A Reduced-Order Two-Degree-of-Freedom Composite Nonlinear Feedback Control for a Rotary DC Servo Motor

We study in this paper nonlinear control of a rotary DC servo motor application. To be more specific, we design a reduced-order two-degree-of-freedom (2DOF) composite nonlinear feedback (CNF) controller for a Quanser QUBE-Servo 2 unit with a disc attachment. We compare our results with a carefully tuned proportional-derivative (PD) controller with set point weighting. Our simulation and experimental results show that the closed-loop system using 2DOF CNF controller yields much better set point tracking performance compared with the system using conventional PD-controller in terms of settling time.
Comparison of laboratory wear test results with the in-service performance of cutting edges of loader buckets

The in-service cutting edge of a mining loader bucket was investigated and its wear behavior compared with samples tested in the laboratory to assess how well the wear testing methods correlate with the in-service conditions. The examined in-service cutting edge of a bucket had been run in an underground mine with quarry gravel and it was made of wear resistant steel. The wear behavior of the cutting edge was simulated in the laboratory scale with several application oriented abrasive and impact-abrasive wear testing methods. In addition to the contact mode, high loads, large abrasive size, abrasive type, and the comminution of the abrasive formed the basis for the design of the laboratory experiments. The wear surfaces and cross-sections of the original cutting edge and the test samples were characterized, and the wear behaviors were compared with each other. Work hardening of the steels occurred in all cases, but the amount of plastic deformation and the depth of the wear scars varied.

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Scopus rating (2013): SJR 1.319 SNIP 2.416 CiteScore 2.37
Scopus rating (2012): SJR 1.36 SNIP 2.178 CiteScore 1.85
Scopus rating (2011): SJR 1.547 SNIP 2.865 CiteScore 2.43
Scopus rating (2010): SJR 1.509 SNIP 2.153
Scopus rating (2009): SJR 1.684 SNIP 2.07
Scopus rating (2008): SJR 1.597 SNIP 1.863
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Scopus rating (2005): SJR 1.473 SNIP 2.007
Scopus rating (2004): SJR 1.335 SNIP 1.965
Scopus rating (2003): SJR 1.104 SNIP 1.788
Scopus rating (2002): SJR 0.958 SNIP 1.365
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Scopus rating (2000): SJR 1.069 SNIP 1.149
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Research output: Scientific - peer-review › Article

Utilization of Models for Online Estimation in Combustion Applications

The emerging environmental and energy system related requirements urge renewed combustion systems, with a focus on extended flexibility and decreased emissions. At the same time, monitoring and measurement reliability requirements are increasing. All these requirements also increasingly affect existing combustion plants.

To tackle the increasing needs and requirements of existing combustion processes, this thesis’ objective is to integrate
process and domain knowledge, models, and online estimation to provide cost effective and practically feasible solutions for online emission monitoring and control in existing combustion processes. These solutions are domain specific, comprising power level, main fuel, boiler technology, process environment, and market. This thesis presents a framework to provide practically justified, online monitoring and control solutions that is applied to selected combustion applications.

The first application is combustion control of small-scale (<0.5 MW) wood chip combustion systems, to tackle fuel feed disturbances and provide stabilized combustion conditions with improved process performance. The second application area is medium-scale (15 MW – 50 MW) natural gas fired boilers. Indirect, data based, NOx monitoring methods were developed for such boilers, to cost effectively fulfill emerging monitoring requirements. The third application area is large-scale power plants (>100 MW). A novel, first principle combustion model was developed for these. The generic combustion model interlinks the combustion related measurements distributed within any boilers regardless of boiler type or fuels. The interlinking enables combustion processes to be considered as an entity that reveals if a measurement provide realistic readings compared with others. The static, computationally light model enables simultaneous data reconciliation and gross error detection and hence several attractive online applications, such as reliable estimation of unmeasured variables, and separation of process disturbances from sensor malfunctions.

The results verify that the process performance improved in all studied practical applications, providing feasible solutions for increasing requirements.

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Indirect NOx emission monitoring in natural gas fired boilers
New emission regulations will increase the need for inexpensive NOx emission monitoring solutions also in smaller power plants. The objective in this study is to find easily maintainable and transparent but still valid models to predict NOx emissions in natural gas fired hot water boilers utilizing existing process instrumentation. With a focus on long-term applicability in practical installations, the performance of linear regression is compared in two municipal 43 MW boilers with three widely used nonlinear methods: multilayer perceptron, support vector regression, and fuzzy inference system. The linear models were the most applicable providing the best estimation results (relative error of 1 applications in practise. However, each boiler model should be identified individually.

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Publication information
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Utilization of Drum Boilers' Storage Capacity for Flexible Operation

Due to increasing amount of intermittent and uncontrollable renewable energy production and reducing amount of stabilizing inertia in power systems, requirements for improved dynamic performance of controllable steam boilers will increase remarkably. Load tracking capacity of steam boilers consists of utilization of fast responding energy storages in boiler structures and change rate of available combustion power. This paper presents results of a simulation based dynamic analysis of the transient operation of a steam boiler exposed to fast load change. The results are evaluated against the requirements set by the maximum allowed thermal stresses in boiler structures and stability of steam parameters set by steam turbine operation. This project is a part of the FLEXe (Flexible Future Energy Systems) research program coordinated by CLIC Innovation Ltd and funded by the Finnish Funding Agency for Innovation TEKES.

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ASJC Scopus subject areas: Control and Systems Engineering
Case Stories – Flexibility with Production Optimization and Advanced Process Control

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Authors: Kaivosoja, J., Ketola, M., Virta, M., Korpela, T., Jalkanen, J.
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Host publication information
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Research output: Professional › Conference contribution

Edge and particle embedment effects in low- and high-stress slurry erosion wear of steels and elastomers
Slurry transportation via pumping is an increasingly viable alternative for the conventional fine particle pumping, but there are also many applications involving larger particles. However, most of the published studies on slurry erosion have been conducted with fine particle sizes. In this work, also large particle slurry erosion of commercial wear resistant materials is studied. A high speed slurry-pot wear tester was used with edge protected samples to simulate the wear conditions in industrial slurry applications where edge wear is minimal. Two wear resistant steels together with natural rubber and polyurethane lining materials were tested, and the results were compared with the results of the same materials tested without sample edge protection. The tests were performed using 15 m/s speed, two sample angles, and slurry concentrations with particle size ranging from large 8/10 mm granite to fine 0.1/0.6 mm quartz. In all conditions, the steel samples showed stable wear behavior, whereas the elastomers gave notably inconsistent results in different test conditions. In general, steels exhibited better wear performance with large particles and elastomers with fine particles, and the wear losses were 40-95 % lower when edge wear was inhibited. With increasing abrasive size, the edge wear becomes more dominant and the particle embedment decreases.
The role of inorganics in modelling of biomass gasification

In this work, a summary of the research carried out about the role of inorganic elements in biomass gasification is presented. The research work has focused on the catalytic effects of alkali and alkaline earth metals in char gasification. The work has included gasification experiments using thermogravimetric analysis (TGA) and fluidized beds as well as modeling techniques. The results of the research presented in this paper indicate that the laboratory measured TGA reactivity numbers and correlations (including the effect of fuel ash inorganics) are possible to be converted to numbers predicting carbon conversion in a large scale fluidized bed gasification reactor. The model, called Carbon Conversion Predictor, is a relatively simple and transparent tool for the comparison of the gasification reactivity of different fuels in fluidized bed gasification.

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Organisations: Chemistry and Bioengineering, Research group: Bio- and Circular Economy, Univ Seville, University of Sevilla, Chem & Environm Engn Dept, Bioenergy Grp, Escuela Super Ingenieros
Authors: Konttinen, J., Kramb, J., DeMartini, N., Gomez-Barea, A.
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Research output: Scientific - peer-review › Conference contribution
Predictive Supply Temperature Optimization of District Heating Networks Using Delay Distributions

Fluctuating power production in combined heat and power (CHP) plants may cause unwanted disturbances in district heating (DH) systems, which leads to the situation that the best efficiency in CHP production is not achieved. DH systems are often automated, however, supply temperature is still primarily chosen manually by the operator. This is because of the uncertain heat demand in near future and uncertain behaviour of delay from heat supplier to consumers, which make the temperature scheduling problematic.

In this work, future heat demand and return water temperature are predicted based on outdoor temperature forecast and process data history using neural network estimators. Consumers in network are presumed to be similar, but their distances from production site vary thus creating a distribution function of range. Delay is modelled as a distribution function based on the distances between heat consumers and the suppliers, which weights the supply temperatures from last few hours calculating the average supply temperature received by the consumers. The derived function models how the temperatures develop along the network, finally covering the entire network.

A brute force optimizer was developed to minimize both pumping costs and heat losses as well as to smooth temperature gradient originated thermal stresses. System delays are fixed during an optimization cycle, and after each cycle the delays are updated according to new system flowing rates and the optimization is recalculated. The resulting supply temperature curve is a discrete curve that cuts the heat load peaks by charging and discharging the energy content of the District heating network (DHN). Optimization keeps the supply water temperature and flow rates in control and stabilizes the network smoothly and efficiently after disturbances. Optimization is demonstrated by using case data of one year from a district heating system in Finland.

Utilization of District Heating Networks to Provide Flexibility in CHP Production

Increasing penetration of intermittent renewable energy production in power systems will remarkably increase the need of flexible and controllable power generation. Subsidised renewable generation has revolutionized energy markets and brought down electricity prices leading to lack of investments to new controllable generation plants. As numerous existing thermal power generation units have been closed down, there is no doubt that all the possible flexibility available in power systems should be harnessed to stabilize the power systems. Combined heat and power (CHP) generation is widely used in district heating (DH) systems. As total heat production into the DH network needs to be balanced with the total heat consumption, this sets significant limitations to the long term power production. However, the coupling between the heat
load and electric production can be decoupled temporarily by using the heat storage capacity of DH network consisting of network volume and optional heat accumulators. This paper presents the results of research work dealing with the analysis of dynamic operability of interconnected CHP plants and district heating networks. The flexibility of generation capacity was compared with the requirements set to power producers to be able to participate the Automatic Frequency Restoration Reserve (FRR-A) market. For that, two case studies were presented that include FRR-A tests in two municipal CHP plants that utilize a heat only boiler and a DH accumulator to balance the heat production variations that are caused by changes in power production. The results indicate that both cases fulfill the requirements and that the DH network operation is affected only slightly. However, the rapid power level change is a disturbance to CHP boilers and DH networks that the process components and automation systems must adapt to. Therefore these aspects must be considered carefully when applying such new operation practises in existing CHP plants.

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Research output: Scientific - peer-review › Article

Environmental Impacts of Co-Combustion of Biomass in Coal Fired Boilers
Abstract: Environmental impacts of power production are a subject of emerging interest due to the global need of reduction of greenhouse gas (GHG) emissions and mitigation of climate change. One way to reduce GHG emissions in thermal power generation is to replace fossil fuels by biofuels. Besides of direct emissions, operation of thermal power plants presents also indirect impacts originated from the production and transportation of fuels and other materials needed for running the process and waste handling. In the decision making and policy planning it is important to evaluate the total impacts of planned operations, not only the direct impacts. Most of the direct emissions are monitored with Continuous Emission Monitoring Systems but assessment of indirect Life Cycle Impacts must be carried out by life cycle modelling. This paper introduces a procedure for the model based Life Cycle Assessment and a case where the total environmental impacts of partial replacement of coal by wood pellets in an existing coal fired power plant were assessed. The procedure can be used e.g. for designing the environmentally friendly operation strategy for the power plant and sustainable purchasing of fuels. This project was a part of the MMEA (Measurement Monitoring and Environmental Assessment) research program coordinated by CLEEN Ltd and funded by the Finnish Funding Agency for Innovation TEKES.

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Authors: Majanne, Y., Korpela, T., Judl, J., Koskela, S., Bqain, D.
Conversion of Iterative Balance Models to Directly Calculating Explicit Models for Real-time Process Optimization and Scheduling

Optimal utilization of complex processes involves real-time operational optimization and scheduling, especially in cases where the production line consists of both continuous and batch operated unit processes. This kind of real-time optimization requires process models which can be computed significantly faster than real-time. Iterative balance calculation is typically far too slow for these cases. This paper presents a method for converting an iterative balance model to a directly calculating model suitable for on-line process optimization. The approach is demonstrated with the first unit process in the copper smelting line, the flash smelting furnace (FSF). The method consisted of formulating an equation group based on the constrained FSF HSC-Sim model and solving the unknown parameters and static states with use of a symbolic calculation software. The solution was implemented as a function whose calculation time fulfilled the requirements for scheduling use.

Application oriented wear testing of wear resistant steels in mining industry

Tampere Wear Center have developed several high-stress wear testers that utilize large sized abrasive particles of natural origin and thus are able to simulate demanding applications of the mining industry. In this work, a versatile high speed slurry-pot wear tester was developed. Research questions studied are: 1) How to set up a wear test method for simulating real applications?, 2) What are the wear mechanisms in high-stress wear?, and 3) What is the role of microstructure and chemical composition on wear performance of wear resistant steels?

The high speed slurry-pot tester was developed for application oriented erosion wear testing of materials used in mineral handling and processing. It enables tests in demanding high-stress abrasive and erosive environments simulating wear, for example, in slurry pumps, tanks and pipes, dredging, mineral crushing and grinding, screening, loader buckets, and rock drilling. The key design features of the test method are the possibility to use up to 10 millimeter sized large abrasives and sample speeds up to 20 m/s in conditions ranging from wet slurry environments to dry sand or gravel.

The work has been done in FIMECC DEMAPP and DIMECC BSA projects, the focus is in the application oriented wear testing of materials intended for
Two-step bioleaching of copper and gold from discarded printed circuit boards (PCB)

An effective strategy for environmentally sound biological recovery of copper and gold from discarded printed circuit boards (PCB) in a two-step bioleaching process was experimented. In the first step, chemolithotrophic acidophilic Acidithiobacillus ferrivorans and Acidithiobacillus thiooxidans were used. In the second step, cyanide-producing heterotrophic Pseudomonas fluorescens and Pseudomonas putida were used. Results showed that at a 1% pulp density (10. g/L PCB concentration), 98.4% of the copper was bioleached by a mixture of A. ferrivorans and A. thiooxidans at pH 1.0-1.6 and ambient temperature (23. ± 2. °C) in 7. days. A pure culture of P. putida (strain WCS361) produced 21.5 (±1.5). mg/L cyanide with 10. g/L glycine as the substrate. This gold complexing agent was used in the subsequent bioleaching step using the Cu-leached (by A. ferrivorans and A. thiooxidans) PCB material, 44.0% of the gold was mobilized in alkaline conditions at pH 7.3-8.6, and 30. °C in 2. days. This study provided a proof-of-concept of a two-step approach in metal bioleaching from PCB, by bacterially produced lixiviants.
The study presents a path for selecting the reaction and reactor parameters of a process applying thermo-catalytic decomposition of methane (TDM). Temperature and catalyst are the main reaction parameters affecting the type of TDM carbon and defining the reaction’s theoretical heat requirement. Secondly, the reaction parameters affect the reactor design including the selection of reactor type and heating source as well as the reactor dimensioning. The reactor dimensioning is discussed by highlighting the methane residence time requirement at different reaction conditions. Finally, the economic value of the TDM products is analyzed. According to the analyses, the reaction temperature and catalyst have a significant effect on reactor design and on the value and utilization possibilities of the TDM carbon. The prices of carbon products vary greatly as does the global demand of those. The utilization possibilities of carbon highly affect the overall viability of the TDM process and therefore should be carefully considered during process design.
From Iterative Balance Models to Directly Calculating Explicit Models for Real-time Process Optimization and Scheduling

Optimal utilization of complex processes involves real-time operational optimization and scheduling, especially in cases where the production line consists of both continuous and batch operated unit processes. This kind of real-time optimization requires process models which can be computed significantly faster than real-time. Iterative balance calculation is typically far too slow for these cases.

