Proceedings of the 2nd Annual SMACC Research Seminar 2017
The Annual SMACC Research Seminar is a forum for researchers from VTT Technical Research Centre of Finland Ltd, Tampere University of Technology (TUT) and industry to present their research in the area of smart machines and manufacturing. The 2nd seminar is held in 7th of November 2017 in Tampere, Finland.

The objective of the seminar is to publish results of the research to wider audiences and to offer researchers a forum to discuss their research and to find common research interests and new research ideas.

Smart Machines and Manufacturing Competence Centre - SMACC is joint strategic alliance of VTT Ltd and TUT in the area of intelligent machines and manufacturing. SMACC offers unique services for SME’s in the field of machinery and manufacturing - key features are rapid solutions, cutting-edge research expertise and extensive partnership networks. SMACC is promoting digitalization in mechanical engineering and making scientific research with domestic and international partners in several different topics (www.smacc.fi).

General information
State: Published
Ministry of Education publication type: C2 Edited books
Organisations: Mechanical Engineering and Industrial Systems
Authors: Aaltonen, J., Koskinen, K., Virkkunen, R., Kuivanen, R.
Number of pages: 62
Publication date: 7 Nov 2017

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Research output: Scientific - peer-review › Anthology

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 fulfil 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.

General information
State: Published
Ministry of Education publication type: G5 Doctoral dissertation (article)
Organisations: Automation and Hydraulic Engineering
Authors: Korpela, T.
Number of pages: 84
Publication date: 13 Oct 2017
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.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Automation and Hydraulic Engineering, Valmet Technologies, Valmet Automation, Aalto University
Authors: Majanne, Y., Yli-Fossi, T., Korpela, T., Nurmoranta, M., Kortela, J.
Number of pages: 6
Pages: 2005-2010
Publication date: 1 Jul 2017

Host publication information
Title of host publication: IFAC-PapersOnLine
Publisher: IFAC

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.

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Authors: Björkqvist, T., Suominen, O., Vilkko, M., Korpi, M.
Pages: 257-266
Publication date: Dec 2016
Peer-reviewed: Yes

Publication information
Journal: Simulation Notes Europe SNE
Volume: 26
Issue number: 4
ISSN (Print): 2305-9974
Original language: English
DOIs:
10.11128/sne.26.tn.10357
Links:

Modelling and Simulation of Radial Spruce Compression to Optimize Energy Efficiency in Mechanical Pulping

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Mechanical Engineering and Industrial Systems, Department of Automation Science and Engineering, Research area: Dynamic Systems, Research area: Measurement Technology and Process Control
Authors: Moilanen, C., Björkqvist, T., Ovaska, M., Koivistio, J., Miksic, A., Engberg, B., Salminen, L., Saarenrinne, P., Alava, M.
Number of pages: 18
Pages: 53-70
Publication date: 26 Sep 2016

Host publication information
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Place of publication: USA
Publisher: TAPPI
Article number: 1.3
ISBN (Print): 978-1-59510-250-7
Electronic versions:
Modelling and simulation of radial spruce compression
Links:
http://urn.fi/URN:NBN:fi:ttty-201708281835
Research output: Scientific - peer-review › Conference contribution

Menetelmä ja laitteisto selluloosapitoisten materiaalien fibrilloimiseksi; Förfarande och anordning för fibrillering av cellulosahaltiga materialer

General information
State: Published
Ministry of Education publication type: H1 Granted patent
Authors: Björkqvist, T., Gustafsson, H., Koskinen, T., Nuoopponen, M., Vehniäinen, A., Fredrikson, A.
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.

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.
Heat Transfer Phenomena in Float Glass Heat Treatment Processes

Glass tempering is a process in which the strength of float glass is improved with heat treatment. In a tempering furnace glass is on top of rotating ceramic rollers. In the process glass plates are heated with thermal radiation and forced convection up to about 640˚C and then cooled by air jets at a cooling rate depending on the glass thickness. The residual stress, i.e., tempering level depends on the cooling speed. In order to solve glass temperatures during a tempering process, the problem is to find solving method for radiation heat flux, convection heat transfer coefficients and contact heat transfer coefficient. The aim of the heat-soak process for tempered glass is to eliminate glasses at risk of spontaneous breakage. In the process glasses are heated up to 290˚C by hot air flowing in a channel between them. The problem is to find solving methods for glass and air temperatures which depend on the stream-wise coordinate and time.

A method for solving radiation heat flux from a tubular resistor to a plate under it was developed. The radiative properties of clear and low emissivity coated soda-lime glass were shown and thermal radiation in a plate glass was described. A new method for solving net radiation heat transfer between a clear plate glass and diffuse surroundings was developed. In the method the radiation between glass volume elements is ignored and integration over hemisphere is covered by using the mean reflectivity of glass surface and the mean propagation angle at which radiation travels in glass. The use of the method is limited to glass temperatures below 700°C. The method was also adapted to coated glass. The method was used to show the effect of the radiation wavelength, glass thickness and low emissivity coating to plate glass radiation properties. The results of the method were compared against results in the literature. The method gave the same results. The simplest version of the new method only the first internal reflection from glass-air interface was considered, and even then the accuracy was high.

