Selection Model of Lean Tools at Company Restructuring Process

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Introduction

Lean methodology has become industrial "standarad" in developed societies. This methodology gives every organisation chance for continuous improvement in order to enhance overall business solvency and profitability. There are twenty five lean tools that provides lean transition, but every tool has its purpose and time of implementation. Implementation of basic lean tools during restructuring process can be hard and complex job because sequence order has to be in time and right. Each tool has its time and purpose of implementation. Sequential order of lean tools implementation has to be perfect if we want fast and efficient transition into lean organisation.

Methods

Good lean transition should be based on proactive, fast and simple decision making principals. Restructuring process of every organisation is long term goal that is driven by enthusiasm of all employees. If there is no positive continuous improvement culture, than transition into lean will be far more difficult and complex. First step of lean implementation has to be focused on creating positive lean culture and putting metric into overall business processes and activities. In next steps organisations should implement lean tools that are most suitable for enhancing effectiveness and optimization of all activities. Basic goal of lean organisations is continuous improvement. This statements are result of study made by accumulation of all key datas about lean implementation in Croatian companies.

Preliminary results

Continuous improvement is state of the art principal in lean methodology that provides long term stability on competitive markets. This continuous improvement has to be accompanied by adequate lean tools such as: 5s, Andon, "Bottleneck analysis", "Continious flow", Gemba, Heijunka, Hoshin Kanri, Jidoka, JIT, Kaizen, Kanban, KPI, Muda, OEE, PDCA, Poka-Yoke, "Root cause analysis", SMED, "Six big losses", Smart goals, "Standardized work", "Takt time", TPM, VSM and "Visual factory. This twenty five lean tools provides essential steps for lean transition and creation of positive working culture. This study will show best practices of lean transition and pinpoint crucial lean tools for each step of lean methodology implementation process. As well it will be represented how bad lean transitions are made where adverse working culture will be pinpointed.

Discussion

Basic lean tools provides essential steps for lean transition and creation of positive working culture. This study will show best practices of lean transition and pinpoint crucial lean tools for each step of lean methodology implementation process. As well it will be represented how bad lean transitions are made where adverse working culture will be pinpointed.

Keywords

lean implementation, lean tools, continuous transition

A Meshless Framework for Marine Hydrodynamics

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Introduction

The lifetime of a ship or other floating body is characterised by vigorous interaction of its semi-immersed hull and surrounding fluid. An insight into the fluid-structure interaction is needed within each stage of the design process of a ship, in order to yield a reliable final design that will satisfy safety and other requirements. Inadequate methods are often reached for when calculating the input needed to solve a problem under consideration. Empirical methods based on statistically analysed finite amount of data can be fast, but inaccurate. On the contrary, classical Computational Fluid Dynamics (CFD) methods are accurate, but can be too slow for preliminar stages of the design process. Besides the CFD simulation process, creation of topologically and geometrically correct mesh is time consuming work and often requires user interventions in mesh generation steps. In this work, a truly mesh-free implementation of a CFD solver is introduced, which requires minimum user intervention effort for the simulation setup and yields satisfactory flow simulation.

Methods

A novel meshless approach to approximating spatial derivatives on scattered point arrangements is derived using the Taylor series expansion and renormalised least-squares correction of the first derivatives. The introduced spatial operators have compact support, and are used to represent discrete Navier-Stokes equations in strong formulation. Unsteady single-fluid flow is solved with the velocity-correction projection scheme. The numerical solver is implemented using GPU and CPU parallel algorithms, and the simulation geometry is set up without any requirement for the volumetric mesh generation, since the boundary conditions are imposed in the immersed-boundary manner.

Preliminary results

In order to validate the method for violent and free-surface flow, two validation tests were simulated: water entry of a wedge-shaped section, and water entry of a cylindrical-shaped section. Numerically obtained results of the pressure field and free surface kinematics during the water entry were compared with the experimental data from the literature. A good agreement was achieved, i.e. the pressure field and free surface evolution during the slamming were well-reproduced.

Discussion

In addition to the validation of the method for the evaluation of slamming loads, future work will include the validation for other violent fluid-structure interaction problems with a fragmented free surface, such as the sloshing in tanks, green water on ship deck, etc. Moreover, the straightforward imposition of boundary conditions offers the possibility of domain partitioning by coupling the introduced solver with other solvers.

Acknowledgments

I wish to thank prof. Degiuli and prof. Ban for their constant encouragement and support.