This paper presents a method for converting an iterative balance model to a directly calculating model suitable for online process optimization. The approach is demonstrated with the first unit process in the copper smelting line, the flash smelting furnace (FSF). The method consisted of formulating an equation group based on the constrained FSF HSC-Sim model and solving the unknown parameters and static states with use of a symbolic calculation software. The solution was implemented as a function whose calculation time fulfilled the requirements for scheduling use.
Robust data reconciliation of combustion variables in multi-fuel fired industrial boilers

This paper introduces an application of simultaneous nonlinear data reconciliation and gross error detection for power plants utilizing a complex but computationally light first principle combustion model. Element and energy balances and robust techniques introduce nonlinearity and the consequent optimization problem is solved using nonlinear optimization. Data reconciliation improves estimation of process variables and enables improved sensor quality control and identification of process anomalies. The approach was applied to an industrial 200 MWth fluidized bed boiler combusting wood, peat, bark, and slurry. The results indicate that the approach is valid and is able to perform in various process conditions. As the combustion model is generic, the method is applicable in any boiler environment.
Edge effect in high speed slurry erosion wear tests of steels and elastomers

While the slurry transportation via pumping is an increasingly viable alternative for the conventional fine particle pumping, there are also many applications involving larger particles. However, the published studies on slurry erosion have mainly been conducted with fine particle sizes. In this work, both fine and large particle high speed slurry erosion of commercial wear resistant materials is studied.

The high speed slurry-pot wear tester was used with edge protected samples to simulate the wear conditions in industrial slurry applications, such as tanks and pipelines. Two quenched wear resistant steels together with natural rubber and polyurethane lining materials were tested, and the results were compared with the results of the same materials tested without sample edge protection. The tests were performed using 15 m/s speed, 45° and 90° sample angles, and 9 wt% and 33 wt% slurry concentrations with particle size ranging from large 8/10 mm granite to fine 0.1/0.6 mm quartz.

With or without edge protection, the steel samples showed stable wear behavior, whereas the elastomers gave notably inconsistent results in different test conditions. Steels exhibited better wear performance with large particles and elastomers with fine particles. In general, the wear losses were 40 – 95 % lower without edge wear, except for elastomers tested with fine quartz at the 45° sample angle, which yielded 25 – 75 % higher weight losses when the sample edges were protected. With increasing abrasive size, the edge wear becomes more dominant.

General information

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ASJC Scopus subject areas: Metals and Alloys, Polymers and Plastics
Research output: Professional › Conference contribution

Processing and Wear Testing of Novel High-Hardness Wear-Resistant Steel

Novel high-hardness medium carbon martensitic laboratory steel has been produced and tested for wear resistance. Different finish rolling temperatures (FRT) and quenching finish temperatures (QFT) were utilized. Composition was selected based on earlier experiments and carbon content was set to 0.35 % to obtain surface hardness of approximately 600 HB. FRT was varied to investigate the effect of prior austenite deformation on the mechanical properties. Direct quenching was implemented in the laboratory rolling trials. Plates were either quenched to room temperature or quenching was finished at 250 °C. The interrupted quenching was tested in order to improve the toughness of the steel via autotempering and possible austenite retention without drastic loss of hardness. The steel samples were tested for hardness and impact toughness. Material characterization included SEM and optical microscopy for microstructural inspection. Direct quenched steel samples exceeded the desired 600 HB surface hardness, but interrupted quenching to 250 °C resulted in lower hardness values. In contrast, the impact toughness was improved with latter quenching method. Impact-abrasion wear testing was conducted for the experimental steels to understand the effect of rolling and quenching parameters on wear resistance. Impeller-tumbler tests were carried out at Tampere Wear Center using natural granite as the abrasive. The results indicate that surface hardness is the main controlling factor of wear, and samples with the highest surface hardness showed the lowest mass loss.
Improving Recovery Boiler Availability through Understanding Fume Behavior

Unexpected recovery boiler shutdowns are rare, but they can cost millions of dollars in lost income. Sometimes the inorganic compounds in black liquor can cause sudden fouling or plugging problems that could not be predicted beforehand. The ash particles can be divided into two main types and size classes: carryover and fume. This paper focuses on the smaller fume particles that form through the condensation of alkali metal vapors, and that deposit via different mechanisms than carryover. The location of fume deposition depends on several factors, such as flue gas and superheater temperatures, black liquor composition, and the flow field in the boiler.

This paper presents results obtained with a computational method that simulates fume formation in recovery boilers. The results in this paper focus on the effect of black liquor composition and elemental release on fume behavior, and the paper suggests how these observations should be taken into account when designing new boilers or retrofits. Moreover, the paper introduces the possible applications of the modeling method. These include, for example, troubleshooting of fouling problems in existing boilers, designing superheater configurations for new boilers, and positioning soot blowers.
Accelerated deactivation, caused by thermal aging (TA) and/or sulfur+water poisoning (SW), of the PtPd/γ-Al₂O₃ natural-gas oxidation catalyst was studied. Thermal aging and poisoning treatments were performed separately and with varied combinations and comprehensive characterization of the catalyst was carried out after each step. The fresh catalyst has small, oxidized PtPd particles (<5nm) uniformly distributed in the γ-alumina washcoat. After the SW-treatment, a small amount of bulk aluminum sulfate was observed near the slightly grown noble metal particles. During the thermal aging, γ-alumina changed to δ-/θ- and α-alumina. In addition, total decomposition of oxidized Pt and partly decomposition of oxidized Pd occurred resulting in the formation of the grown noble metal particles with a bimetallic PtPd core and a
polycrystalline PdO shell. Also few, small (~5nm) bimetallic PtPd particles were still detected. In the TA+SW-treated catalyst with grown noble metal particles, a small amount of bulk aluminum sulfate was detected and it was randomly distributed over the noble metal particles and washcoat. The activity in the terms of methane conversion over the TA-, SW-, and SW+TA-treated catalysts was similar but it was decreased compared to the fresh catalyst. The activity of the TA+SW-treated catalyst was drastically decreased compared to the fresh catalyst due to significant morphological changes and aluminum sulfate formation.

**General information**

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Scopus rating (2014): SJR 2.232 SNIP 2.164 CiteScore 6.92
Scopus rating (2013): SJR 2.345 SNIP 2.134 CiteScore 6.42
Scopus rating (2012): SJR 2.629 SNIP 2.236 CiteScore 6.08
Scopus rating (2011): SJR 2.585 SNIP 2.345 CiteScore 6.14
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Scopus rating (2009): SJR 2.301 SNIP 2.232
Scopus rating (2008): SJR 2.455 SNIP 2.275
Scopus rating (2007): SJR 2.493 SNIP 2.5
Scopus rating (2006): SJR 2.284 SNIP 2.229
Scopus rating (2005): SJR 2.095 SNIP 2.233
Scopus rating (2004): SJR 2.393 SNIP 2.41
Scopus rating (2003): SJR 1.979 SNIP 2.259
Scopus rating (2002): SJR 2.304 SNIP 1.847
Scopus rating (2001): SJR 2.781 SNIP 2.441
Scopus rating (2000): SJR 2.687 SNIP 2.13
Scopus rating (1999): SJR 2.18 SNIP 1.874
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Keywords: Deactivation, Palladium, Platinum, Sulfur poisoning, Thermal aging
Electronic versions:
Honkanen et al_revised manuscript. Embargo ended: 1/10/17
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Source: Scopus
Source-ID: 84943638016
Research output: Scientific - peer-review › Article

A study on raw, torrefied, and steam-exploded wood: Fine grinding, drop-tube reactor combustion tests in N2/O2 and CO2/O2 atmospheres, particle geometry analysis, and numerical kinetics modeling

The purpose of this study was to compare the fine grinding properties and combustion behavior of three wood pellet products: raw, torrefied, and steam-exploded wood. The energy required to fine grind the pellets was tested, and so was the geometry and size distribution of the resulting ground products. Out of all the samples the steam-exploded wood pellet required the most energy for grinding. However, it also produced more sphere-like particles compared to the other two
types of samples. The combustion behavior of the samples was tested in a laminar drop-tube reactor (DTR). The samples were preground and the particles were sieved with vibration sieves with an opening of 112–125 μm. The pyrolysis process was examined separately at a temperature range of 973–1173 K. The combined pyrolysis and combustion tests were carried out at a reactor temperature of 1123 K. The O₂ concentrations used in the measurements were 3–21 vol-% in either N₂ or CO₂ atmospheres. The initial size distribution of the sample particles as well as their diameter evolution during pyrolysis and combustion was studied by using optical techniques. The surface temperature of the combusting particles was measured with a two-color pyrometer from within the DTR. The density, specific surface area, and pore diameter were measured from the ground samples with a mercury porosimeter. The chemical kinetic parameters, which describe the pyrolysis and char oxidation rates of the samples, were determined by using the data from the measurements.

**General information**

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**Functionality Testing of Water Pressure and Flow Calculation for Dynamic Power Plant Modelling**

Water pressure and flow rate calculation in dynamic boiler models is challenging because of stiff system dynamics meaning that time constants of model states vary by several orders of magnitude. Furthermore, strong interconnections between pressures and flow variables may cause instability problems in simulation runs. This study presents a method to implement and test dynamic thermal power plant water-steam system models. A dynamic water-steam system model is presented. The model is applied for testing of the functionality of the presented computation model. Computational performance was tested using different numerical solvers. Also sensitivity to changes in initial values of system states and model parameters was tested. The results indicate that a workable way to make flexible models was found.

**General information**

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Gain-Scheduled Composite Nonlinear Feedback Control of an Exothermic Chemical Reactor

This paper studies gain-scheduled composite nonlinear feedback (CNF) control of a continuous stirred tank reactor (CSTR). Inside the reactor, an exothermic chemical reaction occurs, which is commanded from high to low residual concentration. During the transition, the reaction dynamics change through stable-unstable-stable chain while the residual concentration decreases. Therefore, appropriate cooling is necessary to stabilize the reaction, and to prevent a thermal runaway and overheating of the CSTR. A full-state gain-scheduled CNF controller is designed for adjusting the coolant temperature of the CSTR. A traditional gain-scheduled cascade controller and a gain-scheduled model predictive controller (MPC) are also fabricated for comparison. The simulation results show that the closed-loop system using CNF controller is able to offer the best tracking performance as measured by the integral-of-absolute-error (IAE) criterion. In addition, the CNF controller needs fewer scheduled tuning parameters as opposed to the cascade structure.

Machine-coated starch-based dispersion coatings prevent mineral oil migration from paperboard

Mineral oil migration through paperboard presents a safety risk in modern food packaging. This study aimed to enhance the safety of fiber-based packaging by utilizing a bio-based composite barrier layer to protect against mineral oil. Starch-clay composite coatings on paperboard were created via dispersion coating. Thermal analysis of the coating components and field emission scanning electron microscopy imaging were performed to ascertain the physicochemical properties and morphology of the coatings. Coating functionality was evaluated using contact angles and transmission rate (water and oxygen) measurements. The packaging safety focus was implemented by measuring the gas phase migration of heptane and analyzing the migration of liquid mineral oil through the coated paperboards with FTIR. The functional properties of the coated paperboards were maintained or improved. The studied coatings were effective barriers against the migration of mineral oil and could hence improve the barrier properties and safety of fiber-based primary food packaging.
This paper presents a techno-economic analysis of four concepts that apply the thermal decomposition of methane (TDM) with the aim of reducing carbon dioxide emissions in natural gas combustion. Different technical solutions are applied to convert methane in natural gas to gaseous hydrogen, which is combusted to produce electricity with a steam power cycle, and solid carbon, which is assumed to be sold as carbon black. The cost of electricity production and the potential to reduce CO₂ emissions in each concept were evaluated and compared to the reference case of direct methane combustion. With a moderate emission allowance price (20 €/tCO₂) and product carbon price (500 €/tcarbon) the cost of electricity production in the concepts was 12–58% higher than in the reference case. However, the price of product carbon had a significant effect on the feasibility of the concepts. Thus, the methane burner, which showed the best performance, produced 17% less CO₂ emissions per MWhₑ and had a smaller cost of electricity production than the reference case already with the carbon price of 600–700 €/tcarbon.
The effects of microstructure on erosive-abrasive wear behavior of carbide free bainitic and boron steels
The wear resistance of carbide free bainitic (CFB) microstructures have shown to be excellent in sliding, sliding-rolling and erosive-abrasive wear. Whereas, boron steels are often an economically favorable alternative used in applications subjected to erosive and abrasive wear. In this study the erosive-abrasive wear resistance of CFB and boron steels with different heat treatments were compared and the effect of microstructure on wear was investigated. An application oriented dry-pot laboratory test method with 8-10 mm granite gravel was used to produce erosive-abrasive wear environment. The tested materials were CFB and boron steels. The CFB steels had hardness values of 500 and 600 HV. The boron steels, both quenched and quenched and tempered, had a hardness of 500 HV. The influence of the microstructures on wear was studied by wear test results as well as by optical and scanning electron microscopy. The phase compositions were determined by XRD. The effect of wear, in addition to weight loss was also characterized by surface profilometry, hardness and hardness profile determinations. The wear resistance of the steels was compared with results achieved in a field test in an industrial mining application. Moreover, the effect of the different microstructures on wear behavior is discussed. The carbide free bainitic steels showed better wear performance than the martensitic boron steels. The boron steels were subjected to microcutting and microploughing, whereas the CFB steels exhibited more shallow impact craters with thin platelets.

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Model based NOx emission monitoring in natural gas fired hot water boilers

Due to new emission regulations, coverage of monitoring requirements extends to new boiler classes. In Europe, Industrial Emission Directive brings new 15-50 MW boilers under the directive in special cases, so inexpensive NOx emission monitoring tools are appreciated. This paper presents models to estimate NOx emission in two similar natural gas fired municipal hot water boilers. The models utilize online process measurements also available in relatively simple set-ups. In the context, the performance of linear regression model and nonlinear neural network model are introduced. Despite the similarity, the results state that the examined boilers behave differently in terms of linearity and emission levels. Therefore, every boiler should be identified separately to exploit the simplest models in practical installations.
Monitoring of spraying in semi-dry desulfurization processes in coal fired power plants

The overall objective of the study is to improve usability and efficiency of desulphurization processes by providing assistance for plant operators by indicating arising issues. This paper introduces an indirect method to monitor spraying in semi-dry desulfurization processes, which is based on energy balance and first principle models. The method can e.g. be used to estimate flue gas exit temperature of the reactor, which is the main control variable in the process, and slurry flows to reactors. The temperature estimate indicates what should be the exit temperature if spraying is functioning properly. The method was tested with process data collected from an industrial power plant, and the simulation results state that the method is able to predict the reactor exit temperature by error of typically less than few degrees Celsius regardless of the process state.

