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INSTITUTE OF METALLURGY
VŠB – TECHNICAL UNIVERSITY OF OSTRAVA, FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY,
DEPARTMENT OF METALLURGY AND FOUNDRY

SILESIAN UNIVERSITY OF TECHNOLOGY, DEPARTMENT OF EXTRACTIVE METALLURGY AND
ENVIRONMENTAL PROTECTION

IRON AND STEELMAKING 2019

MODERN METALLURGY

The XXVIII INTERNATIONAL SCIENTIFIC CONFERENCE

Proceedings of abstracts

WELLNESS HOTEL CHOPOK, DEMÄNOVSKÁ DOLINA, LIPTOVSKÝ MIKULÁŠ, SLOVAKIA

23rd to 25th October 2019

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PROGRAM OF THE CONFERENCE

23 October 2019

12.00 - 14.00	Registration of participants (Reception)
from 14.00	Accommodation of participants
12.30 - 14.00	Lunch (Main Restaurant)
15.00 - 19.00	**Plenary Session** (Conference hall A)
19.00	Dinner (Main Restaurant)
20.30 - 22.30	The bowling tournament (Relax bar)

24 October 2019

07.00 - 09.00	Breakfast (Main Restaurant)		
	Lectures		
09.00 - 12.00	**Session: Iron and Steelmaking** (Conference hall A)	09.00 - 12.30	**Session: Non Ferrous and Non - Metallic Materials** (Conference hall B)
12.30 - 14.00	Lunch (Main Restaurant)		
14.30 - 16.10	**Poster session A** (Conference hall A)	14.30 - 16.00	**Session: Energy Transformation in Industry** (Conference hall B)
		16.15 - 16.55	**Poster session B** (Conference hall B)
19.00	Social evening (Main Restaurant)		

25 October 2019

07.00 - 10.00	Breakfast (Main Restaurant)
09.00 - 11.00	Round Table Meeting (Individual meeting of participants)
11.00 - 11.30	Summary and evaluation of the conference (Organizer committee of conference)
Until 11.00	Checkout (Reception)
11.30 - 12.00	Conclusion of the conference

23 October 2019

12.00 - 14.00 Registration of participants

from 14.00 Accommodation of participants

12.30 - 14.00 Lunch

15.00 - 19.00 **Plenary Session**
Chairmen: prof. Ing. Jana Dobrovská, CSc., doc. Ing. Iveta Vasková, PhD., dr hab. inż. Jerzy Łabaj, prof. nadzw. PŚ, doc. Ing. Branislav Buľko, PhD., David Hathaway, Ing. Marcel Novosad, Ing. Branislav Klocok, Ing. Pavol Beraxa, PhD.

15.00 - 15.10 Conference Opening
Iveta Vasková, Faculty of Materials, Metallurgy and Recycling
Branislav Buľko, Guarantee of the conference

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Maroš Halama, Faculty of Materials, Metallurgy and Recycling

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20.30 - 22.30 The bowling tournament

24 October 2019

07.00 - 09.00 Breakfast

Lectures

09.00 - 12.00 **Session: Iron and Steelmaking**

09.00 - 12.30 **Session: Non Ferrous and Non - Metallic Materials**

12.30 - 14.00 Lunch

14.30 - 16.00 **Session: Energy Transformation in Industry**

14.30 - 16.10 **Poster session A**

16.15 - 16.55 **Poster session B**

19.00 Social evening

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IRON AND STEELMAKING

THE BY PRODUCTS CREATED DURING THE OXYGEN STEELMAKING PROCESSES

Dana Baricová[1*], Alena Pribulová[1], Branislav Buľko[1], Peter Demeter[1], Martina Hrubovčáková[1]
[1]Technical University of Košice, Faculty of Materials, Metallurgy and Recycling, Institute of Metallurgy, 04200 Košice, Slovakia
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Abstract
In the technological process of the oxygen steelmaking plant, secondary products are produced in parallel with the production of the main product, which have the character of secondary by products or industrial waste. The major secondary products of steelmaking production include waste gases, process fluids, flue dust, sludge, slags and mill scales. The major waste products of metallurgical production are slags. The amount of steelmaking slag is about 110-150 kg per tonne of crude steel produced, and it is approximately 80% of all by-products arising from the production of steel. Next on as an inevitable by-product of steelmaking in oxygen converters is flue dust. Flue dusts, by-products of oxygen converter process, are together with mill scales the most valuable secondary raw materials produced in steelmaking. The amount of by-products is primarily dependent on the type of technology, the ratio of scrap to pig iron in the batch, the grades of the steel being produced, the initial chemical composition of the pig iron and the amount of slag additives added. The paper presents the results of research project directed to the characterization of oxygen converter slag and oxygen converter flue dust created in oxygen converter, therefore chemical and mineralogical composition of the by-products have a main influence on their next utilization.

Keywords: oxygen converter; oxygen converter slag; oxygen converter flue dust

INFLUENCE OF BATCH CHARACTERISTICS ON PRODUCTS OUTPUT IN IMPERIAL SMELTING PROCESS

Mikolaj Bernasowski[1*], Arkadiusz Klimczyk[1], Ryszard Stachura[1]
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*Correspondence: mbernaso@metal.agh.edu.pl; Tel.: +48-12-617-31-87

Abstract
The article presents research on modelling and calculating of product masses in the process of simultaneous smelting of zinc and lead, commonly known as Imperial Smelting Process. The aim of the study was to determine the output depending on miscellaneous raw materials using as a batch.

