROSLAW BAJDA

**Energy-Efficient Conveyor Belts for Lignite Mines** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

The impact of belt rolling resistance along rollers (indentation resistance of the belt into the roller) on possibilities of reducing the power energy consumption of belt conveyor drives, is discussed in the paper. Possibilities of reducing the power energy consumption by modification of belt construction and by using the bottom cover made of the rubber having special properties, is presented. Through modification of belt construction and choosing the proper materials for bottom cover, it is possible to reduce the rolling resistances, which are the biggest component of conveyor's main resistance and thus to improve the energy efficiency of the conveyor. The results of test on the impact of some belt parameters on the rolling resistance are showed.

**Keywords:** *conveyor belt, energy-efficient belt, rolling resistance, rubber compound*

JÖRG HERMANN, HUBERTUS KRAEMER, PETER STENZEL, AGAH MERIC SEVIM

**Surfacing of Cutting Edges for Clay Cutting** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

Wear or abrasion in lignite opencast mining have a complex appearance and are caused by excavated material. In order to minimize costs for the mining company a project for optimizing geometries and alloys of clay cutting edges has been started by responsible of CORODUR Fülldraht GmbH — Das Original. In this article it is described how an optimisation is setted up — from updated geometries for both, left and right cutting edges, over new alloy compositions to development of welding technologies. Moreover there has been checked the feasibility of PTA-welding and Open Arc welding and also the welding sequence which had to be feasible. Mechanisation by robots resulted in better weldbead appearance, lower costs and an in general more stable quality of welded clay cutting edges. At the end of the study including insitu wear tests it has been showed that the service life in the test period has doubled, compared with the former technology. Beside this it was possible to decrease the energy consumption in operation of the excavator by the new geometries for the cutting edges.

**Keywords:** *Wear, Surfacing, Hardfacing, cladding, Cutting Edges, Clay, welding, flux cored wire, fcw, Open Arc welding, PTA Welding, complex carbides, chromium carbides, fused tungsten carbides, FTC, steel casting, opencast mining, Robot welding, automation*

MARIUSZ JABŁOŃSKI, JAN ANUSZCZYK

**Modern Control Algorithms of Opencast Mining Machines in Application Examples** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

The article discusses the effects of our own service and start-up works, review and projects, carried out in years 2006–2010 in the areas of the of KWB “Bełchatów” quarry and KWB “Turow” quarry. While these work there were made several of studies and analysis of the solutions there were used in both the programming technique, communication and drive systems. Research was focused on the KTZ system machines and their working conditions. All this was supported by graphical verification. Studies carried out in the article consists mainly of inverter drive systems and drive motors control algorithms of the traverse, rotation and lift either using a speed sensor or sensorless. During the research, there was carried out several working tests at working mining machines, and modifications of control algorithms implemented for commercial inverter systems software, PLC and HMI systems responsible for the drive

work of testing machine. The main purpose of all the work was reducing of jittering and vibration during machine operation and ensuring a high level of operational reliability of the solutions, improving of mobility and safety.

**Keywords:** *control algorithms, opencast mining, mining machines, driving systems*

ZBIGNIEW KASZTELEWICZ

**The Analysis of Possible Use of Compact Bucket Wheel Excavators in Polish Lignite Mines** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

The paper presents the technology of exploitation using compact bucket wheel excavators in lignite, clays or hard rocks like limestones. Advantages and disadvantages of these kinds of machines are discussed. A comparison of traditional BWEs used in Polish and foreign lignite mines with compact BWEs is conducted. Conclusions from this analysis allow to state that compact BWEs offer very advantageous mass to efficiency ratio and therefore allow to reduce investment costs in the mines using continuous exploitation systems.

**Keywords:** *bucket wheel excavators, compact excavators, opencast mining*

MAREK KASZUBA

**Comparison of Belt Conveyor Start-Up with Slip-Ring Motors and Fluid Couplings** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

Basic start-up system used for heavy-duty belt conveyors in open-cast mining comprises a slip-ring motor and start-up resistors. Conveyor start-up is effected according to the motor mechanical characteristics, modified by successive switching of so-called start-up resistors or so-called fluid starters. The former solution is more common in surface belt conveyor drives. Unfortunately, it involves rapid changes of the torque generated by the motor and can lead to undesirable high tensions in the belt. This paper attempts to answer the question whether an addition use of constant-fill or control-fill fluid couplings in the drives could lead to reduction of tensions in the belt during the start-up.