The development of an air jet was introduced with equations. The momentum of the jet was solved experimentally and the results were compared against calculated ones. Local convection heat transfer coefficients on a flat surface under a sonic velocity air jet alike in glass tempering furnace were solved experimentally by using a constant heat flux plate. The effect of discharging pressure, orifice diameter and nozzle-to-plate distance to heat transfer was studied. The literature correlations were used and new experiments were made to research heat transfer under an impinging incompressible jet. It was observed that when the momentum of a jet and nozzle to plate distance are equal, then heat transfer is quite equal, even if the nozzle diameter and discharging pressure varied.

Heat transfer under an array of air jets alike in glass tempering chiller was studied experimentally and with a literature correlation. In the experiment three different jet arrays were used in which only the nozzle diameter varied. The heat...
transfer of each jet array was found to be quite equal when the fan power needed to create jets was the same. The heat transfer coefficients given by the correlation corresponded well to the ones given by new measurements. Measured heat transfer coefficients were 11 to 14% higher than the predicted ones, and the change in the overpressure changed the measured heat transfer coefficients in the same relation as it changed the measured ones.

The contact heat transfer between glass and rollers was studied. The following estimate for effective contact heat transfer coefficient of glass on top of ceramic rollers in tempering furnace was found: $1 \leq \epsilon \leq 3$ W/(mK).

The methods for solving heat transfer between glass and air flowing in a narrow channel between glasses were presented for both turbulent and laminar flow. The method for solving heat transfer in a heat soak furnace was developed. In the heat soak furnace studied the flow was found to be turbulent, but also laminar flow could occur during the final stages of the heating due to increasing air temperature, i.e., decreasing Reynolds number. Theoretically predicted and measured temperatures were found to be in reasonable agreement. An extended method for furnace designer and operator for solving heat transfer in a heat soak furnace was developed which was found that in a very narrow channel the heating time increased dramatically because the air temperature at the end of such a channel was almost as low as glass temperature, i.e., heat from the air was already transferred to glass. The heating time also increased with the glass flow-wise length and thickness, although the total mass of the glass loading remained the same.

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Organisations: Department of Mechanical Engineering and Industrial Systems
Authors: Rantala, M.
Number of pages: 135
Publication date: 26 Nov 2015

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Original language: English

**Publication series**
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Publisher: Tampere University of Technology
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Links:

**Bibliographical note**
Awarding institution: Tampere University of Technology
Research output: Monograph › Doctoral Thesis

**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**
State: Published
Ministry of Education publication type: A1 Journal article-refereed
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
Peer-reviewed: Yes

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Volume: 132
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ISSN (Print): 0021-8995
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Scopus rating (2015): SJR 0.574 SNIP 0.827 CiteScore 1.74
Scopus rating (2014): SJR 0.658 SNIP 0.964 CiteScore 1.76
Scopus rating (2013): SJR 0.628 SNIP 1.085 CiteScore 1.71
Scopus rating (2012): SJR 0.658 SNIP 1.081 CiteScore 1.57
Scopus rating (2011): SJR 0.601 SNIP 0.965 CiteScore 1.45
Scopus rating (2010): SJR 0.679 SNIP 0.909
Scopus rating (2009): SJR 0.697 SNIP 0.825
Scopus rating (2008): SJR 0.647 SNIP 0.822
Scopus rating (2007): SJR 0.678 SNIP 0.931
Scopus rating (2006): SJR 0.782 SNIP 1.145
Scopus rating (2005): SJR 0.779 SNIP 0.912
Scopus rating (2004): SJR 0.774 SNIP 0.962
Scopus rating (2003): SJR 0.816 SNIP 1.067
Scopus rating (2002): SJR 0.866 SNIP 1.084
Scopus rating (2001): SJR 0.964 SNIP 1.157
Scopus rating (2000): SJR 0.864 SNIP 1.157
Scopus rating (1999): SJR 0.978 SNIP 1.277
Original language: English
ASJC Scopus subject areas: Materials Chemistry, Polymers and Plastics, Surfaces, Coatings and Films, Chemistry(all)
Keywords: aging, degradation, rheology, thermoplastics, PHOTOOXIDATION, FILMS, PHOTOLYSIS
Electronic versions: comparison_of_rheology_and_ftir_post-print
DOIs: 10.1002/app.42246
Links: http://www.scopus.com/inward/record.url?scp=84928363110&partnerID=8YFLogxK (Link to publication in Scopus)

Bibliographical note
ORG=mol,0.7
ORG=keb,0.2
ORG=mei,0.1
Source: Scopus
Source-ID: 84928363110
Research output: Scientific - peer-review › Article

Systematic search for design contradictions in systems' architecture: Toward a computer aided analysis
Time pressure imposed to the engineering design process is one fundamental constraint pushing engineers to rush into known solutions, to avoid analysing properly the environment of a design problem, to avoid modelling design problems and to take decision based on isolated evidences. Early phases in particular have to be kept short despite the large impact of decisions taken at this stage. Significant efforts are currently spent within different engineering communities to develop a model-based design approach adapted to conceptual stages. Developing such type of models is also challenging due to the fuzziness of the information and due to the complexity of the concepts and processes manipulated at this stage. Currently few support tools are really capable of really supporting an analysis of the early design concepts and architectures. Simultaneously the approach should be fast, easy to use and should provide a real added-value to efficiently support the decision and the design process. The present article is presenting a framework based on a progressive transformation of the design concepts. The final material generated by this transformation process is an
oriented graph with different types of classified variables. This graph can be processed as described in the article to automatically exhibit the conflicts or contradictions present in the design concept architecture. The article is proposing two main contributions which are a real move toward model development at conceptual stage and the possibility to process those models to detect solution weaknesses. The discussion is presenting further developments and possibilities associated with this method.