Real Time Monitoring of Environmental Efficiency of Power Plants

Today total environmental impacts of power production are a subject of emerging interest. Operation of power plants presents direct and indirect impacts to the environment. Direct impacts consist of instant emissions due to the operation of power plants and indirect impacts are originated from the production and transportation of fuels and waste handling. The direct emissions are monitored with Continuous Emission Monitoring Systems (CEMS) but indirect Life Cycle Impacts (LCI) are typically assessed only once during the design phase of process properties such as applied combustion technology and fuels. This paper introduces a procedure for a real time monitoring of total environmental impacts of power plants. The monitoring system aggregates direct and indirect impacts as a total environmental efficiency of the power plant. The procedure can be used e.g. for designing the environmentally friendly operation strategy for the power plant and sustainable purchasing of fuels. This project is a part of the MMEA (Measurement Monitoring and Environmental Assessment) research program coordinated by CLEEN Ltd and funded by the Finnish Funding Agency for Innovation TEKES.
Laser sintering of copper nanoparticles on top of silicon substrates

This study examines the sintering of inkjet printed nanoparticle copper ink in a room environment using a laser as a high speed sintering method. Printed patterns were sintered with increasing laser scanning speed up to 400 mm s$^{-1}$. The resistivities of the sintered structures were measured and plotted against the scanning speeds. Increased resistivity seems to correlate with increased scanning speed. A selection of analytical methods was used to study the differences in microstructure and composition of the sintered structures. Based on the results, no discernable difference in the microstructure was noticed between the structures sintered using 20 mm s$^{-1}$ to 400 mm s$^{-1}$ scanning speeds; only the structure scanned using 5 mm s$^{-1}$ speed showed a vastly different microstructure and no resistivity was measurable on this structure. Compositional studies revealed that, apart from the structure scanned with 5 mm s$^{-1}$ speed which contained the highest oxygen, the rest of the structures showed a steady oxygen increase with increased scanning speed.
Thermal flow permeametry - A rapid method for finding local changes in flow channels
Solid bodies with flow channels can have very heterogeneous structure, whose local variations are difficult to analyze. Yet, this can play an important role affecting characteristics, such as, fluid flow property, strength and heat conductivity. This article presents a method named thermal flow permeametry (TFP) that is applicable for a quick analysis of variations in flow channels, even in meter-sized structures. For illustrating the method, we analyzed the local permeability levels of a large and extremely complex fiber structure. In TFP, hot air is ejected through a structure, while thermal camera measures local surface temperature variations during heating. Gray values of the thermal image are then plotted versus the structures local thickness, density and permeability. We showed that gray values link with local permeability, affected by thickness, density and flow channel tortuousness. We also found out that TFP is very sensitive to local changes in flow channels.
Enhanced pre-treatment of cellulose pulp prior to dissolution into NaOH/ZnO

As a result of the constantly growing demand for textile fibres interest in utilising cellulose pulps for manufacturing regenerated cellulose fibres is growing. One promising water-based process for the manufacture of regenerated cellulose products is the Biocelsol process based on an NaOH/ZnO solvent system. The drawback of the Biocelsol process is the need for pre-treatment of the pulp, i.e. long mechanical pre-treatment (up to 5 h) followed by a 2–3-h enzymatic hydrolysis utilising a rather high amount of cellulolytic enzymes. In this work more efficient conditions to carry out the pre-treatment of cellulose pulp prior to dissolution into NaOH/ZnO are presented. Based on the results, cellulase treatment, when carried out in an extruder, can be used to effectively open up and fibrillate the fibres without completely destroying the fibre structure. The molar mass of the pulp treated enzymatically in an extruder was 14 % lower as compared to the state-of-the-art-treated cellulose. As a consequence, the alkaline solutions prepared from the pulp treated enzymatically in an extruder had clearly lower dope viscosities regarding the cellulose content than the solutions prepared from the state-of-the-art-treated pulp. This enabled increasing the cellulose content in the dope up to 7 % (w/w) without increasing the dope viscosity.
Heap Bioleaching of Low-grade Multimetal Sulphidic Ore in Boreal Conditions

The bioleaching of metal sulphide ore has developed into an important industrial process to recover valuable base metals from low-grade ores, because high grade ore resources are depleting. The Talvivaara deposits in Finland have been known for decades, but have not been utilized until now, because of the low nickel concentration. The aim of this work was to study the bioleaching process of a Finnish complex multimetal black schist ore in boreal conditions. The effects of pH and leaching temperature on the dissolution of valuable metals and gangue minerals were studied. The effect of low temperature on iron oxidation and mineral bioleaching was investigated. Microbial community development at different pH values and temperatures was tested in laboratory-scale bioleaching columns and finally the community dynamics were studied in a demonstration-scale bioheap over a period of three years in Talvivaara Finland.

The experiments were carried out using laboratory-scale columns containing about 9 kg of agglomerated ore. The columns were loaded with the ore, irrigated with pregnant leaching solution (PLS) by recycling and aerated from the bottom. The tested pH range was from 1.5 to 3.0 at 21 °C and temperature range was from 7 to 50 °C at pH 2.5. The particle size (d80) of the ore was 7.6 mm. Surface water taken from lake near the Sotkamo deposit (slightly affected by acid mine drainage) supplemented with nutrients was used for irrigation. Aeration was provided through a diffuser inserted at the base of the column. The iron- and sulphur-oxidizing bacterial culture used in inoculation of the columns, was enriched from surface water samples (pH 4.5-6.9) obtained from the ore deposit. The pH of irrigation solution was maintained with continuous titration with H2SO4. The ore was acid consuming in all tested conditions. The actual pH of the irrigation solutions after 140 days were 0.1-0.5 units over the target values in all columns. Leaching at low pH resulted in increased acid consumption of 160 and 38 H2SO4 g kg-1 ore at pH 1.5 and 2.0 after 140 days. Temperature, at pH 2.5, had also effect on acid consumption. At 50 °C acid consumption was highest and lowest at 21 °C, being 29 and 8 H2SO4 g kg-1 ore, respectively.

The pH of the irrigation solution clearly affected to the dissolution of nickel and zinc. Nickel solubilization rate was 3.3 times higher at pH 1.5 than at pH 3.0, being 0.42 and 0.13 % (Ni) d-1, respectively. At pH 1.5 valuable metals yields were 59 % for Ni, 52 % for Zn, 13 % for Cu and 16 % for Co, whereas at pH 3.0 yields were 15 % for Ni, 10 % for Zn, 0.5 % for Cu and 6 % for Co after 140 days of bioleaching. No significant bioleaching happened after that at pH 1.5, 2.5 or 3.0. At pH 2.0 the maximum yields were achieved after 230 days of bioleaching. Nickel and zinc leaching rates and yields decreased nearly linearly as pH increased. Copper did not bioleach at high pH (2.5-3.0). After the beginning, no further cobalt dissolution happened at pH 3.0. Decrease in leaching rates may be due to a lack of dissolved ferric iron, serving as a leaching agent, or metal dissolution barriers created by precipitates on the ore surfaces. The ferric iron concentration in PLS increased all the time at pH 1.5, being 36 g l-1 after 140 days. At pH 2.0 the ferric iron concentrations varied, being highest 3.8 g l-1 after 97 days. At 2.5 and 3.0 no ferric iron was present in PLS and iron concentration remained low, being 15 mg l-1.

After 60 days of bioleaching the leach liquor at pH 1.5 became jelly-like due to solubilization of Si from the ore, which contained 42 % (w w-1) of SiO2. Quartz, phlogopite, and feldspars (anorthite and microcline) were the main Si-containing phases. After 110 days the Si concentration reached 2.96 g L-1 at pH 1.5. Soluble Si increases the solution viscosity and thus hinders leach liquor percolation trough the heap, lowers the oxygen transfer rate, and complicates subsequent metal extraction. Although, dissolved Si did not affect the solubilization of valuable metals, the pH value of the PLS must be kept at over 1.5 to slow down Si-containing mineral dissolution. At pH 2.5 less than 200 mg L-1 Si was solubilized and different temperatures had no effect on Si dissolution at that pH.

Based on an optimisation between the maximum valuable metal yields, leaching rates, the acid consumption, and the low dissolution of cations (Si, Al, Ca, Mg and Mn), the leaching solution pH of 2.0 was recommended for a bioheap application. At pH 2.0, the maximum leaching yields were achieved after 230 days, being 54 % for Ni, 37 % for Zn, 13 % for Cu and 12 % for Co.

Temperature strongly affected the valuable metal yields at pH 2.5. Leaching at low temperature (7 °C) resulted in yields of 24 % for Ni, 17 % for Zn, 2 % for Cu and 6 % for Co after 496 days. The Cu leaching increased all the time during the
experiment at 7 ºC, while at other temperatures it slowed down after 100 days. The highest yields were obtained at 21 ºC (26 % for Ni, 18 % for Zn, 0.5 % for Cu and 6 % for Co) after 153 days. After re-inoculation (day 65) with a thermophilic Sulfolobus culture, leaching at 50 ºC accelerated but slowed down soon and resulted in 18 % for Ni, 11 % for Zn, 0.3% for Cu and 2% for Co (after 140 days). In the column leaching study, after the maximum yields, longer leaching time did not result more metals in solutions.

The redox increased during the first two months at 7 ºC and reflected the start of ferrous iron oxidation and microbial activity. The concentration of ferric iron was around 400 mg L-1 after two months. After that ferric iron was present all the time at 7 ºC and this demonstrated that more ferric iron was available for the oxidation of the mineral sulphide than at other temperatures. The leach liquor redox potential stabilized to 500-600 mV (Ag0/AgCl reference) at 7 ºC after 40 days and at 21 ºC right after beginning, whereas at 35 ºC and at 50 ºC it varied between 300-500 mV. At 50 ºC, all dissolved iron was in ferrous form inspite the variation of redox. After 50 days Fe2+ and Fetot were both 350 mg L-1 indicating that iron oxidation and precipitation occurred at the same time. Brown precipitates accumulated to the surfaces of the agglomerated ore in columns from 7 ºC to 50 ºC. Additionally, bright yellow precipitates were formed indicating elemental sulphur or Na-jarosite accumulation at 7 ºC and 21 ºC.

After 50 days of bioleaching, at 7 ºC leach liquor total cell counts (108-109 cells mL-1) were significantly higher than at other temperatures (106-107 cells mL-1). Cell counts remained that high throughout the column study. At the end of the experiment, total cell counts in the leach residues were studied. At 7, 21, 35 and 50 ºC cell counts of the leach residues were 3·108, 2.3·108, 1.1·107 and 8.7·106 cells ore g-1, respectively. The pH did not affect at 21 ºC the numbers of microorganisms in the PLS and cell counts remained at 108-106 cell mL-1 throughout the study and the leach residues contained about 108 cells g ore-1.

The microbial community composition and dynamics was by investigated by DNA extraction PCR-DGGE-sequencing approach. The microbial community were not affected by pH. In contrast, temperature affected the microbial populations. After the first months, Acidithiobacillus ferrooxidans AP 310 (96-99% sequence similarity, accession DQ35518) was the only species detected at 7 ºC and was also present at other temperatures. After the data of this study was published (2007), two new Acidithiobacillus species were described, A. ferrivorans and A. ferridurans. Genetically these species are very near each other. The 16S rRNA gene sequences of the bands that corresponded 99% of A. ferrooxidans AP310 (DQ35518) were identified again in 2015 using the basic local alignment search tool (BLAST). The 16S rRNA gene sequences of A. ferrooxidans at temperatures of 7 and 21 ºC corresponded 99% as A. ferrovorans SS3 (CP002985). One of the 16S rRNA gene sequences of A. ferridurans strains at 35 ºC corresponded 99% as A. ferridurans ATCC 3302 (NR_117036). At 50 ºC, no proper A. ferrooxidans 16S rRNA gene sequences were gained with the used methods. The presence of A. ferrometals at 50 ºC was concluded based on the fact that the DGGE band was in the same place as the other A. ferrooxidans bands. The 16S rRNA gene sequences of Acidithiobacillus ferrooxidans strains in pH between 1.5 and 3.0, at 21 ºC, corresponded also 99% as A. ferrovorans SS3 (CP002985). In the light of increased knowledge, these species cannot be separated with the denaturing gradient from 40 to 70% that were used in the DGGE. A. ferrooxidans, A. ferrivorans and A. ferridurans are able to oxidize both iron and sulphur compounds.

Leptospirillum ferrooxidans DSM 2705 (98-100%, X86776) and Sulfobacillus thermotolerans KR-1 (99%, DQ124681) were mainly detected at 21 ºC and 35 ºC. Sb. thermotolerans was present at 50 ºC, L. ferriliphilum D1 (99 %, DQ66590909) appeared after 300 days of bioleaching and was present in every leach residue, except at 7 ºC and pH 3.0. L. ferrooxidans and L. ferriliphilum are able to oxidize only iron. Sb. thermotolerans is able to oxidize both iron and sulphur compounds. Ferroplasma acidiphilum DR1 (98%, AY222042) that can oxidize both iron and sulphur compounds.

Archaeal species were analyzed two times from leach liquors and three species were detected. A species related to an uncultured archaeon clone ant b7 (99%, DQ303249), nearest known species Thermoplasma acidiphilum DSM1728 (91%, AL445067) was present in all of the leach liquors except at pH 1.5. Archaea related to Sulfolobus metallicus DSM 6482 (98%, SM16SRRN1) were present at pH values 2.5 and 3.0 and in all other temperatures, except at 7 ºC. Sulfolobus metallicus is able to oxidize both iron and sulphur compounds. Ferroplasma acidiphilum DR1 (98%, AY222042) that can oxidize only iron, was present at pH 2.5 and 2.0, and in all temperatures, expect at 35 ºC.

The mixed iron- and sulphur-oxidizing culture in the recirculation solution at 7 ºC was used in the experiments where Fe2+ oxidation rate and optimum temperature were determined over a temperature range of 2-40 ºC. Two temperature optima of 22.4 ºC and 32.4 ºC were observed. This indicated the presence of both psychrotolerant and/ or mesophilic microorganisms in the culture. This supports the suggestion that A. ferrooxidans was actually A. ferrivorans, or both species were present. The specific oxidation rates for the culture were similar, with 13.5·10-8 and 12.8·10-8 mg Fe2+ cell-1 h-1 for 22.4 ºC and 32.4 ºC, respectively.

The two demonstration-scale bioheaps (17 000 t) at the Talvivaara mine site were operated and monitored by Talvivaara Mining Company for 30 months. After the start-up of heap irrigation, oxidation of pyrrhotite and pyrite increased the heat temperature in central locations up to 90 ºC. In the second winter temperatures inside the heaps decreased being still 80 ºC at the hottest spots. Leach liquor temperatures varied between 60 ºC and 15 ºC over the whole operation period. The target pH of the PLS was 2.0. Inspite of continuous titration pH varied during the 10 months between 3.5 and 3.0 and after that between 3.0 and 2.5.