Keywords: zinc and lead production; Imperial Smelting Furnace (ISF); Imperial Smelting Process (ISP)

CO_2 EMISSIONS IN LIME INDUSTRY

René Berta[1*], Ladislav Lukáč[2]

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Abstract

Lime industry is of one the industries that have two sources of CO_2 emissions, first from calcination process and second from fuel combustion. Reduction of CO_2 emission in the lime industry is possible in several ways. Increase of efficiency, the substitution of traditional fuels for its alternatives, lime application are three main way to decrease emission impact of lime industry nowadays. The optimal selection of technology and fuel mix brings a potentially significant reduction of CO_2 emissions from lime production.

Two third of emissions originate from raw material and the biggest potential reduction comes from Carbon Capture and Storage and Carbon Capture and Utilization.

Keywords: lime; steel industry; rotary kiln; shaft kiln; PFR kiln; renewable energy; alternative fuels

EFFECT OF LADLE SHROUD MISALIGNMENT IN THREE STRAND T SHAPED TUNDISH

Adrián Bitto[1*], Slavomír Hubatka[1]

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Abstract

The present work involves the use of physical modelling in order to study the effect of slight misalignments of the ladle shroud on wearing of refractory lining of a T shaped three strand continuous casting tundish. For a physical modelling a 1:2 scale water model was used to observe the effect of ladle shroud alignment on residence time distribution of each strand resulting in different wearing of the refractory lining. Those observing should give us better understanding of the importance of accurate ladle shroud placing leading to savings in maintenance of working lining.

Keywords: Physical modeling; residence time distribution; refractory lining

THE COMPARISON OF THE TWO TYPES OF IMPACT PADS IN TUNDISH OF ŽP A.S.

Branislav Bul'ko[1], Peter Demeter[1,*], Vladimír Chomič[2], Pavol Buček[2], Matej Brenkus[3]

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Abstract

The task of the physical simulation of steel flow in a tundish equipped with the KLT 4 impact pad resulted from the requirement of the Steelworks ŽP a.s. to prevent the negative impact of the ladle shroud deflection on the steel flow assessment criteria in the tundish. If the results of experiments using physical model were successful, the KLT 4 impact pad would replace the standard impact pad 4/B. The internal configuration of the tundish would remain the same as that normally used for casting on continuous casting machine in Železiarne Podbrezová, a.s. In addition to the new design of the impact pad, the influence of the ladle shroud deviation on the residence times of the individual strands was analysed. Experiments with KLT 4 impact pad were performed using a physical model in SimConT laboratory "Physical model of tundish of ŽP, a.s." in cooperation with the ŽP VVC s.r.o. and the Institute of Metallurgy of the Faculty of Materials, Metallurgy and Recycling of Technical University of Košice.

Keywords: impact pad; tundish; steel cleanliness

TESTING OF BLACK PELLETS IN IRON ORE SINTERING CONDITIONS

Róbert Findorák[1*], Mária Fröhlichová[1], Jaroslav Legemza[1], Martina Džupková[1]
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Abstract
This paper provides a primary testing records of industrial wood pellets for application in iron ore sintering process conditions. The aim of this research was to analyze burning process of tested biomass and define optimal granularity for application in the sintering mixture. The laboratory sintering pan (LSP) was customized and used for purposes of experimental tests. The obtained results showed important differences in vertical burning speed in regard of testing conditions and parameters. Based on the experiments carried out within of industrial black pellets burning in sintering layer conditions it can be stated that the substitution of coke breeze by the grain size customized pellets is real and expected results should be better or same than sintering results with sawdust and walnuts shells respectively.

Keywords: pellets; burning; sintering; biomass; iron ore

STUDY OF THE SINTERING IRON BEARING RAW MATERIALS OPTIMIZING GRAIN SIZE OF BURDEN

Mária Fröhlichová[1*], Jaroslav Legemza[1], Róbert Findorák[1], Martina Džupková[1], Dušan Ivanišin[2]
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Abstract
In this paper are presented results of study the influence of the ratio between iron ore concentrate and iron ore on quality of iron ore sinter produced. The concentrate has significantly higher iron content than used iron ore. A change in ratio between iron ore concentrate and iron ore sinter is a determining factor, which influences the richness of the batch and consewuently, the richness of the sinter. The possibility of concentrate replacement by iron-.rich iron ore with granulometry similar to that of concentrate was experimentally verified. The effect of the concentrate replacement by the finer iron-rich ore was tested in laboratory sintering pan. There were tested iron ore with very specific grain size and shape of individual grain. 12 tests were perfomed and a proportion of tested sinter ore in concentrate part of the mixture was raised in each test from 25 to 100%. The replacementof an iron concentrate by a new type of iron ore raw material is efficient up to 50% from the technological point of view of iron ore sinter production, as well as from the point of view of improved quality of produced iron ore sinter and a positive environmental impact.