**General information**
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Mechanical Engineering and Industrial Systems, Research area: Manufacturing and Automation, Department of Pervasive Computing, Research area: Software engineering, Intelligent dexterity for secure networked infrastructure and applications (IDSNIA), Aalto University, Department of Mechanical Engineering and Integrated Systems, Applied Physics Laboratory, Johns Hopkins University, Karlsruhe University
Authors: Coatanéa, E., Nonsiri, S., Roca, R., Mokammel, F., Kruck, J., Christophe, F.
Number of pages: 22
Pages: 25-46
Publication date: 6 Jun 2015
Peer-reviewed: Yes

**Publication information**
Journal: Journal of Integrated Design and Process Science
Volume: 19
Issue number: 1
ISSN (Print): 1092-0617
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Original language: English
ASJC Scopus subject areas: Engineering(all)
Keywords: Conceptual design, Conflicts, Contradictions, Dimensional analysis, Graph theory, Model-based design, Qualitative physics, Triz
DOIs:
10.3233/jid-2015-0001

**Bibliographical note**
AUX=mei, "Nonsiri, Sarayut"
AUX=mei, "Mokammel, Faisal"

ORG=tie, 0.5
ORG=mei, 0.5
Source: Scopus
Source-ID: 84931082981
Research output: Scientific - peer-review > Article
Optimal Shapes of Straight Fins and Finned Heat Sinks

Finned heat sinks are used to cool power electronics components. We present optimization results for single rectangular, triangular, and trapezoidal fins. After that, we minimize the mass of an existing heat sink consisting of a base plate and a fin array by optimizing the geometrical variables and component locations on the base plate. An analytical solution is used with rectangular fins and a numerical model with trapezoidal fins. Whereas the triangle is the best shape for single fins, in a heat sink flow velocity coupled with geometry favors trapezoids over triangles and rectangles.

General information
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Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Mechanical Engineering and Industrial Systems, Research area: Applied Mechanics
Authors: Lindstedt, M., Lampio, K., Karvinen, R.
Number of pages: 8
Publication date: Jun 2015
Peer-reviewed: Yes

Publication information
Journal: Journal of Heat Transfer: Transactions of the ASME
Volume: 137
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ISSN (Print): 0022-1481
Ratings:
Scopus rating (2016): SJR 0.834 SNIP 1.038 CiteScore 1.71
Scopus rating (2015): SJR 1.061 SNIP 1.023 CiteScore 1.62
Scopus rating (2014): SJR 0.885 SNIP 1.059 CiteScore 1.53
Scopus rating (2013): SJR 1.017 SNIP 1.224 CiteScore 2.2
Scopus rating (2012): SJR 1.085 SNIP 1.16 CiteScore 1.55
Scopus rating (2011): SJR 1.175 SNIP 1.11 CiteScore 1.99
Scopus rating (2010): SJR 1.128 SNIP 1.381
Scopus rating (2009): SJR 1.457 SNIP 1.517
Scopus rating (2008): SJR 1.384 SNIP 1.544
Scopus rating (2007): SJR 1.404 SNIP 1.462
Scopus rating (2006): SJR 1.533 SNIP 1.582
Scopus rating (2005): SJR 1.522 SNIP 1.679
Scopus rating (2004): SJR 1.322 SNIP 1.867
Scopus rating (2003): SJR 1.707 SNIP 1.703
Scopus rating (2002): SJR 1.089 SNIP 2.013
Scopus rating (2001): SJR 1.813 SNIP 1.874
Scopus rating (2000): SJR 1.511 SNIP 1.59
Scopus rating (1999): SJR 1.165 SNIP 1.385
Original language: English
Keywords: heat sink, trapezoidal fin, forced convection, analytical solution, optimization, component placement, FORCED-CONVECTION, NUMERICAL OPTIMIZATION, PERFORMANCE
DOIs:
10.1115/1.4029854

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publication_forum:60569
Source: WOS
Source-ID: 000353561800007
Research output: Scientific - peer-review › Article

Reframing the value of virtual prototyping: Intermediary virtual prototyping - the evolving approach of virtual environments based virtual prototyping in the context of new product development and low volume production

This thesis studies how the evolving approach of virtual environments-based virtual prototyping can be evaluated in the context of product design and development in the manufacturing industry. The entry point for this research is the relatively long experience in applied research in virtual prototyping with industry. As the virtual prototyping technology has become more mature, the focus of research and development has extended from technology demonstrations towards utilization in product design and development processes. However, lack of scientific and practical knowledge of real benefits and the value of virtual prototyping has seemed to be a deterrent to its wider adoption of industry. The aim of this thesis is by means of scientific research to increase the knowledge of the value contribution of virtual prototyping as well as its impacts.
in a practical industrial context.