The bacterial community composition on the heaps was monitored over time from manholes and the leach liquor collection ponds. At the end of the primary bioleach phase (18 months) cell counts were around 106 cells mL-1. Large temperature
gradients resulted in the simultaneous presence of mesophilic and thermophilic iron- and sulphur-oxidisers in the heap. In the beginning diversity was broad, but decreased with time. A. ferrooxidans/ ferrivorans SS3 (99%, CP002985) was the dominant bacterium and an unknown bacterium related to clone H70 (91%, DQ328625) was present. After six months of bioheap operation L. ferrooxidans DSM 2705 (98%, X86776) was observed for the first time and it was present thereafter in nearly all samples. Archaea were analysed during the primary leaching phase from leach liquors. Two novel archaea and one archaea related to Thermoplasma acidophilum strain 122-1B2 (91-93%, NR_028235) were detected.

Several ore samples were drilled from the primary bioheaps after one year of bioheap operation. A. ferrooxidans/ A. ferrivorans SS3 (99%, CP002985) was present in nearly all samples. The novel bacterium related to clone H70 (91%, DQ328625) and A. caldus related bacteria (95%, AY427958) was detected from the areas of wide temperature variation. St. thermosulfidooxidans strain YN22 (99%, DQ650351) was found from the high temperature zones of the heap. Ferrimicrobium acidiphilum T23 (99%, AF251436) was present in the areas where temperature varied between 20 and 35 ºC. After 18 months of demonstration-scale heap operation, the heaps were reclaimed and restacked to the secondary bioheap. At the secondary leaching phase the community remained steady. A. ferrooxidans/ ferrivorans SS3 (99%, CP002985) dominated and the novel bacterium related to a clone H70 (91%, DQ328625) and L. ferrooxidans DSM 2705 (98-100%, X86776) were present in the leach liquors of secondary phase bioheaps.

Comparison of laboratory rolling-sliding wear tests with in-service wear of nodular cast iron rollers against wire ropes

The present work describes the wear behaviour of nodular cast iron in rolling-sliding contact with steel wire ropes and steel wires in laboratory and in-service conditions. In each of the studied examples, the wear had proceeded through a surface fatigue process, in which inter-nodular crack propagation and simultaneous deformation in a thin sub-surface zone had resulted in the formation of ferrous scales consisting of material from the metal matrix of the cast iron. The scale layers of the wear surface were oriented towards the direction of the sliding component of the motion, and the spalling of the scales was identified as the dominating mechanism for material removal from the wear surface. The initiation behaviour of the inter-nodular cracks was analysed by crack measurements and statistical analysis of the depths and initiation angles of the cracks in relation to the wear surface. The initiation depths of the cracks increased with increasing contact pressure. Roller samples from in-service and from the component wear tests showed closely similar distributions of the crack depths and crack initiation angles. The sample from the twin-disc test showed aspects of cracking behaviour that were typical of both the rolling and the sliding direction of the roller samples.
Preparation of Supercapacitors on Flexible Substrates with Electrodeposited PEDOT/Graphene Composites

Composite films consisting of poly(3,4-ethylenedioxythiophene) (PEDOT) and graphene oxide (GO) were electrochemically polymerized by electrooxidation of EDOT in ionic liquid (BMIMBF₄) onto flexible electrode substrates. Two polymerization approaches were compared, and the cyclic voltammetry (CV) method was found to be superior to potentiostatic polymerization for the growth of PEDOT/GO films. After deposition, incorporated GO was reduced to rGO by a rapid electrochemical method of repetitive cathodic potential cycling, without using any reducing reagents. The films were characterized in 3-electrode configuration in BMIMBF₄. Symmetric supercapacitors with aqueous electrolyte were assembled from the composite films and characterized through cyclic voltammetry and galvanostatic discharge tests. It was shown that PEDOT/rGO composites have better capacitive properties than pure PEDOT or the unreduced composite film. The cycling stability of the supercapacitors was also tested, and the results indicate that the specific capacitance still retains well over 90% of the initial value after 2000 consecutive charging/discharging cycles. The supercapacitors were demonstrated as energy storages in a room light energy harvester with a printed organic solar cell and printed electrochromic display. The results are promising for the development of energy-autonomous, low-power, and disposable electronics.
The Effect of Phosphorus Exposure on Diesel Oxidation Catalysts-Part I: Activity Measurements, Elementary and Surface Analyses

The effects of phosphorus poisoning on the activity of PtPd and Pt diesel oxidation catalysts and on the activity of the support material were investigated using the gas phase laboratory-scale-aging procedure. The catalysts were treated using two different phosphorus concentrations (0.065 and 0.13 mol/L (NH₄)(2)HPO). The deactivation was studied by inductively coupled plasma optical emission spectroscopy, electron microscopy, X-ray diffractometry, X-ray photoelectron spectrometry and Fourier-transform infrared reflectance, N-2-physisorption, and activity measurements with CO, C₃H₆ and NO. The amount of accumulated phosphorus was higher on the Pt catalyst surface than on the PtPd catalyst and significantly higher on the surface of the bare support material. Phosphorus concentration was uniform throughout the support layer (down to the 10 μm), and phosphorus was found as phosphate, although it can also form compounds like AIPO(4) with the support. The treatment with low phosphorus concentration was found to have a clear deactivation effect only for C₃H₆ oxidation activity on PtPd catalysts above 200 degrees C. The treatment with high phosphorus concentration significantly decreased the activity of both the PtPd and Pt catalysts. In particular, the C₃H₆ and NO oxidation activities of the fresh and P-treated Pt catalysts were higher than those of the PtPd catalysts for the entire temperature range.
In this article, the current management paradigm of water services in Finland is conceptualised. For this purpose, the managers of water utility in ten Finnish municipalities were interviewed. Consequently, the ways in which water services are perceived and managed are also described in this article. In addition, it is argued that the current paradigm produces systemic behaviour that can be considered to give rise to unsustainable ways of developing water services. Based on the problems of the current paradigm, an alternative paradigm is drafted that rethinks the value-creation logic. This alternative paradigm implies that one should be aware of the interactions between systems in which water services play a crucial role, and act accordingly.
Effect of spraying parameters on the microstructural and corrosion properties of HVAF-sprayed Fe-Cr-Ni-B-C coatings

Thermally sprayed Fe-based coatings have been extensively studied as future solution in order to replace more expensive, harmful and environmentally dangerous Ni- and WC-based coatings for several industrial applications where high corrosion and wear resistance are required. The aim of the present study is to investigate the effect of spraying parameters on the microstructure and the corrosion resistance of Fe-based coatings manufactured with the High Velocity Air Fuel (HVAF) thermal spray process. Six sets of thermal spraying parameters have been chosen and their effect on the overall quality of coatings was investigated. All HVAF coatings showed comparably dense microstructure with near-zero oxidation, proving the high quality of the deposition process. However, higher anti-corrosion and mechanical properties were achieved by increasing the spraying air pressure and decreasing the particle feeding rate without altering the thickness and the overall deposition rate. Powder feeding rate was reported to have a remarkable effect on microstructure and corrosion properties. Coatings with beneficial compressive residual stresses were successfully obtained by increasing air pressure during spraying which resulted in improved microstructural and corrosion properties.

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Scopus rating (2010): SJR 1.155 SNIP 1.66
Scopus rating (2009): SJR 1.449 SNIP 1.526
Scopus rating (2008): SJR 1.479 SNIP 1.564
Scopus rating (2007): SJR 1.165 SNIP 1.509
Scopus rating (2006): SJR 1.276 SNIP 1.709
Scopus rating (2005): SJR 1.252 SNIP 1.666
Scopus rating (2004): SJR 1.269 SNIP 1.498
Searching for a robust strategy for minimizing alkali chlorides in fluidized bed boilers during burning of high SRF-energy-share fuel

To meet the increasing volume of waste to be treated via energy recovery, high SRF-energy-share fuel is being fired in conventional waste-to-energy facilities. In this work, corrosion related risk during firing of 70 e-% share (target fuel) is studied and compared against the base case fuel containing 50 e-% share. Cl and S concentration is highest in the target fuel as a direct result of increasing the proportion of SRF in the fuel mixture. Br, Zn and Pb showed the same trend. Meanwhile, the concentration of Na, K, Al and Si are highly dependent on the type of the SRF fired. The corrosion risk of the base and target fuels are analyzed using the composition of the fine aerosol fraction and deposit samples measured near the vicinity of the superheater. Surprisingly aerosols for the target fuel are less risky - having less Cl and more S, than that of the base fuel. The effects of sulfur based additives - elemental sulfur and sulfate injection, and fuel substitution on the risk of superheater corrosion are likewise analyzed. All these strategies can reduce the concentration of Cl in the aerosols, however it is concluded that sulfate injection is considered as a robust strategy for mitigating alkali chloride formation. Sulfate injection is able to reduce Cl in the aerosols and deposits regardless of the quality of the fuel mixture. Robust strategies are important in ensuring the boiler performance during high SRF-energy share firing. An attempt of linking the quality of the deposits and the properties of the flue gas and aerosols around the superheater using partial least squares regression is also presented.

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Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Chemistry and Bioengineering, Urban circular bioeconomy (UrCirBio), University of Jyväskylä, Valmet Technologies Oy, VTT Technical Research Centre of Finland, Department of Chemistry, Renewable Natural Resources and Chemistry of Living Environment, Stora Enso
Authors: Bajamundi, C. J. E., Vainikka, P., Hedman, M., Silvennoinen, J., Heinanen, T., Taipale, R., Konttinen, J.
Decomposition analysis of Cuban energy production and use: Analysis of energy transformation for sustainability

The aim of the article to analyse the changes in Cuban energy system. It uses decomposition analysis to reveal the impacts of the changes in key drivers of energy consumption and CO2 emissions. The Cuban Energy Revolution, which was started in 2006, was the policy response to the local energy crisis; oil imports caused serious balance of payment problems, the old centralised electricity production system was inefficient and hurricanes caused wide damage to the transmission and distribution system resulting large black outs. The Energy Revolution has been quite successful in changing the energy use patterns in Cuban households. Switch from kerosene to electricity in cooking and using energy saving pressure cookers have had an effect on energy efficiency. In addition, the decentralisation of electricity production has increased the reliability of supply and improved the efficiency when new smaller scale power plants have replaced older technology. The energy revolution has, so far not had much impact on energy use in industry, transport and agriculture, which are the areas where the future policies should be directed.

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Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Automation Science and Engineering, Research area: Measurement Technology and Process Control
Authors: Vazquez, L., Luukkanen, J., Kaisti, H., Käkönen, M., Majanne, Y.
Number of pages: 8
Pages: 638-645
Publication date: Sep 2015
Column leaching of low-grade sulfide ore from Zijinshan copper mine

Abstract: Copper and iron dissolution of Zijinshan low-grade copper sulfide ores was investigated in ore-packed columns. At 60 °C and pH 1.0, 37.1 g Fe(III) L⁻¹ permitted effective copper dissolution and inhibited the activity of iron-oxidizing microorganisms. At 30 °C, microorganisms stimulated Fe(II) and pyrite oxidation, resulting in 85 and 54% of copper and pyrite extraction yields, respectively. Bacteria belonging to the genera Acidithiobacillus and Leptospirillum were dominant as observed by real-time PCR assay. Aeration and inoculation of columns were not necessary. Solutions had a higher pH of 1.7 in the columns operated without recirculation. Under these conditions, copper extraction was not affected and Fe(III) precipitated as jarosite, indicating a novel method for iron control in Zijinshan copper mine.

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Chemistry and Bioengineering, Research group: Industrial Bioengineering and Applied Organic Chemistry, Urban circular bioeconomy (UrCirBio), Shanghai Institute of Ceramics Chinese Academy of Sciences, Zijin Mining Group Co., Ltd., Institute of Process Engineering, Chinese Academy of Sciences
Authors: Zou, G., Papirio, S., Lai, X., Wu, Z., Zou, L., Puhakka, J., Ruan, R.
Number of pages: 6
Pages: 11-16
Publication date: 15 Jul 2015
Peer-reviewed: Yes
A comparison of rheology and FTIR in the study of polypropylene and polystyrene photodegradation

Rheology and FTIR spectroscopy are compared as methods to study the degree of photodegradation in polypropylene (PP) and polystyrene (PS) sheets. The materials are hot pressed, artificially photo-aged with fluorescent lights for 4-2048 h and then measured with a rotational rheometer and FTIR. Both materials show a tendency for chain scission which can be seen as a reduction in viscosity. Changes in PP can be observed with both methods after 256 h of irradiation. Changes in PS become significant in rheology after 64 h but in FTIR only after 1024 h of irradiation. Due to the different chemical nature of the materials, the degradation of PS is rather linear with exposure, whereas the degradation of PP is more exponential. Using the zero shear viscosities obtained through extrapolations of the Cole-Cole and Carreau-Yasuda models, relative molecular weights are estimated with the aid of the power-law relationship between these two. These results are compared with the carbonyl indices determined from the FTIR spectra. Rheology is found to be a viable alternative for FTIR in certain situations.

General information
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Organisations: Department of Materials Science, Research group: Plastics and Elastomer Technology, Department of Chemistry and Bioengineering, Research group: Supramolecular photochemistry, Research area: Sustainable Machine Systems, Department of Mechanical Engineering and Industrial Systems, Tampere Univ Technol, Tampere University of Technology, Dept Chem & Bioengn
Authors: Mylläri, V., Ruoko, T., Syrjälä, S.
Number of pages: 6
Publication date: 1 Jul 2015
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ISSN (Print): 0021-8995
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Developing Synthetic Biology Tools and Model Chassis: Production of Bioenergy and High-Value Molecules

One of the aims of synthetic biology is the sustainable production of high-value compounds and bioenergy molecules. Synthetic biologists exploit fundamental engineering principles, such as DNA component standardization, modular genetic circuits, and de novo design, to create novel production pathways and products. A well-characterized host cell serves as the chassis for the system construction; generally, the model bacterium Escherichia coli is applied. However, the metabolism and characteristics of E. coli are not ideal for all applications. Furthermore, many E. coli based systems are patent protected which restricts the use in forthcoming application. Acinetobacter baylyi ADP1 is a potential alternative host for synthetic biology. The metabolism and genetics of the strain are well-understood, and the engineering of its genome is technically straightforward. The versatile and unusual metabolic pathways, including those producing long chain hydrocarbons, can be rerouted, modified, and integrated into novel ones. I exploited A. baylyi ADP1 as a model host for the production of high-value hydrocarbons, triacylglycerols and wax esters. I employed metabolic engineering, novel molecular monitoring tools, and synthetic pathway design to improve the production, and to demonstrate the utility of ADP1 as a synthetic biology host. In particular, the production of triacylglycerols was improved over 5-folds by targeted gene deletions which resulted in redirected carbon flux towards the product and elimination of competitive pathways. The long-chain hydrocarbon metabolism, including alcohol and wax ester biosynthesis, is not yet fully understood. These pathways are regulated through several mechanisms sensitive to specific environmental conditions and the cellular states. However, the lack of robust and straightforward analysis tools has restricted the studies of lipid metabolism and production kinetics. I developed a simple in vivo tool for the investigation of the long chain hydrocarbon metabolism in real-time. The tool is based on a light-producing reporter enzyme, bacterial luciferase. The enzyme utilizes a specific intermediate of the hydrocarbon synthesis pathway as a substrate for bioluminescence production. Initially, the tool was applied for monitoring the wax ester metabolism of A. baylyi ADP1. Subsequently, I modified the monitoring tool for studying the degradation of alkanes. The studies suggest that the tool can be applied for production optimization in different hosts and for a variety of products. I also reconstructed the wax ester synthesis pathway of A. baylyi ADP1 by
replacing a natural key enzyme with an alternative well-characterized component, enabling a regulated production of unnatural wax esters. Bioprocess control and scale-up of production systems are challenging. Multispecies cultures are suggested to improve the robustness and performance of bacterial production processes. I exploited the metabolic versatility of A. baylyi ADP1 to construct a rationally engineered synthetic coculture with E. coli. The designed coculture exhibited improved biomass and recombinant protein production compared to the pure culture of E. coli. To conclude, I have shown that the strain ADP1 is a suitable host for synthetic biology applications, especially for long-chain hydrocarbon production, the development of novel tools for metabolic studies, and for exploiting the existing unusual metabolic networks of the cell. Thus, further studies of the remaining challenges related to ADP1 bioprocess and as-of-yet uncharacterized cell mechanisms, are warranted.