**Keywords:** *start-up system, belt conveyors, slip-ring motor, start-up resistors, constant-fill coupling, control-fill fluidcoupling, asynchronous motor, force diagram, comparison*

MARCIN KOŁODZIEJCZAK, LESZEK HERTEL

**Energy Saving Thanks to Implementation of Innovative Method of Conveyors' Control** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

Spoil transport's efficiency in open-cast mines is very often limited due to technical considerations. Moreover, emergency and planned conveyor lines' standstills occur. Control systems may shorten the starting time of the transport lines and limit the operating time of empty conveyors which result in minimizing the costs of energy usage and increasing of output. In the report the solution, allowing to optimise the conveyors operating time, mutually elaborated and implemented by employers of PGE GiEK Bełchatów Plc. and Merrid Controls Ltd., was presented. Following mechanisms were applied: "Reverse" start-up of the empty conveyors process line in the direction from the excavator to the stacker and the standstill of the process line with the command "standstill with drop"; these procedures allow to minimize the operating time of empty conveyors, and "reverse" start-up additionally enable to accelerate the start of excavator's work; Collective start-up of the conveyors process line and velocity and time start-up; these procedures shorten the time of line conveyors start-up operating with limited efficiency and accelerate the start of excavator's work. For the execution of these solutions tight cooperation of Mine Supervision System with the local automatic on the conveyors is essential. Mine Supervision System possesses required information about all conveyors. This system supports the work of dispatcher who, according to obtained information, decides about the type of start-up or about the process line's standstill. Orders implemented by the dispatcher are processed and transferred by the Mine Supervision System to the selected conveyors. On the basis of this orders local PLC controller carries out most of the tasks autonomously, considering required procedures securing safe work of conveyors.

**Keywords:** *energy efficiency, conveyors, remote control, conveyors' start-up, conveyors' standstill*

KONRAD LEŚNIEWSKI, JAROSŁAW WIŚNIEWSKI, RADOSŁAW ZIMROZ

**On-line Diagnostic System for Belt Conveyor** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

This paper deals with description of principle features of the online condition monitoring system designed by Institute of Mining for Lignite Surface Mine PGE KWB Turów. Main topics of the paper cover: basic parameters of monitored belt conveyor, list of elements being monitored and acquired variables. A several types of acquisition channels has been defined, namely: vibration (acceleration), current, rotational shaft speed and temperature. Location of sensor has also been proposed. Some detailed information has been provided regarding diagnostics and monitoring methods. The information stream, its structure and timing and some technical issues as data transmission standards selections have been described. At the end a dedicated user interface has been discussed. It was underlined that system is open and its final shape can evolve depending on the needs of maintenance staff in Turow Mine.

**Keywords:** *monitoring system, diagnostics, belt conveyor, vibration, rotational speed, current intensity, temperature*

ZBIGNIEW MIZERSKI, MATTHIAS GNILKE

**New Bucket Wheel Drive for BWE SRs 2000 in Belchatow Opencast Mine** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

After 25 years of operation in the Polish Lignite Plant of Belchatow the bucket wheel and the drive of the five bucket wheel excavators SRs2000 have been refurbished. The implementation of mining-proven state-of-the-art components improves the availability and reliability of the machines. Operating costs are effectively reduced by low-maintenance solutions. The core of the refurbishment is the new gearbox based on the well-proven TAKRAF series. With regard to the more difficult geological conditions in the future Szczercow mine a newly developed, active overload protection system has been realised. Hitherto 2 years operating experiences have met expectations. Beyond realisation of the contract TAKRAF supports Lignite Plant Belchatow with a specific gearbox service.

**Keyword:** *bucket wheel excavator SRs 2000, refurbishment, gearbox*

MACIEJ PAWLIK, ANDRZEJ OZIEMSKI

**Operational Reliability of Domestic Coal-Fired Power Units Rated at 370 MW** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

The paper presents results of reliability forecasting for domestic, technologically congener power units rated at 370 MW operating in Belchatow Power Plant and Opole Power Plant as lignite fired and hard coal fired respectively. The study includes expected values of reliability indices calculated for main generating installations of both unit types as well as their most unreliable elements. Estimation of parameters for identified empirical probability distribution functions of operation time and repair time was done by the method of a histogram with a set number of observations in each class.

**Keywords:** *power unit, reliability indices, probability distribution functions of operation time and repair time*

EUGENIUSZ RUSIŃSKI, PRZEMYSŁAW MOCZKO

**Modernization of the Bucket Wheel Excavators SchRs 4600 Mining Unit** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

The various stages of the bucket wheel and buckets of the SchRs 4600 excavator modernization are presented in the paper. The complete approach to the design process was taken into account. The following factors were considered in the projects: the dynamic characteristics (modal) of machines with different geometric positions as well as actual excavating conditions present in the open pits. Advanced numerical tools were also used in the process of designing such facilities. New selected concepts that meet the criteria and design solutions a new bucket wheel and buckets were presented.

**Keywords:** *experimental examinations, finite element method, excavating units*

EUGENIUSZ RUSIŃSKI, TADEUSZ SMOLNICKI, GRZEGORZ PRZYBYLEK

**Comparison of the Construction Form of Caterpillar Wheel of Bucket Wheel Excavator** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

Driving centres of surface mining crawlers are high loaded elements. These elements are also strongly abraded. Therefore the mining machine requires frequent replacement of the wearied elements. Driving centre should allow for such replacement, and also meet certain strength requirements. Three versions of the wheel drive mechanism of the Bucket Wheel Excavator have been presented. Geometric forms of various construction solutions have been also shown in the paper. Apart from this, boundary conditions have been identified to carry out the numerical analysis with the use of FEM. Finally, advantages and disadvantages of proposed solutions have been presented.