This problem was approached from the science base by formulating an expanded theory framework for value modelling, and from the problem base by an empirical case study in one manufacturing company. The research approach was constructive and exploratory.

The research results consist of three types of knowledge. Firstly, the scientific theoretical foundation was elaborated for initiating value modelling of virtual prototyping and virtual environments. Secondly, new knowledge on the value of virtual prototyping within new product development was created in an industrial case study. Finally, knowledge on how virtual prototyping (VP) impacts the company was reported. The impact was discussed in the dimensions of process, social and technological implications.

This research contributed to engineering design science by conceptualizing virtual prototyping in the context of product design and development expanding to the dimensions of human factors and management theory. Thus, the contribution is also manifested by constructing the expanded theory framework for virtual prototyping value modelling in four dimensions with causal justification from virtual reality technology to business value elements which led to the new concept of Intermediary Virtual Prototyping (IVP). The discussed concept of IVP underscores the many layers from technical advantages of virtual reality to the expanded mediating object of product development activity system.

The discussion was carried on from the perspective of a partially configurable products and manual work-intensive variant production mode. This perspective is novel compared to the majority of virtual prototyping and virtual environments literature. It is proposed that IVP is particularly beneficial in this context, where human skills and knowledge contribute to the flexibility of production system.

IVP should be considered as a strategic investment that will produce income in the long run. IVP contributes to the co-creation and variant production paradigms by involving human creativity at an early product design and development phase, thus increasing flexibility. IVP creates value in use, but in turn it impacts the company in all the four dimensions mentioned.

General information
State: Published
Ministry of Education publication type: G4 Doctoral dissertation (monograph)
Organisations: Department of Mechanical Engineering and Industrial Systems
Authors: Leino, S.
Number of pages: 312
Publication date: 22 May 2015

Publication information
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Original language: English

Publication series
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Links:

Bibliographical note
Awarding institution:Tampere University of Technology
Versio ok 16.12.2015

Research output: Monograph ▶ Doctoral Thesis

On the choice of damage variable in the continuum fatigue model based on a moving endurance surface
This paper considers two different damage formulations for modelling high-cycle fatigue of materials. The underlying fatigue model is formulated within continuum mechanics framework with the concept of a moving endurance surface. Such a model has a unique feature that it allows for the concepts of fatigue limits and damage accumulation during the load history thus avoiding cycle-counting techniques. A Scalar and tensor type of damage variables are utilized with an
essentially similar type of damage evolution law. The tensor damage model capable of accounting for damage induced
anisotropy is based on the gradient of the endurance surface. The performance of the scalar and tensor damage
formulations are compared with different multidimensional stress histories.

General information
State: Published
Ministry of Education publication type: B3 Non-refereed article in conference proceedings
Organisations: Department of Mechanical Engineering and Industrial Systems, Research area: Applied Mechanics
Authors: Saksala, T., Holopainen, S., Kouhia, R.
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Publication date: May 2015

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ISBN (Print): 978-952-93-5608-9
Keywords: high-cycle fatigue modelling, isotropic damage, anisotropic damage, endurance surface, evolution equations
Links:
Research output: Scientific › Conference contribution

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.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Research area: Information Systems in Automation, Research area: Dynamic Systems, Department of
Automation Science and Engineering, Smart Energy Systems (SES)
Authors: Pyrhönen, V., Koivisto, H.
Number of pages: 6
Pages: 147 - 152
Publication date: 1 Apr 2015

Host publication information
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Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-5685-2
Keywords: Composite nonlinear feedback, actuator saturation, high performance, robust control, set point filter, control
system synthesis, feedback, nonlinear control systems, transient response
DOI:
10.1109/ICCSCE.2014.7072705
Links:
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7072705
Research output: Scientific - peer-review › Conference contribution

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.

General information
A Method and an Apparatus for Producing Nanocellulose

General information
State: Published
Ministry of Education publication type: H1 Granted patent
Authors: Björkqvist, T., Koskinen, T., Nuopponen, M., Vehniäinen, A., Gustafsson, H.
Publication date: 18 Feb 2015

Publication information
IPC: D21H 11/18 A I
Patent number: EP2659061
Priority date: 31/12/10
Priority number: FI 20106402
Original language: English
Source: espacenet
Source-ID: EP2659061
Research output: Scientific › Patent

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/alumino-silicate (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
State: Published
Ministry of Education publication type: A1 Journal article-refereed
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.
Number of pages: 13
Pages: 3427-3439
Publication date: 9 Feb 2015
Peer-reviewed: Yes

Publication information
Journal: Optics Express
Volume: 23
High performance wear and corrosion resistant coatings by novel cladding techniques