Keywords: sintering process; sinter; concentrate; iron ore; particulate mater

RELATED ASPECTS OF CO2 RECYCLING FROM METALLURGICAL PROCESSES

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Abstract

Carbon is a chemical element that makes up all living organisms on this planet. It belongs to biogenic elements and its cycle on the planet is a natural process. Carbon compounds are very important fuels and their extraction takes place in different ways. The most important extracted materials are oil and coal. These energy sources serve as highly concentrated energies for the development of industry and technology used by man. In metallurgy, carbon is an integral part of pig iron production. In the blast furnace, coke is burned to produce CO2. The carbon dioxide produced in this way has no other major uses. Therefore, it is considered waste. Carbon dioxide as a "greenhouse gas" contributes to the climate change occurring on Earth. Modern metallurgy aims to search for alternatives limiting waste production and its environmental impact. An alternative is the possibility of recycling waste to produce products with higher added value and long-term usability, for example, using carbon dioxide as waste from metallurgical production with hydrogen - a product realized by electrolysis from "waste" electricity.

The VŠB-TU Ostrava team has long been involved in the issue of renewable and alternative energy sources and waste utilization, also from metallurgical production in the region. Renewable and alternative energy sources are increasingly being used for electricity generation. These do not in principle have a continuous character of electric power production. The quality parameters of the supplied electricity fluctuate; there is an excess of electricity in the grid, which may be problematic to use. In the moment, electricity is “waste”. The regional concept of using CO2 as waste from metallurgical production and hydrogen generated from electricity surplus in the electricity grid gives the activities of VŠB-TUO laboratories and the team another dimension of the application of knowledge and experience in industry.

Keywords: metallurgy; energy; resources; renewable and alternative sources; low carbon economy

ASPECTS OF EXTENDING THE LIFE OF A BLAST FURNACE SLAG RUNNER

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Abstract

The metallurgical industry is a material base for engineering, construction and other industries, and is therefore a core industry not only in the Czech Republic but also in the world. From this point of view, the main task is to intensify the metallurgical production, which can be achieved by improving technological processes. The quality of technological processes can be improved by treatment of feedstock, oxygen enrichment of blast furnace wind, equipment modernization, etc. Unfortunately, these efforts are currently complicated by the slowing development of Czech metallurgy, which translates into reduced transport capacity, fuel and energy provision. charges etc.

The metallurgical industry is connected with other equally important sectors without which it would not be possible to develop metallurgy. The industrial refractory industry is proof of this. Versatility and a wide range of ceramic materials have helped in the development of metallurgy. In the metallurgy, refractory materials are used primarily for protection, construction, load-bearing skeleton in the form of working lining, permanent lining or insulation in various high-temperature aggregates.

Blast furnaces are a typical example of the use of refractory materials. These are used for the transport and distribution of pig iron and slag. The gutters consist of multiple layers of refractory materials and must withstand temperatures around 1450 ° C. There are high demands on materials:

- Corrosion resistance
- Abrasion resistance
- Minimum volume changes
- heat resistance
- chemical resistance, etc.

Keywords: blast furnace; blast furnace trough; metallurgy; slag; pig iron

STUDY OF HYDROGEN REDUCTION EFFECT ON METALLURGICAL MATERIALS

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Abstrakt
Reduction with hydrogen produced via renewable energies is an intended alternative to commonly used fossil fuels in future ironmaking. Hydrogen substitution for carbon as reducing agent and energy source presents opportunity how to avoid or reduce greenhouse gas emissions in metallurgy. The paper deals with the initial study of ENET Centre in the field of hydrogen metallurgy and presents first results in it. The paper is aimed at the hydrogen reduction effect on metallurgical materials such as sinter and coke at zone of lower temperatures. It studies mass loss and disintegration of this material and interprets the results in thermodynamical and kinetic point of view on base of experimental tests carried out in laboratory scale.

Keywords: reduction; hydrogen; sinter; coke; ironmaking

LADLE SLAG FORMING WITH OPTIMAL PHYSICOCHEMICAL PROPERTIES FOR MINIMIZATION OF NONMETALLIC INCLUSIONSS

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Abstract

The production of steel with high metallurgical purity is associated with the formation of ladle slag with appropriate physicochemical properties. Such slag must be characterized by a low degree of oxidation and good ability to absorb non-metallic inclusions. The results of industrial research with the use of new slag forming materials to create good quality of a ladle slag will be presented. Chemical compositions of slags obtained after the use of new slag forming materials as well as obtained oxygen contents and types of non-metallic inclusions will be also presented.

The obtained results indicate that due to the appropriate selection of the type and amount of slagging materials, it is possible to obtain steel with high metallurgical purity, meaning low content of oxygen and non-metallic inclusions.

Keywords: ladle slag formation; non-metallic inclusions; dephosphorization; desulphurization

NUMERICAL SIMULATION OF LIQUID STEEL FLOWING INTO THE INGOT MOULD FOR DIFFERENT TYPES OF FLOW CHANNELS

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Abstract
During the casting of the steel into the ingot mould, one of the key parts is the initial input and the subsequent flow of the steel into the ingot mould. Especially in terms of the possibility of spraying steel on the mould walls or mixing the liquid steel with the casting powder. If we focus on the shape of the casting channel, its small design change affects the flow and shape of the melt flow in the ingot mould both at the beginning and during the casting of the ingot body. The initial casting phase has the greatest influence on the possibility of exogenous inclusions input into the body of the ingot, in particular from the casting powder lying on the surface of the cast melt. Using the numerical simulation in the MAGMA 5 software, three different types of casting channels were compared in terms of flow. The present work deals with the influence of shapes of outflow casting channels on the possibility of clogging exogenous inclusions into the body of cast 5 t of ingot, in the first half of the steel melt casting with 1 % C and 1.5 % Cr.