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Authors: Santala, S.
Number of pages: 99
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santala.pdf: 2452576 bytes, checksum: 4ec3671718abab24507b10ee16ba8b0a (MD5)<br/>Submitter:Approved for entry into archive by Kaisa Kulkki (kaisa.kulkki@tut.fi) on 2015-03-26T10:20:38Z (GMT) No. of bitstreams: 1
santala.pdf: 2452576 bytes, checksum: 4ec3671718abab24507b10ee16ba8b0a (MD5)<br/>Submitter:Made available in DSpace on 2015-03-26T10:20:38Z (GMT). No. of bitstreams: 1
santala.pdf: 2452576 bytes, checksum: 4ec3671718abab24507b10ee16ba8b0a (MD5)
Source: researchoutputwizard
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Research output: Collection of articles › Doctoral Thesis

Biohydrogen Production: A Protein to Community Level Perspective Study
Excessive usage of traditional energy reserves leading to increased environmental pollution and global warming have strongly urged for alternative sustainable energy sources. Due to non-polluting nature and high energy yields, hydrogen (H₂) gas is considered as an ideal candidate for alternative fuel. Biohydrogen (bioH₂) production from organic wastes is a sustainable approach, addressing energy production through organic waste disposal. Organic wastes such as lignocellulosic biomass and industrial glycerol, a by-product of biodiesel manufacturing process, have been recently investigated for their bioconversion potential. However, bioconversion of such organic wastes is a challenge due to the presence of impurities, toxic degradation products and complex nature. In comparison to pure bacterial strains, natural microflora could be an ideal inoculum choice offering better adaptability, substrate utilization efficiency and bioconversion rates. Another challenge to ensure efficient fermentation is to optimize various physico-chemical factors such as pH, temperature, substrate selection and concentration, medium compounds, and H₂ removal and collection due to individual and interactive effects on microbial growth, metabolism and hydrogenase enzyme. Hydrogenases are metalloenzymes that reversibly catalyzes proton reduction to H₂, and are divided into three classes based on the metal cofactor at the active site, [Fe-Fe], [Ni-Fe] and [Fe] hydrogenase. Among the hydrogenase classes, [Fe-Fe] hydrogenases exhibit highest catalytic activity involving mostly in H₂ production. Apart from their pivotal role in fermentative H₂ production, [Fe-Fe] hydrogenases promise an alternative catalyst choice in fuel cells. However, in spite of their preference towards H₂ production, [Fe-Fe] hydrogenases are extremely prone to catalytic inactivation upon oxygen exposure. This is the major
challenge, at the protein level, that hinders a cost-effective approach for biotechnological applications and suggests the requirement of targeted tools to investigate the inactivation process at the molecular level. The purpose of the present study was to investigate bioH₂ production in protein to community level perspective. More specifically the aims were to (1) establish an anaerobic biopanning procedure to enrich antibody binders specific against clostridial [Fe-Fe] hydrogenase protein, (2) develop and standardize a novel enrichment system, (3) implement the enrichment technique to enrich functional inoculum capable of degrading complex substrates, (4) enrich crude glycerol fermenting microbial community and finally, (5) optimize the physico-chemical factors influencing fermentative H₂ production for efficient bioprocess. In the present study, biopanning with synthetic ‘mixed’ single chain variable fragment (scFv) libraries against active and inactive clostridial [Fe-Fe] hydrogenases aided the enrichment of anti-hydrogenase antibodies. Out of ninety four (from inactive hydrogenase) and ninety two (from active hydrogenase) random clones screened, nine potential antibody clones with recognition specificity towards Clostridium acetobutylicum [Fe-Fe] hydrogenase were selected. The enriched binders also recognized [Fe-Fe] hydrogenase from C. butyricum. Based on the results from this study, it could be reasoned that the binders with generic specificity against closely related clostridial [Fe-Fe] hydrogenases can be used as novel molecular tools for quantitative monitoring [Fe-Fe] hydrogenases at the protein level. Another of-note observation was the specificity of the antibody binders towards active and inactive hydrogenases. Preliminary experiments indicated 7Ac binder (enriched against active hydrogenase) specificity towards the catalytically active [Fe-Fe] hydrogenase rather to the inactive state and 48In (enriched against inactive hydrogenase) recognized both catalytic states. These findings indicate the possibility to apply the isolated antibody clones for functional detection of clostridial [Fe-Fe] hydrogenases. The study progresses in investigating bioH₂ production in perspective of microbial community. The novel microbial enrichment system was developed and the proof-of-principle experiments conducted using artificial mixed microbial community and varied selection criteria allowed the enrichment of the best H₂ producer. The system was implemented in enriching cellobiose degrading H₂ producer from an environmental sample. The bacterial strain isolated by spread plate technique on agar plates containing CMC was affiliated with Citrobacter sp. and named as Citrobacter sp. CMC-1. Citrobacter sp. CMC-1 utilized glucose, cellobiose and CMC and followed mixed-acid fermentation profile producing H₂ and carbon dioxide (CO₂) as gaseous metabolites and acetate, formate, lactate and ethanol as liquid metabolites. At optimized values of cultivation conditions (pH 6.0 and 34 °C) the H₂ yield was 1.82 mol-H₂/mol-glucose. The isolate efficiently fermented monomeric hemi-cellulose sugars to H₂ (mol-H₂/mol-substrate): Galactose, 1.18; Mannose, 1.23; Xylose, 1.22; Arabinose, 0.94 and Rhamnose, 1.01. Except for arabinose, an increase in cultivation period improved the biomass and H₂ yield (mol-H₂/mol-substrate): Galactose, 1.68; Mannose, 1.93 and Xylose, 1.63) followed with observations of reduced formate accumulation in the medium, indicating that Citrobacter sp. CMC-1 produced H₂ from formate breakdown via the FHL complex. Microbial community pre-dominated with Clostridium spp. enriched from activated sludge fermented crude glycerol mainly to H₂, CO₂, acetate, butyrate and ethanol. Optimal bioprocess conditions for the enriched inoculum were experimentally observed to be pH 6.5, 40 °C and 1g/L crude glycerol. The H₂ yield from raw glycerol at optimal cultivation conditions was 1.1 mol-H₂/mol-glycerol consumed. At elevated crude glycerol concentrations, substrate utilization and H₂ production were limited due to the presence of impurities in the crude glycerol fraction. The bioconversion of crude glycerol to H₂ was further improved by statistical optimization of the growth medium composition. Initial screening with Plackett – Burman design identified NH₄Cl, KH₂PO₄ and KH₂PO₄ with individual and interactive effects on H₂ yield. Among the three identified media components, NH₄Cl and KH₂PO₄ imparted the maximal significance and were optimized in scrutiny. A series of statistical models identified the optimal media composition for improved H₂ production from crude glycerol fermentations and were successful in improving the H₂ yield by 29% (1.42 mol-H₂/mol-glycerol consumed) in comparison to previously reported value (1.1 mol-H₂/mol-glycerol consumed).

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On improvement of transient stage of composite nonlinear feedback control using arbitrary order set point filters

This paper studies the generalization of composite nonlinear feedback (CNF) control using arbitrary order set point filters, which focus on the initial stage of the transient response. The set point filters can be used to provide more performance by shortening the rise and settling times of the control system. Furthermore, the filters operate outside the feedback loop, and hence, they do not sacrifice loop robustness. The new method is illustrated by a benchmark problem found in an open literature. The simulation results show that the proposed method improves the set point response more than 10% in terms of settling time.

Composite Nonlinear Feedback Control of a Chemical Reactor

This paper studies the application of composite nonlinear feedback (CNF) control for a continuous time stirred tank reactor. Inside the reactor, an exothermic chemical reaction occurs, which requires cooling when concentration is commanded from low to high conversion rate to prevent a thermal runaway. A full-state CNF controller is designed for adjusting the temperature of the cooling jacket using concentration and temperature measurements. A continuous time gain-scheduled cascade controller, as well as a model predictive controller (MPC) is also fabricated for comparison. The gain-scheduled cascade controller has a proportional-integral (PI) controller as a primary loop controller, and a P-controller as a secondary loop controller. The simulation results show that the CNF controller is able to offer the best overall tracking performance as measured by the integral-of-absolute-error (IAE) criterion. In addition, the CNF controller does not need gain-scheduling for tuning purposes; the CNF controller is capable of changing its tuning as a function of control error only.
Copper Production as an Application of Optimization and Scheduling

Copper production in a copper smelter is a process comprised of batch and continuous production tasks. Typically, subprocesses have been operated in a locally optimal way though significant interdependencies exist. In general, copper production presents a harsh environment where production is often disturbed by unforeseen events and frequent maintenance operations. Optimization of production is further complicated by the significantly differing timescales with recycling of some materials. This work presents first the main production tasks related to copper production and then details requirements and procedures in modelling the full task with the goal of producing models suitable for a global scheduling solution. The main scheduling decision variables are detailed and a simplified example of scheduling two converters is included. The scheduling and optimization is to provide operators with advice on timings and resource use to maximize equipment use and production throughput. The solution structure may be viewed as a combination of scheduling and predictive control techniques. By considering material inputs over the complete production cycle, the optimization is to provide improvements especially in impurity control.

A Method and an Apparatus for Producing Nanocellulose

A method and an apparatus for producing nanocellulose is described. The method involves the use of a nanocellulose production system that includes a reactor for producing nanocellulose. The apparatus includes a reactor for producing nanocellulose and a controller for controlling the reactor. The method and apparatus are designed to produce nanocellulose with high yield and purity.

General information

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Authors: Suominen, O., Björkqvist, K., Vilkko, M., Korpi, M.
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Publication date: 17 Mar 2015
High speed, high strength microwelding of Si/glass using ps-laser pulses

A novel microwelding procedure to join Si-to-glass using ps-laser pulses with high repetition rates is presented. The procedure provides weld joint with mechanical strength as high as 85 MPa and 45 MPa in sample pairs of Si/aluminosilicate (Si/SW-Y) and Si/borosilicate (Si/Borofloat 33), respectively, which are higher than anodic bonding, at high spatial resolution (< 20 μm) and very high throughput without pre- and post-heating. Laser-matter interaction analysis indicates that excellent weld joint of Si/glass is obtained by avoiding violent evaporation of Si substrate using ps-laser pulses. Laser welded Si/glass samples can be singulated along the weld lines by standard blade dicer without defects, demonstrating welding by ps-laser pulses is applicable to wafer-level packaging.

General information

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Organisations: Department of Mechanical Engineering and Industrial Systems, Research area: Manufacturing and Automation, Osaka University, Erlangen Graduate School of Advanced Optical Technologies (SAOT), Okayama University, Corelase, Ltd.
Authors: Miyamoto, I., Okamoto, Y., Hansen, A., Vihinen, J., Amberla, T., Kangastupa, J.
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Scopus rating (2014): SJR 2.349 SNIP 2.166 CiteScore 4.18
Scopus rating (2013): SJR 2.358 SNIP 2.226 CiteScore 4.38
Scopus rating (2012): SJR 2.587 SNIP 2.145 CiteScore 3.85
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Scopus rating (2010): SJR 2.943 SNIP 2.466
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Scopus rating (2008): SJR 3.195 SNIP 2.393
Scopus rating (2007): SJR 3.27 SNIP 2.032
Scopus rating (2006): SJR 3.233 SNIP 2.326
Scopus rating (2005): SJR 3.334 SNIP 2.379
Scopus rating (2004): SJR 2.833 SNIP 2.499
Scopus rating (2003): SJR 2.688 SNIP 2.193
Scopus rating (2002): SJR 1.547 SNIP 1.673
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Scopus rating (2000): SJR 1.246 SNIP 0.714
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ASJC Scopus subject areas: Atomic and Molecular Physics, and Optics
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http://www.scopus.com/inward/record.url?scp=84922814586&partnerID=8YFlOgxK (Link to publication in Scopus)
Method and an Apparatus for Producing Nanocellulose
Described herein is nanocellulose produced by introducing a mixture of cellulose based fiber raw material and water through a refining gap, having a width smaller than 0.1 mm. In the refining gap, the fiber raw material is subjected to processing forces varying in the direction of introducing said mixture, by means of refining zones provided in the gap one after each other in the feeding direction, whereby the refining surfaces differ in surface patterning and/or surface roughness. The mixture of fiber raw material and water is guided past the refining surfaces in the feeding direction to different locations in the refining zone by by-pass channels provided in the stator. The width of the refining gap is maintained by the combined effect of the feeding pressure of the mixture of fiber raw material and water fed into the refining gap and the axial force of the rotor.