In the field of surface engineering, cladding or overlay welding is a group of coating methods used in manufacturing fusion-bonded thick metallic and metal matrix composite (MMC) coatings on a wide variety of metallic base materials with varying degree of deposition rate, dilution and heat input. Growing demands for more material-, energy- and cost-effective overlay welding processes as well as sustainable solutions for performance-critical applications have boosted to develop methods that are capable of producing low diluted and fusion-bonded single layer coatings with high deposition rates. Such novel cladding methods include for instance laser-based high power laser cladding, coaxial hot-wire laser cladding, laser-arc hybrid cladding, non-laser-based Cold Metal Transfer (CMT) cladding and methods that utilize high intensity infrared (IR) light. This paper introduces some of such highly innovative cladding techniques and highlights some microstructural and geometrical features, abrasion and sliding wear, and wet corrosion properties of Fe-, Ni- and Co-based metallic coatings manufactured by novel laser and CMT cladding methods. The research results evidence that with the choice of optimal processing parameters, novel cladding techniques are capable of manufacturing high performance weld overlays with the properties equivalent or near to corresponding wrought alloys and reference overlays with net deposition rates of approximately 5 kg/h and more. Overall, the presented work suggests that discussed methods have high potential in surfacing of new and remanufacturing of service-damaged surfaces in high value components, in building up complex features on existing components and also in near net shape additive manufacturing of functional 3D objects.
A model for anisotropic magnetostriction

General information
State: Published
Ministry of Education publication type: B3 Non-refereed article in conference proceedings
Organisations: Department of Mechanical Engineering and Industrial Systems, Research area: Applied Mechanics, Lund University, Aalto University
Authors: Belahcen, A., Kouhia, R., Rasilo, P., Ristinmaa, M.
Number of pages: 3
Pages: 201-203
Publication date: 2015

Host publication information
Title of host publication: Proceedings of the XII Finnish Mechanics Days
Publisher: Rakenteiden Mekaniikan Seura ry
ISBN (Print): 978-952-93-5608-9

Bibliographical note
EXT="Rasilo, Paavo"
Research output: Scientific › peer-review › Conference contribution

A new method to calculate natural convection heat transfer from a non-isothermal fin array

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Mechanical Engineering and Industrial Systems, Research area: Applied Mechanics, Research group: Lämpö- ja virtaustekniikka
Authors: Lampio, K., Karvinen, R.
Publication date: 2015

Host publication information
Title of host publication: Proceedings of the 7th Baltic Heat Transfer Conference, August 24-26 2015, Tallinn Estonia
Place of publication: Tallinn
Publisher: Tallinn University of Technology
Editors: Neshumayev, D., Sunden, B.
ISBN (Print): 978-9949-23-817-0

Publication series
Name: Baltic Heat Transfer Conference BHTC
Publisher: Tallinn University of Technology

Bibliographical note
Research output: Scientific › peer-review › Conference contribution

Brownfield process for the rationalisation of existing product variety towards a modular product family
Modularisation, product platforms, product families and product configuration are efficient product structuring tactics for providing of product variants for customers. This paper studies how the design information related to designing of modular product family that supports product configuration can be structured and how to support defining of this kind of design information in a design situation in which existing product assortment should be rationalised towards a modular product
family that supports product configuration. Research approach bases on literature review and empirical findings. Categorisation to five design information elements including partitioning logic, set of modules, interfaces, architecture and configuration knowledge is suggested.Existing methods consider partly or as different combinations these elements but considering of all of them is rare although all of them have been recognised as important. Thus a design method known as the Brownfield Process is introduced. Steps of the method are tested in industrial cases. As a conclusion we state that the method can be applied also to other cases in which rationalisation of existing product assortment is sought.

**General information**
- **State:** Published
- **Ministry of Education publication type:** A4 Article in a conference publication
- **Organisations:** Department of Mechanical Engineering and Industrial Systems, Research area: Design, Development and LCM
- **Authors:** Pakkanen, J., Juuti, T., Lehtonen, T.
- **Number of pages:** 10
- **Publication date:** 2015

**Host publication information**
- **Title of host publication:** ICED 15, vol 7: Product Modularisation, Product Architecture, Systems Engineering, Product Service Systems
- **Volume:** 7
- **Publisher:** The Design Society
- **Editors:** Weber, C., Husung, S., Cascini, G., Cantamessa, M., Marjanovic, D., Rotini, F.
- **ISBN (Print):** 978-1-904670-70-4

**Publication series**
- **Name:** International Conference on Engineering Design
- **Publisher:** DESIGN SOC
- **ISSN (Print):** 2220-4334
- **Keywords:** Design methods, Product families, Product structuring, modularisation, Product architecture, DEFINITION, DESIGN
- **Source:** WOS
- **Source-ID:** 000366305800014
- **Research output:** Scientific - peer-review › Conference contribution

**Experimental and numerical study of a choke valve in a turbulent flow**

This study investigates a flow past a choke valve by experimental and numerical means. The flow profile after a choke valve with high Reynolds number of approximately 1,000,000 was measured using a LDV and computed using RANS simulations. Two turbulence models were used for the simulation, namely k-ε and k-ω turbulence models. It was found out that the k-ω model produces more similar results to LDV measurements than the k-ε model. This study also reports citeable flow profiles past a choke valve computed by both turbulence models. Furthermore, the accuracy of the LDV based volume flow measurements was also discussed. The volume flow estimates were compared with simulation results, and with flow meter results. Results showed that LDV can be used for volume flow estimation even in unsymmetrical situations, such as after the choke valve, with error ranging from 0.3% to 2.6%.