Keywords: numerical simulation; steel melt; steel flow; casting channel; ingot mould

THERMODYNAMIC MODELLING OF MASS–THERMAL BALANCE OF SINTERING PROCESS

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Abstract
This paper specifies new computational model for modelling of the mass-thermal balance of iron sintering process. The main criterion of the iron sintering process is the quality produced sinter while maintaining the ecological nature of the production. The creation of models, simulations and predictions in the sintering process is very important today. This paper is aimed to predict the thermodynamic conditions of carbonaceous fuel combustion (including biomass) in the sintering layer. For the modelling the basic chemical reactions with standard Gibbs energy and mass and thermal balance were calculated using the software HSC Chemistry 9. HSC Chemistry offers powerful calculation methods for studying the effects of different variables on the chemical system at equilibrium. Results from mass-thermal balance correlates to results of sinter production in a laboratory sintering pan. It is apparent that the model calculations of added fuel, quantity of sinter, content of Fe_{TOT} are highly correlated with the experimentally determined values. The benefit of the new computational model is the possibility to predict the mineral phases of the product during the actual sintering process—high-temperature sintering. The developed computational program is universally utilisable in various academic, industrial and technical applications.

Keywords: sinter; carbon fuel; biomass; modelling; mass-thermal balance

MIXING OF LIQUID STEEL IN A STEEL LADLE BY A COMBINED METHOD

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Abstract

Purging of liquid steel with inert gases belongs to the basic operations in secondary metallurgy treatment. Its main objectives are homogenization and refining of liquid steel. Basically, it consists of purging argon through a porous plug installed at the bottom of the steel ladle. In special cases, there is a need to support this process by using an additional blow through the lance from above. The article presents the results of model research on the application of a combined blow (porous plug + lance) in a steel ladle. The research has visualized character, also mixing curves were determined for different variants of purging. As a consequence, the obtained results were used to determine the optimal purging method.

Keywords: ladle; homogenization of liquid steel; porous plug; lance; physical modeling

IMPACT OF THE MEASURING POINTS NUMBER ON THE HEAT TRANSFER COEFFICIENT VALUE IN THE PRIMARY COOLING ZONE OF THE CCS PROCESS USING THE INVERSE METHOD

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Abstract

When the boundary conditions cannot be determined in a classic way – directly from the process data – it is possible to use inverse analysis to find the searched heat transfer coefficient. In the Inverse method, contrary to the direct solution, where the equation parameters are known, the input data are the results of the conducted tests. Determination of the empirical values of the boundary conditions and material related parameters is a crucial in order to obtain correct numerical modeling results. Calculation of the heat transfer coefficient value in the continuous casting machine primary cooling zone is a complex task, concerning heat transfer model between the mould and the strand surface. This paper presents method for the heat transfer coefficient average value calculation, between the outer layer of the solidified strand shell and the mould wall surface. The values of the temperature measured by thermocouples – installed in the walls of slab casting machine mould - were used as a input parameters. The influence of the measuring points number on the value of the heat trensfer coefficient in the primary cooling zone has been established. The *ProCAST ESI Group®* software package with a *ProCAST2016* solver was used for the numerical calculations.

Keywords: continuous casting of steel; heat transfer coefficient; inverse method

LABORATORY OF MODEL RESEARCH AT WIMIM SILESIAN UNIVERSITY OF TECHNOLOGY

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Abstract
The article presents information on the equipment and research capabilities of the Laboratory of Modeling Research at the Faculty of Materials Science of the Silesian University of Technology. The modernization carried out in it recently and the significant enrichment with new positions for model research meant that it has become an important research center in the country for conducting research in the field of modeling the metallurgical processes. This is evidenced by the implementation of many projects, both in cooperation with industrial entities and other scientific centers, both in the country and abroad. The information presented at the Iron and Steelmaking Conference is aimed at even wider dissemination of knowledge about the capabilities of this laboratory and is an invitation to constructive cooperation.

Keywords: physical modeling; iron, steel; aluminium refining

CURRENT PROCESSING OF MINERALS, FUELS AND SECONDARY PRODUCTS, THEIR USE IN THE CZECH REPUBLIC AND POLAND

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Abstract

Raw and fuel sources, their mining and utilization within the Czech and Polish border regions. The associated problems of environmental protection and the possibilities of using secondary raw materials of metallurgical production. Specific problems of border regions of the Czech Republic and Poland related to mining of raw materials and fuels. Saving primary sources in the Czech Republic and Poland.

Keywords: Raw and fuel sources; environmental protection; metallurgical production

OPTIMIZATION OF SLAG FORMATION CONDITIONS IN THE STEELMAKING PROCESS IN ORDER TO INCREASE THEIR DEPHOSPHORIZATION AND DESULPHURIZATION CAPACITY

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Abstract

Phosphorus and sulfur are undesirable elements in the steel and they should be controlled at every stage of production, especially in liquid state. One of the conditions for good dephosphorization and desulphurization of a metal bath is the formation of slag with appropriate properties in the furnace as well as during secondary metallurgy processes.