Modeling Fume Particle Dynamics and Deposition with Alkali Metal Chemistry in Kraft Recovery Boilers
The kraft recovery boiler is the largest single unit in the pulp-making process, which makes its reliable operation important. However, the fuel of the recovery boiler, black liquor, contains large quantities of ash-forming elements that pose challenges to the efficient operation of the boiler. A fraction of these elements vaporizes in the recovery boiler and condenses to form submicron-sized particles, called fume. The fume particles may form fouling deposits on the heat transfer surfaces, cause plugging of the flue gas channels, and even expose the surfaces to corrosion. These problems often lead to unscheduled shutdowns of the boiler, which are expensive due to the large size of the modern pulp mills. Significant savings could be achieved if the behavior of the ash-forming elements could be better predicted. The objective of this thesis is to develop a CFD-based (computational fluid dynamics) model for the alkali metal chemistry, fume particles, and fume deposits in the kraft recovery boiler, and to use the model to simulate real recovery boilers. The model combines 3-dimensional CFD, fine particle dynamics, and equilibrium chemistry in a novel way, and solves the fume particle and deposit composition at different locations in the superheater area of the boiler. The model contains certain limitations, such as the steady-state approximation because a compromise has to be made between accuracy and computational cost, which is a significant factor when developing tools for industrial use. The model has been partially validated with measurements in an operating recovery boiler, and the modeling results are in good qualitative agreement with the measurements. Furthermore, the modeling results suggest that deposition through thermophoresis is the main mechanism of fume deposit formation in a recovery boiler, but also that the direct condensation of alkali chloride vapors to heat transfer surfaces can be significant if the black liquor chlorine content is high. According to the model sensitivity analysis, fume deposit growth seems to be a self-limiting process, since an increase in the deposit thickness lowers the rate of deposition by thermophoresis. Another important result is that chlorine enriches in the deposit layers closer to the tube surfaces, which is a result of the high temperature dependence of alkali chloride condensation. The CFD-based model developed here improves understanding of the fume formation mechanisms, shedding light on processes that would be difficult to investigate through experimental methods alone in the corrosive boiler environment. In particular, the model can simulate how certain operational changes, such as increasing boiler load or steam temperatures, affect the alkali metal and fume behavior. In the future, the model can be utilized in the industry to support the engineering of new recovery boilers, and minimize fouling, plugging, and corrosion problems.
Analysis of the aircraft operational reliability research series: From statistical models to avionics data monitoring

General information
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Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Mechanical Engineering and Industrial Systems, Research group: Käyttövarmuuden suunnittelu ja kunnossapito
Authors: Laitinen, J., Niemi, A.
Number of pages: 15
Publication date: 2015

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Bibliographical note

Biological Nitrogen Removal from Acidic, Heavy-metal Containing Waters

General information
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Organisations: Department of Chemistry and Bioengineering, Research group: Industrial Bioengineering and Applied Organic Chemistry
Chemolithotrophic denitrification in biofilm reactors

Chemolithotrophic denitrification is an inexpensive and advantageous process for nitrate removal and represents a promising alternative to classical denitrification with organics. Chemolithotrophic denitrifiers are microorganisms able to reduce nitrate and nitrite using inorganic compounds as source of energy. Ferrous iron, sulfur-reduced compounds (e.g. hydrogen sulfide, elemental sulfur and thiosulfate), hydrogen gas, pyrite and arsenite have been used as inorganic electron donors resulting in diverse outcomes. In the last 40 years, a large number of engineered systems have been used to maintain chemolithotrophic denitrification and improve rate and efficiency of the process. Among them, biofilm reactors proved to be robust and high-performing technologies. Packed bed reactors are particularly suitable for the removal of low nitrate concentrations, since high retention times are required to complete denitrification. Fluidized bed and membrane biofilm reactors result in the highest denitrification rates (>20 kg N-NO\textsubscript{3}/m\textsuperscript{3}d) when hydrogen gas and sulfur reduced compounds are used as electron donors. Hydrogen gas pressure and current intensity rule the performance of membrane biofilm and biofilm electrode reactors, respectively. Biofouling is the most common and detrimental issue in biofilm reactors. Bed fluidization and hydrogen supply limitation are convenient and effective solutions to mitigate biofouling.
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Scopus rating (2005): SJR 1.113 SNIP 1.482
Scopus rating (2004): SJR 0.916 SNIP 1.39
Scopus rating (2003): SJR 0.848 SNIP 1.109
Scopus rating (2002): SJR 0.692 SNIP 0.983
Scopus rating (2001): SJR 0.672 SNIP 0.854
Scopus rating (2000): SJR 0.611 SNIP 0.738
Scopus rating (1999): SJR 0.391 SNIP 0.805

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Research output: Scientific - peer-review › Article

Effect of heat transfer on glass quality in tempering

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Authors: Karvinen, R., Mikkonen, A.
Publication date: 2015

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Research output: Scientific › Conference contribution

Enhanced in-line detection, cleaning and repair of nano-scale defects in thin-films used for flexible photovoltaic and food packaging applications

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High-temperature slurry erosion of vinylester matrix composites – The effect of test parameters
Glass fibre (GF) reinforced vinylester composites (VE-FRP) are commonly used materials in hydrometallurgical reactors, the pulp and paper industry and waste water treatment plants, due to their excellent chemical resistance combined with good mechanical performance. In these applications, materials can be subjected to erosion, elevated temperatures (as high as 95 °C) and various chemical environments. However, studies on the slurry erosion of vinylester-based composites at high temperatures have not yet been reported. In this study, the erosion resistance of GF reinforced VE-FRP was investigated with a pilot-scale reactor. The effect of slurry concentration, erodent particle kinetic energy and slurry temperature was studied. The dominating wear mechanism was found to be abrasive wear. The VE-FRP structure was
found to be prone to erosive turbulent flow and cavitation. Moreover, an increase in the erodent concentration of the slurry (10-20. wt%) or in the total kinetic energy of the erodent particles (30-770. kJ) increased the wear rate of the material markedly (up to 6 times higher weight loss). However, the total effect of different interrelated parameters was found to be complex. Consequently, it is recommended that predictions of the erosion rate of VE-FRP components are based on tests carried out in conditions that simulate the actual service environment.

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Organisations: Department of Materials Science, Research group: Plastics and Elastomer Technology, Engineering materials science and solutions (EMASS), Outotec Research Center
Authors: Sarlin, E. L., Lindgren, M., Suihkonen, R. J., Siljander, S. M. K., Kakkonen, M. M. S., Vuorinen, J. E.
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Scopus rating (2013): SJR 1.319 SNIP 2.416 CiteScore 2.37
Scopus rating (2012): SJR 1.36 SNIP 2.178 CiteScore 1.85
Scopus rating (2011): SJR 1.547 SNIP 2.865 CiteScore 2.43
Scopus rating (2010): SJR 1.509 SNIP 2.153
Scopus rating (2009): SJR 1.684 SNIP 2.07
Scopus rating (2008): SJR 1.597 SNIP 1.863
Scopus rating (2007): SJR 1.286 SNIP 1.889
Scopus rating (2006): SJR 1.435 SNIP 2.036
Scopus rating (2005): SJR 1.473 SNIP 2.007
Scopus rating (2004): SJR 1.335 SNIP 1.965
Scopus rating (2003): SJR 1.104 SNIP 1.788
Scopus rating (2002): SJR 0.958 SNIP 1.365
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Research output: Scientific - peer-review › Article

Hydraulic Cylinder Models for Flexible Multibody System Simulation

General information
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Ministry of Education publication type: G4 Doctoral dissertation (monograph)
Organisations: Department of Mechanical Engineering and Industrial Systems, Research group: Teknillinen mekanikka ja lujusoppi
Authors: Ylinen, A.
Number of pages: 136
Improving Recovery Boiler Availability through Understanding Fume Behavior

Unexpected recovery boiler shutdowns are rare, but they can cost millions of dollars in lost income. Sometimes the inorganic compounds in black liquor can cause sudden fouling or plugging problems that could not be predicted beforehand. The ash particles can be divided into two main types and size classes: carryover and fume. This paper focuses on the smaller fume particles that form through the condensation of alkali metal vapors, and that deposit via different mechanisms than carryover. The location of fume deposition depends on several factors, such as flue gas and superheater temperatures, black liquor composition, and the flow field in the boiler.

This paper presents results obtained with a computational method that simulates fume formation in recovery boilers. The results in this paper focus on the effect of black liquor composition and elemental release on fume behavior, and the paper suggests how these observations should be taken into account when designing new boilers or retrofits. Moreover, the paper introduces the possible applications of the modeling method. These include, for example, troubleshooting of fouling problems in existing boilers, designing superheater configurations for new boilers, and positioning soot blowers.

Metals removal and recovery in bioelectrochemical systems: A review

Metal laden wastes and contamination pose a threat to ecosystem well being and human health. Metal containing waste streams are also a valuable resource for recovery of precious and scarce elements. Although biological methods are inexpensive and effective for treating metal wastewaters and in situ bioremediation of metal(loid) contamination, little progress has been made towards metal(loid) recovery. Bioelectrochemical systems are emerging as a new technology platform for removal and recovery of metal ions from metallurgical wastes, process streams and wastewaters. Biodegradation of organic matter by electroactive biofilms at the anode has been successfully coupled to cathodic reduction of metal ions. Until now, leaching of Co(II) from LiCoO$_2$ particles, and removal of metal ions i.e. Co(III/II), Cr(VI), Hg(II), Ag(I), Se(IV), and Cd(II) from aqueous solutions has been demonstrated. This article reviews the state of art research of bioelectrochemical systems for removal and recovery of metal(loid) ions and pertaining removal mechanisms.
Monitoring of flue gas desulphurization process in coal fired power plants

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New routes from cellulose to textile fiber and ready products

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Organisations: Department of Materials Science, Research group: Fibre Materials, Aalto University, VTT Tech Res Ctr Finland, VTT Technical Research Center Finland
Authors: Nousiainen, P., Rissanen, M., Michud, A., Sixta, H., Hummel, M., Setälä, H.
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OPC UA security for protecting substation and control center data communication in the distribution domain of the smart grid

The distribution domain of the smart grid incorporates advantages of the newest substation automation standards in order to enhance distribution network automation. State-of-the-art distribution automation solutions use the public Internet for exchanging data between substation and control center. This presents challenges for cybersecurity, particularly for critical data determining distribution network operation. Therefore, Internet communication between substation and control center should be carried out via a secure communication protocol. OPC Unified Architecture (UA) is an interoperable communication standard supports Internet protocols from one hand and obtains benefits from mature built-in security mechanisms from other hand. This paper describes a solution for secure data transmission between modern substation and control center over the Internet. In this approach, circuit breaker position data is chosen as the data example that is defined in respect to the IEC 61850 data model and securely transmitted to OPC UA client application at remote control center by employing the OPC UA security architecture functions.
Pt-functionalized Fe2O3 photoanodes for solar water splitting: the role of hematite nano-organization and the platinum redox state

Pt/alpha-Fe2O3 nanocomposites were synthesized on fluorine-doped tin oxide (FTO) substrates by a sequential plasma enhanced-chemical vapor deposition (PE-CVD)/radio frequency (RF) sputtering approach, tailoring the overall Pt content as a function of sputtering time. The chemico-physical properties of the as-prepared systems were extensively investigated by means of complementary techniques, including X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), field emission-scanning electron microscopy (FE-SEM), energy dispersive X-ray spectroscopy (EDXS), and optical absorption spectroscopy, and compared to those of the homologous Pt/alpha-Fe2O3 systems annealed in air prior and/or after sputtering. The obtained results evidenced that the material compositional, structural and morphological features, with particular regard to the Pt oxidation state and hematite nano-organization, could be finely tailored as a function of the adopted processing conditions. Pt/alpha-Fe2O3 systems were finally tested as photoanodes in photoelectrochemical (PEC) water splitting experiments, evidencing a remarkable interplay between functional performances and the above-mentioned material properties, as also testified by transient absorption spectroscopy (TAS) results.
Simulation of ash-forming compounds in the kraft recovery boiler

This paper presents a summary of the doctoral dissertation titled “Modeling Fume Particle Dynamics and Deposition with Alkali Metal Chemistry in Kraft Recovery Boilers”. In the thesis, a computational model was developed and used to simulate the behavior of alkali metal compounds in kraft recovery boilers. The model combines, for the first time, the methods of CFD (Computational Fluid Dynamics), equilibrium chemistry, and fine particle dynamics to model the formation and deposition of fume particles. Fume particles are below 1 μm in diameter and form through the condensation of the alkali metal compounds. The model has been partially validated in an operating recovery boiler in terms of fume particle composition, but the modeling results also shed light on processes that cannot be investigated through experimental methods alone. For example, the modeling results indicate that thermophoresis is the main factor leading to fume deposit formation.
Vapor phase processing of $\alpha$-Fe$_2$O$_3$ photoelectrodes for water splitting: An insight into the structure/property interplay

Harvesting radiant energy to trigger water photoelectrolysis and produce clean hydrogen is receiving increasing attention in the search of alternative energy resources. In this regard, hematite ($\alpha$-Fe$_2$O$_3$) nanostructures with controlled nano-organization have been fabricated and investigated for use as anodes in photoelectrochemical (PEC) cells. The target systems have been grown on conductive substrates by plasma enhanced-chemical vapor deposition (PE-CVD) and subjected to eventual ex situ annealing in air to further tailor their structure and properties. A detailed multitechnique approach has enabled to elucidate between system characteristics and the generated photocurrent. The present alpha-Fe$_2$O$_3$ systems are characterized by a high purity and hierarchical morphologies consisting of nanopyramids/organized dendrites, offering a high contact area with the electrolyte. PEC data reveal a dramatic response enhancement upon thermal treatment, related to a more efficient electron transfer. The reasons underlying such a phenomenon are elucidated and discussed by transient absorption spectroscopy (TAS) studies of photogenerated charge carrier kinetics, investigated on different time scales for the first time on PE-CVD Fe$_2$O$_3$ nanostructures.
Rationally engineered synthetic coculture for improved biomass and product formation

In microbial ecosystems, bacteria are dependent on dynamic interspecific interactions related to carbon and energy flow. Substrates and end-metabolites are rapidly converted to other compounds, which protects the community from high concentrations of inhibitory molecules. In biotechnological applications, pure cultures are preferred because of the more straightforward metabolic engineering and bioprocess control. However, the accumulation of unwanted side products can limit the cell growth and process efficiency. In this study, a rationally engineered coculture with a carbon channeling system was constructed using two well-characterized model strains Escherichia coli K12 and Acinetobacter baylyi ADP1. The directed carbon flow resulted in efficient acetate removal, and the coculture showed symbiotic nature in terms of substrate utilization and growth. Recombinant protein production was used as a proof-of-principle example to demonstrate the coculture utility and the effects on product formation. As a result, the biomass and recombinant protein titers of E. coli were enhanced in both minimal and rich medium simple batch cocultures. Finally, harnessing both the strains to the production resulted in enhanced recombinant protein titers. The study demonstrates the potential of rationally engineered cocultures for synthetic biology applications.

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Scopus rating (2012): SJR 1.945 SNIP 1.142 CiteScore 4.15
Scopus rating (2011): SJR 2.369 SNIP 1.23 CiteScore 4.58
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Versatile erosion wear testing with the high speed slurry-pot

The high speed slurry-pot tester was developed for application oriented erosion wear testing of materials used in mineral handling and processing. It enables tests in demanding high stress abrasive and erosive environments simulating wear, for example in slurry pumps, tanks and pipes, mineral crushing and grinding, loader buckets, dredging, and drilling. The key design features of the test method are the possibility to use up to 10 millimeter sized particles and sample speeds up to 20 m/s in conditions ranging from wet slurry environments to dry sand or gravel.

The tester has been used to test many different material types, including conventional steels, surface treated steels, cast irons, thick and thin coatings, ceramics, hybrid materials, polymers and elastomers. With the high speed slurry-pot tester, samples of various types and sizes can be tested.
In the FIMECC BSA/P2/SP3 project, the focus is in the testing of materials intended for demanding wear related applications. Moreover, the test system is further developed for various wear conditions, including slurry-erosion, grinding abrasion, and sub-zero temperatures.

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Electronic versions:
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Research output: Scientific > Paper, poster or abstract

**Numerical modeling of fine particle and deposit formation in a recovery boiler**

In kraft pulp mills, black liquor is concentrated and burned in recovery boilers to produce steam and power and to recover pulping chemicals. Black liquor contains a large amount of alkali compounds, which form ash with low melting temperatures upon combustion. This causes many problems in recovery boiler operation, including fouling of the heat transfer surfaces, plugging of the flue gas passages, reduction of the heat transfer rate, and corrosion of the superheater tubes. This paper presents a model for simulating fine fume particles formed as a result of condensation of alkali compound vapors in the recovery boiler. The modeling method combines CFD modeling, equilibrium chemistry, and fine particle dynamics in a way that enables simulation of a full scale three-dimensional boiler environment. The model has been partially validated with measurements performed in an operating recovery boiler. The modeling results, particularly for the fume particle composition, agree well with the actual measurements. (C) 2014 Elsevier Ltd. All rights reserved.