**General information**
- **State:** Published
- **Ministry of Education publication type:** A1 Journal article-refereed
- **Organisations:** Department of Mechanical Engineering and Industrial Systems, Research area: Applied Mechanics, VTT Technical Research Centre of Finland
- **Authors:** Huovinen, M., Kolehmainen, J., Koponen, P., Nissilä, T., Saarenrinne, P.
- **Number of pages:** 11
- **Pages:** 151-161
- **Publication date:** 2015
- **Peer-reviewed:** Yes

**Publication information**
- **Journal:** Flow Measurement and Instrumentation
- **Volume:** 45
- **ISSN (Print):** 0955-5986
- **Ratings:**
  - Scopus rating (2016): SJR 0.53 SNIP 1.355 CiteScore 1.45
  - Scopus rating (2015): SJR 0.533 SNIP 1.642 CiteScore 1.67
  - Scopus rating (2014): SJR 0.51 SNIP 1.647 CiteScore 1.52
  - Scopus rating (2013): SJR 0.567 SNIP 1.927 CiteScore 1.6
Industrial Tools for micromanipulation

General information
State: Published
Ministry of Education publication type: B2 Part of a book or another research book
Authors: Gauthier, M., Clevy, C., Kallio, P., Heriban, D.
Number of pages: 23
Pages: 369-392
Publication date: 2015

Host publication information
Title of host publication: Micro- and Nanomanipulation Tools
Publisher: Wiley
Editors: Sun, Y., Liu, X.
ISBN (Print): 978-3-527-33784-2
ISBN (Electronic): 978-3-527-69022-0

Publication series
Name: Advanced Micro & Nanosystems
Publisher: Wiley-VCH
Research output: Scientific › Chapter

Micro-factories
Micro- and desktop factories are small-size production systems suitable for the manufacture of small products with micro- and/or macro-size features. The development originates in Japan, where small machines were developed in order to save resources when producing small products. In the late 1980s, the research spread around the world, and since then multiple miniaturized production systems, both academic and commercial, have been developed. Academic research literature speculates with several advantages of using miniaturized production equipment ranging from reduced use of energy and other resources to better operator ergonomics, and from greater equipment flexibility to ubiquitous manufacturing (manufacturing on the spot). This paper will give a thorough introduction to existing micro-factory solutions and their potential application areas. It will also discuss the benefits of miniaturized production systems compared to traditional larger scale systems from three sustainability perspectives, namely environmental, economic, and social ones.

General information
State: Published
Ministry of Education publication type: B2 Part of a book or another research book
Organisations: Department of Mechanical Engineering and Industrial Systems, Research area: Engineering Intelligence, Research area: Life-cycle Management, Research area: Manufacturing and Automation
Authors: Järvenpää, E., Heikkilä, R., Siltala, N., Prusi, T., Tuokko, R.
Some aspects on efficient solution of creep problems
Integration of inelastic constitutive models by implicit schemes, require local Newton’s iteration to solve the discretized non-linear evolution equations at the integration point level. Choice of the starting values in the Newton’s iteration affects on the success of the iteration at the local integration point level. This note describes a simple modification on the approach proposed by Schreyer giving increased robustness on the local iteration process. Also the effect of line search and quasi-Newton methods in the solution of the global equilibrium iterations is investigated.

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Mechanical Engineering and Industrial Systems, Research area: Applied Mechanics, Research group: Teknillinen mekaniikka ja lujuusoppi
Authors: Kouhia, R., Marjamäki, P., Kivilahti, J.
Number of pages: 12
Pages: 199-210
Publication date: 2015
Peer-reviewed: Yes

Publication information
Journal: Rakenteiden mekaniikka
Volume: 48
Issue number: 4
ISSN (Print): 0783-6104
Original language: English
Electronic versions:
RakMek_48_4_2015_2
Links:
Research output: Scientific - peer-review › Article
Using maintenance data for extended warranty simulation

General information
State: Published
Ministry of Education publication type: D3 Professional conference proceedings
Organisations: Department of Mechanical Engineering and Industrial Systems, Research group: Käyttövarmuuden suunnittelu ja kunnossapito, Research area: Life-cycle Management
Authors: Mahlamäki, K., Jokinen, J., Borgman, J., Niemi, A., Rämänen, J.
Number of pages: 7
Publication date: 2015

Host publication information
Title of host publication: COMADEM 2014, Implications of life cycle analysis in asset and maintenance management, 16-18 September 2014, Brisbane Convention and Exhibition Centre, Australia

Method and apparatus for cooling material by atomised spray
The invention relates to a method and apparatus for tempering material. According to the invention, one or more liquids are atomized by at least one sprayer into droplets which are guided towards a surface of a hot material so that at least some of the droplets collide with the surface of the hot material and evaporate, thus removing thermal energy from the surface layer of the hot material. Impact members may be used to further reduce the size of the droplets. The droplets may be guided to the surface by a separate guiding gas flow.