The principles of slag formation in a steel shop equipped with an electric arc furnace, a ladle furnace and a vacuum chamber will be discusses in this paper. Based on results of chemical compositions of slags and metal baths obtained from industrial conditions, optimal processes parameters have been proposed. Parameters have been verified.

Verification studies showed that in the analyzed heats conditions for lowering the sulfur and phosphorus content in the metal were obtained, although their unstable parameters were observed. Nevertheless, despite the lack of stability of these conditions, at the end of refining both elements content are always lower than the norm permits.

Keywords: steelmaking slag formation; dephosphorization; desulphurization

APPROACHES TO COMPUTATIONAL MESH GENERATION AND MONITORING OF STEEL FLOW IN TUNDISH DURING NUMERICAL MODELLING

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Abstract

Continuous casting technology is currently the primary method used for production of steel billets, blooms or slabs. Flow in the tundish region during the continuous casting of steel can influence many important phenomenon, especially the inclusions removal or the range of transition zone. Flow in the tundish can be simulated using numerical modelling. The numerical modelling offers fast answer to many questions. But the results of numerical modelling depend on the accuracy of model setting. The stability of calculation convergence is influenced by the quality of the model computational mesh. Especially in the case of verification of difficult internal geometry arrangement on steel flow in tundish, the method of computational mesh generation and the form of results monitoring must be the same. Therefore, we validated the approaches of computational mesh generation and the types of results monitoring. We compared the numerical results using the tetrahedral and hexahedral mesh elements. We used the Multizone and Hexa dominant meshing. The Assembly method was achieved as the most appropriate. The point and surface monitors enabled us to control the stability of calculation.

Keywords: steel; continuous casting; tundish; computional fluid dynamiscs (CFD); computational mesh

RATE OF REDUCTION AND DEGREE OF METALLIZATION OF MILL-SCALE SLUDGES, REDUCED IN THE TEMPERATURE RANGE OF 850-1050°C

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Abstract
Due to the amount of waste generated in the steel production process, attempts were made to reduce direct and indirect sludge. Studies on the reduction of iron oxides were carried out for selected fine-grained iron-bearing materials using carbon monoxide as a reducing agent. Industrial waste sludge was used. Indirect reduction was carried out in the temperature range of 950 - 1050 ° C with variable alkalinity, grain size and height of waste material samples. To assess the speed of the reduction process, tests using carbon monoxide were carried out. The degree of metallization of the tested materials was determined. An indirect reduction was carried out using hydrogen as a reducer and a mixture of carbon monoxide and hydrogen at extreme test temperatures of 850° and 1050°C. Comparative pure hydrogen reduction tests were also performed.

Keywords: sludge; reduction; carbon monoxide; hydrogen

SESSION

ENERGY TRANSFORMATION IN INDUSTRY

MATHEMATICAL MODEL OF HEAT TRANSFER IN NON-OXIDISING FURNACE

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Abstract

Created mathematical model partially described here allows processing of static state simulations of continuous direct-fired annealing furnace operation in different configurations. It allows the evaluation of the effects of variant operating modes, production speeds or heated body dimensions on the resulting temperature fields. A part of the heat treatment technology for steel strip at a specific continuous hot-dip galvanising line is a non-oxidising furnace. A comparison of measurement data from the furnace to simulation results of the referential configuration demonstrates the accuracy of the model. The other two simulations provide a test of the applicability of configurations that offer more intense heat transfer. Since the presented model requires low computational power, it is also suitable for operational control at the real plant. A heat transfer intensification upgrade of the non-oxidising furnace was suggested based on the interpretation of the simulation outputs. High combustion temperatures indicate that installation of more powerful burners is not an optimal form of increasing the heating capacity. Elongation of the burner section increases the heat exchange surface and is more suitable for achieving the desired effect.

Keywords: hot-dip galvanising line; heat transfer modelling; emissivity; direct-fired furnace; view factor

DEVICE FOR REGULATION OF THE FLAME LENGTH IN THE THERMAL AGGREGATE

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Abstract

At present, the modernization of thermal aggregates is aimed at increasing energy efficiency and reducing the amount of technology emissions. One such way is the enrichment of combustion air with oxygen. Increasing the oxygen in the combustion air leads to an increase in the combustion temperature and to the reduction of the amount of fuel to achieve the same performance. The result of this change is to reduce of amount emissions. In the article the authors approached the issue of combustion of gaseous fuels with oxygen enrichment of combustion air. They focused on the design of the combustion device (burner) given achieving a constant flame length at various concentrations of enriched oxidizer. The positive effect of flame length preservation during the heating of the charge material in the thermal aggregate was confirmed by experimental measurements and mathematical simulations. The evaluation criteria are the temperature field in the furnace space, the amount of emissions generated and the combustion rate of the gas-air mixture in the burner.