**General information**

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Authors: Leppänen, A., Tran, H., Taipale, R., Välimäki, E., Oksanen, A.
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Early online date: 16 Apr 2014

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Scopus rating (2013): SJR 1.811 SNIP 2.595 CiteScore 4.31
Scopus rating (2012): SJR 1.852 SNIP 2.465 CiteScore 3.99
Scopus rating (2011): SJR 2.093 SNIP 2.427 CiteScore 4.1
Scopus rating (2010): SJR 1.984 SNIP 2.319
Scopus rating (2009): SJR 2.012 SNIP 2.277
Scopus rating (2008): SJR 1.635 SNIP 2.184
Scopus rating (2007): SJR 1.383 SNIP 1.86
Scopus rating (2006): SJR 1.278 SNIP 1.64
Scopus rating (2005): SJR 1.623 SNIP 1.73
Scopus rating (2004): SJR 1.273 SNIP 1.883
Scopus rating (2003): SJR 1.103 SNIP 1.481
University-Industry Co-operation Using a Practice-based Innovation Tool: Case Advisory Professorship Programme in Materials Technology

In the thesis the usability and effectiveness of a practice-based innovation tool for university–industry co-operation, the advisory professorship model, is evaluated. The research material was collected by applying the tool with a materials technological emphasis in the regional co-operation network in 2008–2012. The inputs, functions and internal dynamics of the innovation environment, as well as the results and effects of innovation activities in the materials technology advisory professorship programme (MTAP) network, are analysed qualitatively using a conceptual framework for the evaluation of regional innovative capability and the Network-Based Innovative Capability (NBIC) matrix. In the network of the MTAP programme, new practice-based innovation processes, concentrated in practice-based problems and development targets in companies products, operational environment or markets were created. The role of the university was especially in producing of information in the front-end phases of innovation processes, related mostly to properties and processing knowledge of materials, the feasibility of development ideas and in searching of new R&D opportunities. The nature of university based research inputs was typically fast and short-termed. Some innovation processes ended up as new products or product improvements. New knowledge, information and knowledge networks were created. The advisory professorship model can be considered a useful practice-based innovation tool for regional university–industry cooperation with some limitations. In the thesis the materials technology related regional resources, infrastructure and needs from both private and public sectors are also studied and levels of regional availability, access and delivery options for materials technological research are analysed in the Lahti region. Based on this information, it is suggested how the knowledge, network and innovation system related to materials technology should be developed further by public policies and strategies in the region.
Bioprocessing of enhanced cellulase production from a mutant of Trichoderma asperellum RCK2011 and its application in hydrolysis of cellulose

A mutant strain of Trichoderma asperellum RCK2011 was developed through UV-irradiation for enhanced cellulase production and lower catabolite repression. The production of FPase, CMCase and β-glucosidase was optimized under solid state fermentation; up to 20 mM of glucose did not inhibit cellulase production. The mutant strain T. asperellum SR1-7 produced FPase (2.2 IU/gds), CMCase (13.2 IU/gds), and β-glucosidase (9.2 IU/gds) under optimized conditions, which is, 1.4, 1.3, 1.5-fold higher than the wild type. The wild as well as mutant strain produced the cellulases at pH range, 4.0-10.0. Saccharification of pretreated corn cob, wheat straw, and sugarcane bagasse by cellulase from mutant strain SR1-7 resulted in release of reducing sugar at the rate of 530.0 mg/g, 290.0 mg/g, and 335.0 mg/g of substrate, respectively; this is 1.6-fold higher than the wild type strain. © 2014 Published by Elsevier Ltd.
Rewiring the wax ester production pathway of acinetobacter baylyi ADP1

Wax esters are industrially relevant high-value molecules. For sustainable production of wax esters, bacterial cell factories are suggested to replace the chemical processes exploiting expensive starting materials. However, it is well recognized that new sophisticated solutions employing synthetic biology toolbox are required to improve and tune the cellular production platform to meet the product requirements. For example, saturated wax esters with alkanol chain lengths C12 or C14 that are convenient for industrial uses are rare among bacteria. Acinetobacter baylyi ADP1, a natural producer of wax esters, is a convenient model organism for studying the potentiality and modifiability of wax esters in a natural host by means of synthetic biology. In order to establish a controllable production platform exploiting well-characterized biocomponents, and to modify the wax ester synthesis pathway of A. baylyi ADP1 in terms product quality, a fatty acid reductase complex LuxCDE with an inducible arabinose promoter was employed to replace the natural fatty acyl-CoA reductase acr1 in ADP1. The engineered strain was able to produce wax esters by the introduced synthetic pathway. Moreover, the fatty alkanol chain length profile of wax esters was found to shift toward shorter and more saturated carbon chains, C16:0 accounting for most of the alkanos. The study demonstrates the potentiality of recircuiting a biosynthesis pathway in a natural producer, enabling a regulated production of a customized bioproduct. Furthermore, the LuxCDE complex can be potentially used as a well-characterized biopart in a variety of synthetic biology applications involving the production of long-chain hydrocarbons. © 2014 American Chemical Society.

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Adaptive mass flow sensor calibration method for crushing circuits

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Research output: Scientific › Conference contribution

CFD based on-line process analysis - applied to circulating and bubbling fluidized bed processes

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Source-ID: 640
Research output: Professional › Commissioned report

Effect of abrasive properties on the high-stress three-body abrasion of steels and hard metals

Especially in tunneling, the abrasiveness of rock is an important property, which can easily be determined by several methods developed for the purpose. With this in mind, it is rather surprising that the effects of different rock types on the wear mechanisms of engineering materials have not been too widely studied. In this paper, high stress three-body abrasive tests were conducted with four different abrasives with a relatively large (2-10 mm) particle size. As test materials, three different steels and three hard metals were used. The tests clearly showed that material type has an influence on how different abrasive and material properties affect the abrasive wear mechanisms and severity. For example with hard metals, me most important property of the abrasives is their crushability, as only small abrasive particles are able to properly attack the binder phase and cause high wear rates. On the other hand, it seems that the abrasiveness of rock is not the dominating property determining the severity of wear in the current test conditions for any of the tested materials. In fact, with steels no single abrasive property could be shown to clearly govern the abrasive wear processes. In any case, when using the determined abrasiveness values in wear estimations, the contact conditions in the method used for determining the abrasiveness values should be as similar as possible with the end application.

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Effect of test parameters on large particle high speed slurry erosion testing

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Scopus rating (2012): SJR 0.333 SNIP 0.376 CiteScore 0.27
Scopus rating (2011): SJR 0.276 SNIP 0.363 CiteScore 0.3
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Scopus rating (2009): SJR 0.155 SNIP 0.114
Scopus rating (2008): SJR 0.122 SNIP 0
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High Performance Particle Tracking Velocimetry for Fluidized Beds

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http://www.visapp.visigrapp.org/

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Image based measurement techniques for particulate flows

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Interference-based overlapping particle tracking velocimetry for fluidized beds

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Publication date: 2014
Peer-reviewed: Yes

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Ratings:
Modelling fume deposit growth in recovery boilers: effect of flue gas and deposit temperature

The high ash content of black liquor causes fouling problems in the Kraft recovery boiler. The ash-forming elements condense into submicron-sized fume particles in the superheater area and the boiler bank and can deposit on heat-transfer surfaces. The fume deposits can then lower heat-transfer rate, plug flue gas flow, and expose surfaces to corrosion. This paper presents the results of a sensitivity analysis obtained using a CFD (computational fluid dynamics)-based sub-model of the formation of fume particles and deposits, showing how flue gas and deposit surface temperatures affect instantaneous fume deposit growth. The results indicate that fume deposit growth is a self-limiting process because the growth rate decreases as the deposit surface temperature increases. On the other hand, increasing the flue gas temperature increases the fume deposition rate when the element release factors are kept constant.
PTV and PIV based dispersed phase velocity measurements in a pseudo-2D turbulent fluidized bed

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Chemistry and Bioengineering, Research group: Power Plant and Combustion Technology, University of Toronto, Canada, Valmet Technologies Oy
Authors: Leppänen, A., Tran, H., Välimäki, E., Oksanen, A.
Number of pages: 8
Pages: 50-57
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Journal of Science and Technology for Forest Products and Processes
Volume: 4
Issue number: 1
ISSN (Print): 1927-6311
Original language: English
Links:

Bibliographical note
Contribution: organisation=keb,FACT1=1<br/>Portfolio EDEND: 2014-12-12<br/>Publisher name: PAPTAC, Pulp and Paper Technical Association of Canada
Source: researchoutputwizard
Source-ID: 924
Research output: Scientific - peer-review › Article

Strategies for size reduction control in cone crushers

General information
State: Published
Ministry of Education publication type: B3 Non-refereed article in conference proceedings
Organisations: Department of Automation Science and Engineering
Authors: Itävuo, P., Väyrynen, T., Vilkko, M., Jaatinen, A.
Number of pages: 7
Publication date: 2014

Host publication information
Title of host publication: Proceedings of Comminution ’14, April 7-10, 2014, Cape Town, South Africa
Links:
Teknisten tekstiilien tulevaisuus; Osa 1. Kasvunnäkymät ja yleiskatsaus

General information
State: Published
Ministry of Education publication type: D1 Article in a trade journal
Organisations: Department of Materials Science
Authors: Nousiainen, P.
Number of pages: 2
Pages: 24-25
Publication date: 2014
Peer-reviewed: Unknown

Publication information
Journal: Tekstiililehti
Issue number: 3
ISSN (Print): 0040-2370
Original language: Finnish

Bibliographical note
Contribution: organisation=mol,FACT1=1<br/>Portfolio EDEND: 2014-06-26<br/>Publisher name: Suomen tekstiiliteknillinen liitto
Source: researchoutputwizard
Source-ID: 1156
Research output: Professional › Article

Tekstiilien testaus on olennainen osa tekstiillidiplomi-insinöörin koulutusta

General information
State: Published
Ministry of Education publication type: D1 Article in a trade journal
Organisations: Department of Materials Science
Authors: Puolakka, A., Rissanen, M., Varheenmaa, M.
Number of pages: 1
Pages: 14-14
Publication date: 2014
Peer-reviewed: Unknown

Publication information
Journal: Tekstiililehti
Issue number: 2
ISSN (Print): 0040-2370
Original language: Finnish

Bibliographical note
Contribution: organisation=mol,FACT1=1<br/>Portfolio EDEND: 2014-05-27<br/>Publisher name: Suomen tekstiiliteknillinen Liitto r. y.
Source: researchoutputwizard
Source-ID: 1306
Research output: Professional › Article

Tight feed-hopper level control in cone crushers

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Automation Science and Engineering, Smart Energy Systems (SES)
Non-sterile process for biohydrogen and 1,3-propanediol production from raw glycerol

Raw glycerol is a tempting substrate for fermentations, but contains impurities that can be inhibitory for organisms. In this study, raw glycerol tolerance and contamination risk of pure bacterial culture at hypersaline process conditions were evaluated. The inhibitory effect of raw glycerol was similar on a halophilic (Halanaerobium saccharolyticum) and a non-halophilic (Clostridium butyricum) bacterium implying the inhibition originating from methanol or other impurities rather than salt. The hypersaline process conditions decreased efficiently contaminations and no growth of contaminants was observed at and above 125 g/l NaCl. Halophilic H₂ and 1,3-PD production from raw glycerol were studied separately as 1-stage processes and jointly as 2-stage process in non-sterile conditions. Non-sterile conditions were successfully applied and the highest production yields obtained were 3.0 mol H₂/mol glycerol and 0.66 mol 1,3-PD/mol glycerol (1-stage processes), whereas the highest cumulative production was 74 mmol H₂/l culture and 31 mmol 1,3-PD/l culture (2-stage process). © 2013, Hydrogen Energy Publications, LLC. Published by Elsevier Ltd. All rights.

Non-sterile process for biohydrogen and 1,3-propanediol production from raw glycerol

Raw glycerol is a tempting substrate for fermentations, but contains impurities that can be inhibitory for organisms. In this study, raw glycerol tolerance and contamination risk of pure bacterial culture at hypersaline process conditions were evaluated. The inhibitory effect of raw glycerol was similar on a halophilic (Halanaerobium saccharolyticum) and a non-halophilic (Clostridium butyricum) bacterium implying the inhibition originating from methanol or other impurities rather than salt. The hypersaline process conditions decreased efficiently contaminations and no growth of contaminants was observed at and above 125 g/l NaCl. Halophilic H₂ and 1,3-PD production from raw glycerol were studied separately as 1-stage processes and jointly as 2-stage process in non-sterile conditions. Non-sterile conditions were successfully applied and the highest production yields obtained were 3.0 mol H₂/mol glycerol and 0.66 mol 1,3-PD/mol glycerol (1-stage processes), whereas the highest cumulative production was 74 mmol H₂/l culture and 31 mmol 1,3-PD/l culture (2-stage process). © 2013, Hydrogen Energy Publications, LLC. Published by Elsevier Ltd. All rights.

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Chemistry and Bioengineering, Research group: Industrial Bioengineering and Applied Organic Chemistry, Tampere University of Technology, Urban circular bioeconomy (UrCirBio)
Authors: Kivistö, A., Santala, V., Karp, M.
Number of pages: 7
Pages: 11749-11755
Publication date: 10 Sep 2013
Bioprocess data mining using regularized regression and random forests

Background: In bioprocess development, the needs of data analysis include (1) getting overview to existing data sets, (2) identifying primary control parameters, (3) determining a useful control direction, and (4) planning future experiments. In particular, the integration of multiple data sets causes that these needs cannot be properly addressed by regression models that assume linear input-output relationship or unimodality of the response function. Regularized regression and random forests, on the other hand, have several properties that may appear important in this context. They are capable, e.g., in handling small number of samples with respect to the number of variables, feature selection, and the visualization of response surfaces in order to present the prediction results in an illustrative way.

Results: In this work, the applicability of regularized regression (Lasso) and random forests (RF) in bioprocess data mining was examined, and their performance was benchmarked against multiple linear regression. As an example, we used data from a culture media optimization study for microbial hydrogen production. All the three methods were capable in providing a significant model when the five variables of the culture media optimization were linearly included in modeling. However, multiple linear regression failed when also the multiplications and squares of the variables were included in modeling. In this case, the modeling was still successful with Lasso (correlation between the observed and predicted yield was 0.69) and RF (0.91).