**Keywords:** *caterpillar wheel, surface mining machines, finite element method, strength analysis*

TADEUSZ SMOLNICKI, MARIUSZ STAŃCO

**The Effect of Deformational Wear of Raceway on the Load Distribution in the Large-Diameter Bearing** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

Large size bearings with the monolithic and soft raceway are commonly used as a bearing for the main rotation of the basic surface mining machines body. The raceways of these bearings undergo a significant rolling, that changes the primary load distribution on the rolling elements of the bearing. The study presents the comparison of the rolling elements loading in the ZGOT 11500 conveyor for the new bearing as well as after five year bearing operation. The wear values are also presented. The loading distribution calculations were performed by the finite element method with the use of super-element type raceway-rolling element-raceway.

**Keywords:** *slewing bearing, plastic wear, finite element method, surface mining machines*

ZBIGNIEW STOBIECKI, MAREK MARCINIAK

**Using the Paramex Method to the Evaluation of the Technical Condition of Piezometers in the Mine of the Lignite Coal Belchatow** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

The paper states theoretical assumptions of a new method of assessing the technical condition of piezometers. It presents the necessary instruments to carry out the assessment and discusses the research methodology of piezometers. The paper provides indicators and criteria for assessment of the technical condition of piezometers. The new method was introduced to hydrogeological practise in Belchatów Lignite Mine. The paper presents the results obtained during the period of two years of application of the methods of the NSA Paramex Station. The summary contains the conclusions of existing applications.

**Keywords:** *groundwater monitoring, piezometer, technical condition*

PAWEŁ URBAŃSKI, DARIUSZ LATOŃ

**Technical Progress in the Construction of Pumping Stations in the KWB "Belchatow"** • Kwartalnik Górnictwo i Geoinżynieria • z. 3/1, 2011

Drainage of coal mine excavation, which consists of deep and surface water drainage is an essential and extremely important technological subject. An effective drainage system guarantees the safety of mining operations. Additionally, drainage system affects the environment therefore we carry out detailed monitoring which enables us to observe achieved results and changes in the hydrogeological and hydrochemical conditions. The article presents the technical progress of construction process of the mine's large pumping stations and pumping of groundwater, which is being continuously carried out by KWB "Belchatow" professionals. Innovative technical solutions applied in the optimization of pumping systems lead to increased energy efficiency and reduction of the pumping costs. Good cooperation between the pump manufacturers and the mine allows creation of innovative solutions to design high power submersible pump with high energy efficiencies. As a result of the use of submersible OZ pumps pumping systems

became fully automated hence they do not require an ongoing service. An energy efficient operation of a new type of pump, which is used in drainage systems of coal mine excavation, can be used successfully in other pumping systems.

**Keywords:** *mine excavation, drainage system, surface drainage system, pumping station, immersible pump, pump installation, automation*

*REIK WINKEL, CHRISTIAN AUGUSTIN, KARL NIENHAUS*

**2D Radar Technology increasing Productivity by Volumetric Control and Hopper Car Positioning in Brown Coal Mining** • *Kwartalnik Górnictwo i Geoinżynieria* • z. 3/1, 2011

The continuous brown coal mining technology has been highly advancing by mechanical design within the last decades. The driving factor has been the demand for increasing productivity and total availability. Indurad — the industrial radar company — addresses both of these factors with its solutions in increasing the utilization of mining machinery. Indurad's technological solutions are helping to optimize the brown coal flow chain from across the. Starting at the excavators working bench (cutting depth control) via the belt transfer units (positioning), on the conveyor belt (volumetric flow) and finally to the stockpile volume scan (stockpile inventory control). The key for its solutions is a highly robust unique two-dimensional radar technology which has been specially developed for the rough mining environment. Within the paper successful applications are shown for the German brown coal mining as well as other solutions realized with indurad's technology in the global mining industry.

**Keywords:** *slope scanning, cutting depth control, belt transfer units, positioning, conveyor belt volumetric flow, 2D Radar Sensor, stockpile volume scan, inventory control, silo level gauge, bunker measurement*

*NORBERT WOCKA, ANDRZEJ WARCHOLAK*

**Innovative Activities to Increase Exploitative Durability and Reliability of Crawler Mechanism for Driving Excavators and Spreaders in Polish Coal Mines** • *Kwartalnik Górnictwo i Geoinżynieria* • z. 3/1, 2011

Some innovative operations to improve crawler's assemblies of heavy duty machines in Polish open — pit mines, which took place in past 10 years, were described. Structure changes which have improved assembly life and reduced failure frequency were specified.

**Keywords:** *crawler assembly, innovations*