Keywords: oxygen enhanced combustion; burner; air nozzle; flame length

POSSIBLE USE OF WASTE HEAT FOR THE ELECTRIC POWER PRODUCTION

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Abstract
A necessary condition for energy efficiency is to increase the efficiency of existing facilities, including heat recovery. The supply of thermal energy in our country is currently heavily dependent on the import of energy sources. The constant increase in the prices of energy resources leads to a reassessment of the relationship of consumers to efficient use of all types of energy and to savings in its production. Therefore, in order to further develop the economy and to ensure an adequate quality of life, it is necessary to increase energy security by effective use of low and medium potential thermal energy sources. This is the main objective, why the recovery of waste heat is becoming a necessary trend. Of the various options, the heat recovery from waste air and flue gas using a heat recovery exchanger is currently most commonly used. Industrial waste heat can be considered as the most important secondary energy source. This paper presents the possibilities of utilizing waste heat for the purposes of electricity production.

Keywords: waste heat; heat recovery; hot air engine

ASSESSMENT OF THE ENERGY POTENTIAL OF SOLAR ENERGY IN INDUSTRIAL APPLICATIONS

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Abstract

The submitted paper deals with possibilities of solar energy application in metallurgical industry. The paper presents comparison of the most significant presently working devices which use solar energy concentration. The experimental part is focused on the measurements of the incident solar energy in selected localities in Slovakia. The results provide the theoretical potential for the solar energy application in similar devices, taking into account the sunshine duration as well as the amount of potential energy.

Keywords: solar energy; concentration; solar radiation; energy potential

ANALYSIS OF THE ENERGY CONSUPTION DURING THE ELECTRIC ARC PROCESS

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Abstract
Electrical energy consumption and optimization of the chemical energy contribution in the process of melting the charge in the electric arc furnace is a decisive importance in steel production costs. The development of mathematical model that takes into account the relationships of electrical and chemical energy input or output to the steel production process, especially in industrial conditions, is not easy. This is mainly due to the fact that it is not possible to measure some parameters, such as eg. thermal losses. Analysis of the energy consumption, using industrial technological data of the electric arc furnace with a nominal capacity of 45 Mg was presented in this paper. The developed model makes it possible to calculate the theoretical demand for electric energy needed for the process and to compare this quantity with the measured values. In the case of furnaces with lower production capacity it seems necessary to more accurately characterize energy efficiency and the ability to control and optimize the production process.

Keywords: electric arc process; energy consumption; modelling of energy demand

SESSION

NON FERROUS AND NON - METALLIC MATERIALS

THERMAL ANALYSIS OF CAST IRON - POSSIBILITIS OF USE IN FOUNDRY AND ITS RESTRICTION

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Abstract

The solidification of cast iron is the complex process. The influence of solidification process on the final quality of the cast is significant. Cast iron production is a difficult process with a large number of variables. For cast iron foundries, for the production of quality castings, is important appropriate pouring temperature (but also thermal process of melting), chemical composition, effective inoculation and modification, casting time, etc. - they have a great effect on solidification. One of the process which allowed to observe solidification of alloys is the thermal analysis.

Thermal analysis is based on the recording and evaluation of a cooling curve, used to determine solidification characteristics of cast iron. In the foundries, various types of test cup are used to sense the cooling curves. Using cup with tellurium there is possibility to take off typical temperatures values from cooling curve (liquidus temperature – min., max., solidus temperature) and following statistical correlation functionality to asses the value of carbon, silicium content and carbon equivalent. By using cup without tellurium (liquidus temperature – min., max., eutectic temperature – min., max., solidus temperature), relative relations between metallurgical quality of melting cast iron and final cast quality.

This article deals possibilitis of use thermal analysis in various metallurgical processes and its restriction. The aim of this research is to study reliability of thermal analysis results of cast iron.

Keywords: thermal analysis; solidification of cast iron; cooling curve; quality control

HYDROMETALLURGICAL TREATMENT OF METAL-BEARING WASTES USING NON-FERROUS METALS

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Abstract

The article deals with further possibilities of processing of metal-bearing wastes in the form of steel drifts by hydrometallurgy. The main part of the research focused on the development of suitable technology of leaching of steel flakes with the aim to obtain selected non-ferrous metals, mainly zinc and lead for economic and environmental reasons. Laboratory experiments were carried out to verify a suitable leaching agent in the form of high temperature acid leaching, neutralizing leaching and magnetic separation was verified in lead seals. From the results of the experiments, a suitable technology for processing steel fumes was proposed.

Keywords: hydrometallurgy; metal-bearing waste; steel drift

MODIFICATION OF LIQUID FESI75 FERROSILICON LADLE REFINING TO IMPROVE ITS PURITY

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Abstract

The paper presents a proposed modification of liquid FeSi75 ferrosilicon ladle refining with technical gases to improve its purity. Depending on the requirements, refining gases can be oxygen, air or oxygen-enriched air. Compression gas will be delivered to liquid metal through a gas lance or, optionally, through a specially designed porous plug located in the ladle bottom (the gas lance was used in the experiments). Physical model studies have shown that the optimal depth of lance immersion should be 2/3 of the metal height in the refining ladle. Chemical composition analyses of individual fractions of both ordinary and refined FeSi75 ferrosilicon after the process of mechanical milling and sieving have confirmed the presented mechanism of carbon removal during ferrosilicon refining through floatation of SiC carbide inclusions in liquid metal bath using slag-forming CaO, Al_2O_3, MgO carriers. The most considerable changes in refined ferrosilicon

Keywords: Ferrosilicon; submerged arc furnace; casting ladles; improving purity of alloy

FLOTATION CONCENTRATE AS A CARBONACEOUS MATERIAL FOR APPLICATIONS IN COPPER PYROMETALLURGY PROCESSES

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Abstract

Evaporation of volatile components of liquid metal phenomenon could occur during every single metal and their alloys melting and in their refining process as well. As many researches proved the type of gas atmosphere used affects the rapidity of that process, especially, when is carried out under atmospheric pressure. In the given article the results of researches of zinc evaporating rapidity during its melting proceeds in atmospheres of helium, carbon monoxide and helium-carbon monoxide mixture are shown.