Conclusion: We found that both regularized regression and random forests were able to produce feasible models, and the latter was efficient in capturing the non-linearity in the data. In this kind of a data mining task of bioprocess data, both methods outperform multiple linear regression.
Broadband Methods for Online Grid Impedance Measurement

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Automation Science and Engineering, Smart Energy Systems (SES)
Authors: Roinila, T., Vilkko, M., Sun, J.
Number of pages: 6
Pages: 3003-3010
Publication date: 2013

Host publication information
Title of host publication: 2013 IEEE Energy Conversion Congress & Exposition ECCE, Denver Colorado, USA; September 15-19, 2013
Place of publication: Piscataway
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-0336-8

Publication series
Name: IEEE Energy Conversion Congress and Exposition
DOIs:
10.1109/ECCE.2013.6647093
Dynaamisten voimalaitosmallien parametrien määrittäminen ja virittäminen

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Automation Science and Engineering
Authors: Yli-Fossi, T.
Number of pages: 6
Pages: 1-6
Publication date: 2013

Host publication information
Title of host publication: Proceedings of Automaatio XX-seminaari, Automation and systems without borders - beyond future, 21.-22.5.2013, Helsinki
Publisher: Suomen Automaatioseura ry
Editor: Vilkko, M.
ISBN (Print): 978-952-5183-44-3

Publication series
Name: SAS julkaisusarja
No.: 42
ISSN (Print): 1455-6502

Bibliographical note
Contribution: organisation=ase,FACT1=1<br/>Portfolio EDEND: 2013-09-29<br/>Publisher name: Suomen Automaatioseura ry
Source: researchoutputwizard
Source-ID: 3766
Research output: Scientific - peer-review › Conference contribution

Dynamic modeling and simulation of power plants with biomass as a fuel

General information
State: Published
Ministry of Education publication type: A3 Part of a book or another research book
Organisations: Department of Automation Science and Engineering
Authors: Majanne, Y.
Number of pages: 15
Pages: 357-371
Publication date: 2013

Host publication information
Title of host publication: Technologies for Converting Biomass to Useful Energy, Combustion, Gasification, Pyrolysis, Torrefaction and Fermentation, Series: Sustainable Energy Developments 4
Publisher: CRC Press Taylor & Francis Group, a Bakema Book
Editor: Dahlquist, E.
ISBN (Print): 978-0-415-62088-8
Links:

Bibliographical note
Contribution: organisation=ase,FACT1=1<br/>Portfolio EDEND: 2013-12-29
Source: researchoutputwizard
Source-ID: 2851
Research output: Scientific - peer-review › Chapter
Huokisen keraamin karakterisointi sähköisellä herätteellä

**General information**
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Materials Science, Department of Automation Science and Engineering
Authors: Järveläinen, M., Salpavaara, T., Seppälä, S., Roinila, T., Vilkko, M., Levänen, E.
Number of pages: 6
Pages: 1-6
Publication date: 2013

**Host publication Information**
Title of host publication: Proceedings of Automaatio XX-seminaari, Automation and systems without borders - beyond future, 21.-22.5.2013, Helsinki
Publisher: Suomen Automaatioseura
Editor: Vilkko, M.
ISBN (Print): 978-952-5183-44-3

**Publication series**
Name: SAS julkaisusarja
No.: 42
ISSN (Print): 1455-6502

**Bibliographical note**
Contribution: organisation=mol,FACT1=0.5<br/>Contribution: organisation=ase,FACT2=0.5<br/>Portfolio EDEND: 2013-11-29<br/>Publisher name: Suomen Automaatioseura
Source: researchoutputwizard
Source-ID: 2409
Research output: Scientific - peer-review › Conference contribution

Introduction to Fast Frequency-Response Measurement in Micro and Nano Technology

**General information**
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Automation Science and Engineering
Authors: Roinila, T., Kai, L., Wen-ming, X., Li-hui, L., Yu, X., Hui-guo, Z., Vilkko, M.
Number of pages: 7
Pages: 24-30
Publication date: 2013
Peer-reviewed: Yes

**Publication information**
Journal: Changshu Gao-Zhuan Xuebao
Volume: 27
Issue number: 4
ISSN (Print): 1008-2794
Original language: Chinese

**Bibliographical note**
Contribution: organisation=ase,FACT1=1<br/>Portfolio EDEND: 2013-12-29<br/>Publisher name: Changshu Ligong Xueyuan
Source: researchoutputwizard
Source-ID: 3279
Research output: Scientific - peer-review › Article

Local compression behaviour of moist wood at quasi static state

**General information**
State: Published
Ministry of Education publication type: B3 Non-refereed article in conference proceedings
Organisations: Department of Automation Science and Engineering, Department of Engineering Design
Authors: Björkqvist, T., Moilanen, C., Saarenrinne, P., Koivisto, J., Miksic, A., Alava, M., Salminen, L., Engberg, B. A.
Number of pages: 2
Pages: 47-48
Measuring Resistive Characteristics of Silicon Nanowire by Applying Electrostatic Tensile Device and Broadband Test Signal

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Automation Science and Engineering, Integrated Technologies for Tissue Engineering Research (ITTE), Smart Energy Systems (SES)
Number of pages: 4
Pages: 23-26
Publication date: 2013

Host publication information
Title of host publication: Nanotechnology 2013: Advanced Materials, CNTs, Particles, Films and Composites Nanotech, Conference & Expo 2013, May 12-16, 2013 Washington, DC
Publisher: Nano Science and Technology Institute
ISBN (Print): 978-1-4822-0581-7

Publication series
Name: Nanotechnology Conference and Expo
Publisher: Nano Science and Technology Institute
Volume: 1

Bibliographical note
Contribution: organisation=ase,FACT1=1<br/>Portfolio EDEND: 2013-10-29
Source: researchoutputwizard
Source-ID: 3280
Research output: Scientific - peer-review › Conference contribution

Monitoring of CO2 emissions in coal fired power plants

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Automation Science and Engineering
Authors: Uotila, T., Korpela, T., Majanne, Y.
Number of pages: 6
Pages: 1-6
Publication date: 2013

Host publication information
Title of host publication: Proceedings of Automaatio XX-seminaari, Automation and systems without borders - beyond future, 21.-22.5.2013, Helsinki
Publisher: Suomen Automaatioseura ry
Editor: Vilkko, M.
ISBN (Print): 978-952-5183-44-3

Publication series
On frequency-response measurements of power-electronic systems applying MIMO identification techniques

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering, Department of Automation Science and Engineering, Smart Energy Systems (SES)
Authors: Roinila, T., Huusari, J., Vilkko, M.
Number of pages: 7
Pages: 5270-5276
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Industrial Electronics
Volume: 60
Issue number: 11
ISSN (Print): 0278-0046
Ratings:
Scopus rating (2016): CiteScore 9.95 SJR 2.742 SNIP 3.696
Scopus rating (2015): SJR 2.732 SNIP 4.073 CiteScore 9.47
Scopus rating (2014): SJR 2.53 SNIP 4.7 CiteScore 9.19
Scopus rating (2013): SJR 2.45 SNIP 5.098 CiteScore 9.14
Scopus rating (2012): SJR 2.198 SNIP 4.316 CiteScore 8.27
Scopus rating (2011): SJR 1.988 SNIP 3.937 CiteScore 7.72
Scopus rating (2010): SJR 1.814 SNIP 3.265
Scopus rating (2009): SJR 1.971 SNIP 3.234
Scopus rating (2008): SJR 2.451 SNIP 3.482
Scopus rating (2007): SJR 2.133 SNIP 2.863
Scopus rating (2006): SJR 1.072 SNIP 2.632
Scopus rating (2005): SJR 2.257 SNIP 2.796
Scopus rating (2004): SJR 2.074 SNIP 2.951
Scopus rating (2003): SJR 2.34 SNIP 2.292
Scopus rating (2002): SJR 1.301 SNIP 1.626
Scopus rating (2001): SJR 1.804 SNIP 1.531
Scopus rating (2000): SJR 0.914 SNIP 1.713
Scopus rating (1999): SJR 0.522 SNIP 1.356
Original language: English
DOIs: 10.1109/TIE.2012.2221118

Bibliographical note
Contribution: organisation=ase,FACT1=1
Contribution: organisation=dee,FACT2=0.3
Portfolio EDEND: 2013-02-27
Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 3281
Research output: Scientific - peer-review › Article
Online Grid Impedance Measurement Using Discrete-Interval Binary Sequence Injection

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Automation Science and Engineering, Smart Energy Systems (SES)
Authors: Roinila, T., Vilkko, M., Sun, J.
Number of pages: 8
Pages: 1-8
Publication date: 2013

Host publication information
Title of host publication: 2013 IEEE 14th Workshop on Control and Modeling for Power Electronics COMPEL, The University of Utah, Salt Lake City, Utah, USA June 23 - 26, 2013
Place of publication: Piscataway
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4673-4914-7

Publication series
Name: IEEE Workshop on Control and Modeling for Power Electronics
ISSN (Print): 1093-5142
DOIs: 10.1109/COMPEL.2013.6626407

Bibliographical note
Contribution: organisation=ase,FACT1=1
Portfolio EDEND: 2013-12-29
Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 3282
Research output: Scientific - peer-review > Conference contribution

Projektilähtöinen työkurssi osana ei-parametriseden mallinnuksen opetusmenetelmiä

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Automation Science and Engineering
Authors: Roinila, T., Vilkko, M., Taskinen, A.
Number of pages: 6
Pages: 1-6
Publication date: 2013

Host publication information
Title of host publication: Proceedings of Automaatio XX-seminaari, Automation and systems without borders - beyond future, 21.-22.5.2013, Helsinki
Publisher: Suomen Automaatioseura ry
Editor: Vilkko, M.
ISBN (Print): 978-952-5183-44-3

Publication series
Name: SAS julkaisusarja
No.: 42
ISSN (Print): 1455-6502

Bibliographical note
Contribution: organisation=ase,FACT1=1
Portfolio EDEND: 2013-11-29
Publisher name: Suomen Automaatioseura ry
Source: researchoutputwizard
Source-ID: 3284
Research output: Scientific - peer-review > Conference contribution

Radial compression behavior of Norway spruce at high strain-rate

General information
State: Published
Reconstruction and characterization of grinding wheel and grit topography from scanning electron microscopy stereo micrographs with digital photogrammetry

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Automation Science and Engineering, Smart Energy Systems (SES)
Authors: Tuovinen, O., Björkqvist, T., Fardim, P.
Number of pages: 8
Pages: 51-58
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: O Papel
Volume: 74
Issue number: 4
ISSN (Print): 0031-1057
Ratings:
Scopus rating (2016): SJR 0.106 SNIP 0.274 CiteScore 0.05
Scopus rating (2015): SJR 0.131 SNIP 0.171 CiteScore 0.05
Scopus rating (2014): SJR 0.116 SNIP 0.373 CiteScore 0.07
Scopus rating (2013): SJR 0.124 SNIP 0.086 CiteScore 0.05
Scopus rating (2012): SJR 0.132 SNIP 0.077 CiteScore 0.02
Scopus rating (2011): SJR 0.119 SNIP 0.862 CiteScore 0.07
Scopus rating (2010): SJR 0.137 SNIP 0.156
Scopus rating (2009): SJR 0.138 SNIP 0.116
Scopus rating (2008): SJR 0.154 SNIP 0.103
Scopus rating (2007): SJR 0.108 SNIP 0.084
Scopus rating (2006): SJR 0.1 SNIP 0
Scopus rating (2005): SJR 0.11 SNIP 0
Scopus rating (2004): SJR 0.1 SNIP 0
Scopus rating (2003): SJR 0.113 SNIP 0.032
Scopus rating (2002): SJR 0.1 SNIP 0
Scopus rating (2001): SJR 0.101 SNIP 0.02
Scopus rating (2000): SJR 0.1 SNIP 0
Scopus rating (1999): SJR 0.1 SNIP 0.019
Original language: English

Bibliographical note
Contribution: organisation=ase,FACT1=1
Portfolio EDEND: 2013-09-29
Publisher name: Associacao Tecnica Brasileira de Celulose e Papel
Teollisuusvoimalaitoksen liukuva vastapaineen säätö

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Automation Science and Engineering
Authors: Majanne, Y., Maasalo, M., Nyman, J.
Number of pages: 6
Pages: 1-6
Publication date: 2013

Host publication information
Title of host publication: Proceedings of Automaatio XX-seminaari, Automation and systems without borders - beyond future, 21.-22.5.2013, Helsinki
Publisher: Suomen Automaatioseura ry
Editor: Vilkko, M.
ISBN (Print): 978-952-5183-44-3

Publication series
Name: SAS julkaisusarja
No.: 42
ISSN (Print): 1455-6502

Bibliographical note
Contribution: organisation=ase,FACT1=1<br/>Portfolio EDEND: 2013-11-29<br/>Publisher name: Suomen Automaatioseura ry
Source: researchoutputwizard
Source-ID: 2852
Research output: Scientific - peer-review › Conference contribution

CFD-Modeling of Fume Formation in Kraft Recovery Boilers

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Energy and Process Engineering, Research group: Power Plant and Combustion Technology, Urban circular bioeconomy (UrCirBio), Valmet Technologies Oy, University of Toronto, Canada
Authors: Leppänen, A., Välimäki, E., Oksanen, A., Tran, H.
Publication date: 2012

Host publication information
Title of host publication: TAPPI PEERS Conference Proceedings 14.-18.10.2012, Savannah, USA
Publisher: TAPPI

Publication series
Name: TAPPI PEERS Conference
Links:

Bibliographical note
Contribution: organisation=epr,FACT1=1<br/>Portfolio EDEND: 2013-11-29<br/>Publisher name: TAPPI
Source: researchoutputwizard
Source-ID: 4695
Research output: Scientific - peer-review › Conference contribution

On-line data reconciliation as a tool to improve the environmental efficiency assessment in power plant environment

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
CFD Based Modelling for Predicting Fouling and Corrosion in Kraft Recovery Boilers

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Authors: Leppänen, A., Välimäki, E., Oksanen, A.
Pages: 1033-1040
Publication date: 2011

Host publication information
Title of host publication: 19th European Biomass Conference and Exhibition, 6-10 June 2011, Berlin Germany
Place of publication: Berlin
Publisher: European Biomass Conference and Exhibition
ISBN (Print): 978-88-89407-55-7

Publication series
Name: European Biomass Conference and Exhibition
Publisher: European Biomass Conference and Exhibition
DOI: 10.5071/19thEUBCE2011-OA10.3
Links:
http://www.conference-biomass.com

Bibliographical note
ei ut-numeroa 5.4.2014<br/>Contribution: organisation=epr,FACT1=1
Source: researchoutputwizard
Source-ID: 6598
Research output: Scientific - peer-review › Conference contribution
Modeling of Fine Particles and Alkali Metal Compounds in Kraft Recovery Boiler Furnace

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Authors: Leppänen, A., Välimäki, E., Oksanen, A.
Number of pages: 8
Pages: 1-8
Publication date: 2011

Host publication information
Title of host publication: The 2011 TAPPI PEERS Conference, 2-5 October 2011, Oregon Convention Center in Portland, Oregon USA
Place of publication: Norcross, GA
Publisher: TAPPI

Publication series
Name: TAPPI PEERS Conference
Publisher: TAPPI
Links:
http://www.tappipeers.org

Bibliographical note
ei ut-numeroa 5.4.2014<br/>Contribution: organisation=epr,FACT1=1
Source: researchoutputwizard
Source-ID: 6599
Research output: Scientific - peer-review › Conference contribution

Study of Aerosols of Black Liquor Combustion

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Authors: Leppänen, A., Välimäki, E., Oksanen, A.
Number of pages: 11
Pages: 1-11
Publication date: 2011

Host publication information
Title of host publication: 11th International Conference on Energy for Clean Environment, 5-8 July 2011, Lisbon Portugal
Place of publication: Lisbon
Publisher: Clean Air conference series

Publication series
Name: International Conference on Energy for Clean Environment
Publisher: Clean Air conference series

Bibliographical note
ei ut-numeroa 5.4.2014<br/>Contribution: organisation=epr,FACT1=1
Source: researchoutputwizard
Source-ID: 6600
Research output: Scientific - peer-review › Conference contribution