General information
State: Published
Ministry of Education publication type: H1 Granted patent
Organisations: Department of Mechanical Engineering and Industrial Systems, Research area: Applied Mechanics, Research group: Lämpö- ja virtaustekniikka, BENEQ OY
Authors: Ahonen, S., Karvinen, R., Vainio, T.
Publication date: 31 Dec 2014

Publication information
IPC: C03B 27/02 A1
Patent number: CN102803520
Priority date: 15/06/10
Priority number: WO2010FI50499
Original language: English
Source: espacenet
Source-ID: CN102803520
Research output: Scientific › Patent

Application of Design Review to Probabilistic Risk Assessment in a Large Investment Project

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Mechanical Engineering and Industrial Systems
Authors: Virtanen, S., Penttinen, J., Kiiski, M., Jokinen, J.
Number of pages: 12
Pages: 1-12
Publication date: 2014

Host publication information
Concerns over students role as test users in virtual environments

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Mechanical Engineering and Industrial Systems
Authors: Tiainen, T., Ellman, A.
Number of pages: 8
Pages: 11-18
Publication date: 2014

Host publication information
Title of host publication: Proceedings of the 18th Academic MindTrek Conference 2014 "Media business, management, content & services" 4-6 November, 2014, Tampere, Finland
Place of publication: New York, NY
Publisher: The Association for Computing Machinery
Editors: Lugmayr, A., Franssila, H., Paavilainen, J.
ISBN (Print): 978-1-4503-3006-0

Bibliographical note
Contribution: organisation=mei,FACT1=1
Portfolio EDEND: 2014-12-13
Source: researchoutputwizard
Source-ID: 1626
Research output: Scientific - peer-review › Conference contribution

EU Emission Trading Related CO2 Monitoring in 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: Majanne, Y., Korpela, T., Uotila, T.
Number of pages: 6
Pages: 1361-1366
Publication date: 2014

Host publication information
Title of host publication: Proceedings of 19th IFAC World Congress, Cape Town, South Africa, August 24-29, 2014
Publisher: International Federation of Automatic Control
Editors: Boje, E., Xia, X.

Publication series
Name: IFAC proceedings volumes
Publisher: International Federation of Automatic Control
Volume: 19
No.: 1
ISSN (Print): 1474-6670
DOIs:
10.3182/20140824-6-ZA-1003.02230
Links:
http://www.ifac-papersonline.net/Detailed/65641.html

Bibliographical note
Functional failure modes cause-consequence logic suited for mobile robots used at scientific facilities

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Mechanical Engineering and Industrial Systems
Authors: Douzi, I. K., Virtanen, S., Bonnal, P., Verma, A.
Number of pages: 9
Pages: 10-18
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Reliability Engineering and System Safety
Volume: 129
ISSN (Print): 0951-8320
Ratings:
Scopus rating (2016): SJR 1.407 SNIP 2.366 CiteScore 3.78
Scopus rating (2015): SJR 1.373 SNIP 2.403 CiteScore 3.93
Scopus rating (2014): SJR 1.467 SNIP 2.714 CiteScore 3.4
Scopus rating (2013): SJR 1.381 SNIP 2.939 CiteScore 3.28
Scopus rating (2012): SJR 1.566 SNIP 3.008 CiteScore 3.55
Scopus rating (2011): SJR 0.825 SNIP 2.945 CiteScore 3.15
Scopus rating (2010): SJR 1.268 SNIP 2.345
Scopus rating (2009): SJR 1.198 SNIP 2.634
Scopus rating (2008): SJR 0.95 SNIP 2.313
Scopus rating (2007): SJR 0.77 SNIP 2.13
Scopus rating (2006): SJR 0.692 SNIP 1.944
Scopus rating (2005): SJR 0.544 SNIP 1.667
Scopus rating (2004): SJR 0.489 SNIP 1.623
Scopus rating (2003): SJR 0.409 SNIP 1.321
Scopus rating (2002): SJR 0.483 SNIP 1.02
Scopus rating (2001): SJR 0.416 SNIP 1.066
Scopus rating (2000): SJR 0.219 SNIP 0.93
Scopus rating (1999): SJR 0.301 SNIP 1.136
Original language: English
DOIs: 10.1016/j.ress.2014.03.012
Links: http://www.journals.elsevier.com/reliability-engineering-and-system-safety/

Bibliographical note
Contribution: organisation=mei,FACT1=1<br/>Portfolio EDEND: 2014-12-12<br/>Publisher name: Elsevier; Safety Engineering and Risk Analysis Division
Source: researchoutputwizard
Source-ID: 266
Research output: Scientific - peer-review › Article

Image based measurement techniques for particulate flows

General information
State: Published
Ministry of Education publication type: G5 Doctoral dissertation (article)
Organisations: Department of Mechanical Engineering and Industrial Systems
Authors: Kolehmainen, J.
Innovative tool for specifying customer requirements

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Mechanical Engineering and Industrial Systems
Authors: Ellman, A., Wendrich, R., Tiainen, T.
Number of pages: 5
Pages: 1-5
Publication date: 2014

Host publication information

Method and apparatus for mechanical defibration of wood

General information
State: Published
Ministry of Education publication type: H1 Granted patent
Organisations: Former organisation of the author
Authors: Lukander, M., Björkqvist, T., Tuovinen, O.
Publication date: 2014

Publication information
Patent number: Pat. CA 2608207 C
Priority date: 25/03/14
Priority number: 2005/06/03 US 60/686,919 : 686919
Original language: English

Bibliographical note
US 7819149 B2 (julk2011) : CA2608207A1, CN101208472B
Contribution: organisation=ase,FACT1=1
Portfolio EDEND: 2014-10-08
Source: researchoutputwizard
Source-ID: 971
Research output: Scientific - Patent
Modeling of Age-Dependent Failure Tendency from Incomplete Data