Keywords: alloys melting; refining process; zinc evaporating

SOLUTION OF NON-CONFORMITIES IN THE CASE OF ALUMINIUM CASTINGS MADE IN METAL MOULDS

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Abstract

The contribution is aimed at identifying and eliminating defects occurred during gravity casting of aluminium alloys into metal moulds. The actual experiment of the work consists of analysis and processing of data about the defects formed directly in the production, with which the manufacturer of components for the automotive industry is confronted. Based on the production data the most frequently occurring defects and examples of their elimination are described.

Keywords: aluminium alloy; casting defect; gravity casting; automotive

EVAPORATION OF METALS IN INERT ATMOSPHERES

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Abstract

Evaporation of volatile components of liquid metal phenomenon could occur during every single metal and their alloys melting and in their refining process as well. As many researches proved the type of gas atmosphere used affects the rapidity of that process, especially, when is carried out under atmospheric pressure. In the given article the results of researches of zinc evaporating rapidity during its melting proceeds in atmospheres of helium, carbon monoxide and helium-carbon monoxide mixture are shown.

Keywords: alloys melting; refining process; zinc evaporating

THE POSSIBILITIES OF REFINING ALUMINIUM ALLOY MELTS USING GRAPHITE ROTORS

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Abstract
The contribution is devoted to the issue of refining aluminium melts. The theoretical part focuses on the sources of pollution and their influence on the quality of the melt and the final casting. For refining the AlSi7Mg0.3 alloy two types of graphite rotors and a different type of refining gas (argon and nitrogen) were used in the experiment. Results are evaluated from the point of view of the gassing value (Dichte Index). At the same time the microstructure of samples before and after refining was monitored. The results showed that the use of argon as a refining gas is more effective. In terms of use under real operating conditions, it is also necessary to assess the economic aspect.

Keywords: aluminium alloy; degassing; microstructure; Dichte Index

INFLUENCE OF BASIC PRODUCTION PARAMETERS ON MECHANICAL PROPERTIES OF CORES PRODUCED BY C-METHOD

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Abstract

Croning process (C-method) has its roots in the 1940s and marks the beginning of the chemistry of the foundry core production. Although at present the cold processes in the production of cores predominate and this process of core production seems long overdue, the cores so produced and in particular their applications have their place in the common foundry practice in the production of cast parts. It is a technology that allows the production of very shaped cores with high mechanical properties, which cannot be produced by commonly available and most commonly used processes (eg PUR COLD-BOX). The aim of this paper is to determine the basic parameters of core production, respectively. optimization of methodology for evaluation of basic parameters of core mixture for production of cores by C-method.

Keywords: foundry; core making; croning process; C-method

DESIGN OF CASTING TECHNOLOGY USING SIMULATION PROGRAM

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Abstract

In this paper design and the optimization of foundry production of a porous metal are described. The formation of porous metal by infiltration of liquid metal into the mould cavity ensures the fastest and most efficient way of production. But even in this case, it is necessary to use correct and verified input data for manufacture process. For successful production the casting model should be firstly created using 3D drawing software and then the MAGMASOFT® 5.4 software for the numerical simulation should be applied. Utilization of MAGMASOFT® 5.4 provides optimisation of the whole manufacturing process. The accurate conditions for the real production of castings can be defined exactly by realisation of simulations of pouring and solidification. To create cavities in the casting the usage of sand cores is required. The bentonite mixture (UBM) should be used as the mould material. The following decrease of scrap rate during production saves time and incurred costs. Therefore the main aim of this research is to ensure the production of sound castings, which would be used in the field of power industry, specifically for heat exchangers manufacturing.

Keywords: porous metal; simulation program; casting; heat exchanger

APPARATUS FOR PROCESSING METALS OF LOOSE NATURE TENDING TO AIR OXIDATION, ESPECIALLY ALKALINE EARTH METALS

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Abstract

The paper deals with an experience and a methodology of innovation process of a technical solution of apparatus for processing metals of loose nature tending to air oxidation, especially alkaline earth metals. The apparatus has been developed in an utility model. The aim of this technical solution is to design a device facilitating the process of treating rare earth metals in a way that would prevent their air oxidation and thus facilitate their handling in the next technological process. The utility model has been created of a standard device to prevent air oxidation without the use of protective devices and thus to facilitate their further handling. The paper has been carried out with an experience with master degree education of students in the subject Equipments in Processing Plant I., in which the apparatus for processing metals of loose nature tending to air oxidation, especially alkaline earth metals has been developed. The education model can be used for a teaching of students in the subjects of innovation focus. The utility model has been published in Espacenet database under European Patent Office

(https://worldwide.espacenet.com/publicationDetails/biblio?DB=EPODOC&II=3&ND=3&adjacent=true&locale=en_EP&FT=D&date=20150429&CC=CZ&NR=28113U1&KC=U1).