This paper addresses modeling of age-dependent failure rates from incomplete data that includes interval-censored failure ages. Two estimators for cumulative failure rates are presented: a simple non-parametric estimator and a maximum-likelihood method based on the gamma distribution and the non-homogeneous Poisson process. The maximum-likelihood fit of familiar parametric models (e.g., the power law) to the available field data from an aircraft component was far from satisfactory, so a special three-parameter model function had to be worked out. The maximum-likelihood estimate obtained is then used for repeated random generation of different data sets akin to the field data. This way the effect of data set size, censoring rate, and randomness on the non-parametric estimate can be analyzed to get practical appraisals.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Mechanical Engineering and Industrial Systems, Research area: Life-cycle Management, Research group: Käyttövarmuuden suunnittelu ja kunnossapito
Authors: Hagmark, P., Laitinen, J.
Number of pages: 11
Pages: 449-459
Publication date: 2014

Host publication information
Title of host publication: Engineering Asset Management 2011 : Proceedings of the Sixth World Congress on Engineering Asset Management
Place of publication: London
Publisher: Springer-Verlag London Limited
Editors: Lee, J., Ni, J., Sarangapani, J., Mathew, J.
ISBN (Print): 978-1-4471-4993-4

Publication series
Name: Lecture Notes in Mechanical Engineering
ISSN (Print): 2195-4356
DOIs:
10.1007/978-1-4471-4993-4_40
Source: Bibtex
Source-ID: urn:d7b891dd2fe21c5e9c101c432e092e18
Research output: Scientific - peer-review » Conference contribution

Simulation Based Methods for Flexible Maintenance Program Development

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Mechanical Engineering and Industrial Systems, Department of Industrial Management
Authors: Aaltonen, J., Koskinen, K. T., Vainio, H., Martinsuo, M.
Number of pages: 5
Pages: 446-450
Publication date: 2014

Host publication information
Title of host publication: EuroMaintenance 2014, Congress proceedings May 5-7, Helsinki, Finland, 22nd European Congress & Expo on Maintenance and Asset Management, 6th World Congress & Global Forum on Maintenance and Asset Management
Publisher: European Federation of National Maintenance Societies
ISBN (Print): 978-952-67981-1-0

Bibliographical note
Contribution: organisation=mei,FACT1=0.9<br/>Contribution: organisation=tta,FACT2=0.1<br/>Portfolio EDEND: 2014-12-30<br/>Publisher name: European Federation of National Maintenance Societies
Source: researchoutputwizard
Source-ID: 38
Research output: Scientific - peer-review » Conference contribution

User Interpretations of Virtual Prototypes: Physical Place Matters
Virtual prototypes reveal more development ideas: comparison between customers’ evaluation of virtual and physical prototypes

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Mechanical Engineering and Industrial Systems
Authors: Tiainen, T., Ellman, A., Kaapu, T.
Number of pages: 11
Pages: 169-180
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Virtual and Physical Prototyping
Volume: 9
Issue number: 3
ISSN (Print): 1745-2759
Ratings:
Scopus rating (2016): SJR 0.661 SNIP 1.526 CiteScore 3.31
Scopus rating (2015): SJR 0.393 SNIP 0.825 CiteScore 1.23
Scopus rating (2014): SJR 0.477 SNIP 0.978 CiteScore 1.66
Scopus rating (2013): SJR 0.37 SNIP 0.697 CiteScore 1.17
Scopus rating (2012): SJR 0.216 SNIP 0.884 CiteScore 0.71
Scopus rating (2011): SJR 0.236 SNIP 0.669 CiteScore 0.77
Scopus rating (2010): SJR 0.31 SNIP 0.906
Scopus rating (2009): SJR 0.356 SNIP 0.753
Scopus rating (2008): SJR 0.396 SNIP 0.628
Scopus rating (2007): SJR 0.468 SNIP 0.734
Water Hydraulics Pushes Into High-Pressure Systems

General information
State: Published
Ministry of Education publication type: D1 Article in a trade journal
Organisations: Department of Mechanical Engineering and Industrial Systems
Authors: Koskinen, K. T., Aaltonen, J.
Number of pages: 4
Pages: 84-89
Publication date: 2014
Peer-reviewed: Unknown

Publication information
Journal: Hydraulics & Pneumatics
Volume: 67
Issue number: 2
Original language: English

Bibliographical note
Contribution: organisation=mei,FACT1=1<br/>Portfolio EDEND: 2014-12-03<br/>Publisher name: Taylor & Francis
Source: researchoutputwizard
Source-ID: 1627
Research output: Scientific › peer-review › Article

Kivihiilen ja puupelletin seospoltto energiantuotannossa

General information
State: Published
Ministry of Education publication type: D1 Article in a trade journal
Organisations: Department of Automation Science and Engineering
Authors: Rantsi, J., Judl, J., Koskela, S., Karvosenoja, N., Korpela, T.
Number of pages: 3
Pages: 4-6
Publication date: 2013
Peer-reviewed: Unknown

Publication information
Journal: Ilmansuojelu
Issue number: 4
Original language: Finnish
Links:

Bibliographical note
Contribution: organisation=ase,FACT1=1<br/>Portfolio EDEND: 2013-12-29<br/>Publisher name: Ilmansuojeluyhdistys ry
Source: researchoutputwizard
Source-ID: 3231
Research output: Professional › Article