Keywords: innovation; rare earth metals; apparatus; oxidation

STUDY OF THE TEMPERATURES OF PHASE TRANSFORMATIONS OF STEELS AND THEIR APPLICABILITY IN THE TECHNOLOGY OF STEEL CASTING

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Abstract

A comprehensive experimental and theoretical study of the thermo-physical, thermodynamic, physio-chemical properties of steels and also the modeling of the processes of steelmaking it allows to achieve the top quality of the cast, semi-finished steel product, which is comparable or superior with the quality of world producers of these materials. The paper is focused on the study of phase transformations temperatures in different types of high-alloy steels during its solidification process. The field of the research reflects current world trends in the field of new steel grades, microstructure and mechanical properties of steel, subsurface and surface quality of final products, etc. The realization of highly specialized measurements of thermo-physical properties of steels, respectively the knowledge of phase transformation temperatures (liquidus and solidus temperatures) of steels, is the basic precondition for successfully understanding (manage) the process of cast of steels with the high internal homogeneity. Based on this information, important and significant parameters are specified in the whole technological flow of steelmaking production. Knowledge of those temperatures in combination with utilisation of the method of numerical modeling (setting of boundary condition of numerical simulation of steel solidification process) can then improve the quality of cast steel without any additional treatment.

Keywords: steel casting technology; phase transformation temperature; direct thermal analysis; differential thermal analysis; high-alloy steel

NUMERICAL STUDY OF ALUMINIUM MELT DEGASSING PROCESS BY SUBMERSIBLE DEVICE

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Abstract

The increase in the use of aluminium is also accompanied by increasing demands for chemical and metallographic cleanliness of this metal. The presence of unwanted phases in the molten metal can cause changes in final castings properties. These phases include also hydrogen dissolved in the aluminium melt which is usually removed by inert gas. In operating conditions, aluminium refinement can be conducted by a submersible device consisting of a hollow shaft, rotor and breakwaters. The paper is devoted to numerical simulations of this process. Actual phase of numerical research and development of refining technology of aluminium melt by an inert gas, carried out in Department of Metallurgy and Foundry of Faculty of Materials Science and Technology of VŠB-TU Ostrava is described.

Keywords: aluminium; aluminium refinement; inert gas; numerical simulation; computational fluid dynamics

MODELLING OF MELT DEGASSING BY BLOWING OF INERT GAS THROUGH THE ROTATING IMPELLER

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Abstract

Presented paper deals with the use of physical modelling to study the degassing process of aluminium melts in the refining ladle by blowing of inert gas through a rotating impeller. The method of blowing inert gas, so-called refining gas, through a rotating impeller into the ladle presents the most common operational technology to reduce of impurities content from molten aluminium, e.g. hydrogen. The efficiency of this refining process depends to the creation of fine bubbles with a high interphase surface, their regular distribution and regular arrangement of bubbles into the whole volume of the refining ladle and with long period of its effect in the melt. Physical modelling represents the basic method of modelling and it makes it possible to obtain information about the course of refining processes. On the basis of obtained results, it is possible to predict the behaviour of the real system. This paper is aimed on the evaluation of laboratory experiments obtained by the method of physical modelling; attention is focused on the assessment of relevant parameters for the degassing process – mainly rotary impeller speeds and volume flow rate of inert gas.

Keywords: physical modelling; refining ladle; inert gas blowing; degassing of the melt; impeller

ZINC LOSSES IN THE MELTING PROCESS OF AL-ZN ALLOYS IN INDUCTION CRUCIBLE FURNACES

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Abstract

During the melting of the metal alloy we may have to deal with the unfavourable phenomenon of evaporation of alloy elements with high vapour pressure from the bath. An example of such an alloy is Al-Zn. In the process of melting in melting induction furnace, the process of zinc evaporation can be intensified by a significant increase in the bath surface due to the formation of meniscus. The paper presents the results of studies on the evaporation of zinc from the alloy. Al-Zn5.5MgCu in VIM 20-50 furnace taking into account the influence of electrical parameters of furnace operation on the size of mass exchange surface in the analysed evaporation process.

Keywords: metals evaporatio; induction melting; meniscus

USE OF WASTE FROM COAL MINING IN Fe-Si-Al ALLOY PRODUCTION PROCESSES

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Abstract
The article presents issues related to the use of industrial waste, especially this generated in mining and processing of hard coal as charge material in the electrothermal reduction of silicon and aluminum oxides in a six-electrode submerged arc furnace. A broad qualitative and quantitative analysis of various industrial waste, characterized by the closest to the optimal content of compounds of silicon, aluminum, iron, "hard" carbon and trace elements that allow the use of the raw material in the production of FeSiAl alloy, was performed. The paper presents results of tests carried out in an electric furnace with a capacity of 2·7.75 MVA where iron alloys with silicon and aluminum, with Al content of 4 ÷ 20 % mass and Si content of 55 ÷ 75 % mass, were obtained using a clay-bearing mineral substance from hard coal mining as raw material and high-ash fine coal as a reducer.

Keywords: ferrosilicon-aluminum, submerged arc furnace

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