Keywords

CFD, meshless method, Navier-Stokes, marine hydrodynamics

Aerodynamic and Aeroelastic Characteristics of Cable-Supported Bridges with Roadway Wind Barriers

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Introduction

Strong cross-winds that commonly blow on bridges and viaducts are observed to cause dynamic instabilities for passing vehicles, which may overturn or collide with other vehicles. Hence, wind barriers are developed to protect vehicles from cross-wind effects. While these barriers proved to be successful in sheltering vehicles on bridges, their influence on bridge dynamic stability is not well known. Long-span cable-supported bridges are flexible structures susceptible to self-excited oscillations, such as flutter or galloping. Thus, experimental research on influence of wind barriers on aerodynamic and aeroelastic characteristics of three different types of bridge-deck sections is carried out in collaboration with the Institute of Theoretical and Applied Mechanics in Prague (ITAM). Wind-tunnel models of bridge sections are studied for various wind barrier height and porosity using the experimental mechanisms for advanced aeroelastic and aerodynamic tests.

Methods

Experiments are carried out in the climatic boundary-layer wind tunnel of the ITAM. During the experiments on bridge-deck dynamic response, the bridge-deck models are placed on the custom-made mechanism for measurements of complex aeroelastic phenomena. This mechanism is designed to allow for large generalized dynamic deflections with a linear behavior in the heave and pitch motions. Aerodynamic force and moment coefficients are determined using the custom-designed mechanism that allows for measuring aerodynamic lift and drag forces and the pitch moment. Flow characteristics downwind from the bridge-deck models are measured using the CTA (Constant Temperature Anemometer) device. Flow field around the bridge-deck section models is obtained using the PIV (Particle Image Velocimetry) technique.

Preliminary results

The wind barriers prove to considerably influence the aerodynamic loads of bridge-deck sections, that is more exhibited for low-porous and high wind barriers. The wind barriers prove not to induce the galloping instability that is based on the results of the Glauert – Den Hartog criterion. Flutter stability of studied bridge-decks is deteriorated, while the critical flutter wind velocity is reduced when wind barriers are placed on bridge decks. The eigenvalue analysis indicates a significant decrease in the critical flow velocity for flutter when the wind barriers are in place. The influence of the wind barriers is larger for low-porous wind barriers, while the influence of the wind barrier height depends on the shape of the bridge-deck section.

Discussion

The experimental results indicate an exhibited influence of porosity and height of the wind barriers on aerodynamic and aeroelastic characteristics of studied bridge-deck sections. Wind barriers present an additional obstacle to the wind flow and create an increased flow pressure on the leading edge of bridge decks. Bridge decks with wind barriers experience negative aerodynamic damping in torsional motion at certain wind velocity, thus the net damping of the system (consisting of aerodynamic and mechanical damping) is reduced. Therefore, bridges with wind barriers could become dynamically unstable in torsional motion, thus indicating an adverse effect of wind barriers on torsional flutter.

Acknowledgments

The research is supported by the Croatian Science Foundation.

Keywords

Bridge deck, Wind-tunnel experiments, Wind barriers, Galloping, Flutter.

Numerical Simulation of Lubricated Wire Rolling and Drawing

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Introduction

Numerical method for calculating lubricated contact pressures, friction and heat transfer during the metal forming simulations is presented in this study. Parameters of contact between metal forming tool (e.g. roller) and workpiece (e.g. wire, sheet) are important factors in metal forming processes since non-optimal frictional effects can result in lower productivity of process machinery, and in unacceptable shape and surface quality of the products. In order to control friction and heat transfer during the metal forming processes lubricant is applied between the tool and workpiece surfaces in contact.

Methods

Tool and workpiece surfaces, seemingly smooth, have a large number of micro-asperities which play a significant role in frictional contact effects, thus capturing interaction between the asperities, i.e. surface roughness, and lubricant flow inside surface contact is required in order to have a good representation of contact phenomena. During tool and workpiece interaction thickness of the lubricant film changes with the deformation of surface asperities. Depending on thickness of the film, lubricant flows in four characteristic local regimes: hydrodynamic (thick or thin), mixed and boundary regime. In order to calculate lubricant flow between two rough surfaces in contact the modified Reynolds equation is used. The modified Reynolds equation is a 2D partial differential pressure equation discretized using the Finite Area Method over a workpiece contact patch. In order to represent interaction between two rough surfaces in contact an asperity contact model is required. Several contact models were implemented: Greenwood-Williamson, Wadwalkar's and Peng's models. Wadwalkar's model is an elasto-plastic model derived using finite element simulations of spherical asperities. It is an extension to Jackson-Green model enabling large asperity deformations. Peng's model was based on finite element simulations of spherical asperities on deformable substrate. All three implemented contact models can be used in statistical or deterministic rough surface framework. Statistical framework uses measured surface roughness to calculate average surface parameters (asperity radius, asperity density and surface roughness), while deterministic framework calculates contact areas and loads directly from measured roughness data. Previously described contact models are implemented as a solid contact boundary condition for a large strain hyperelastoplastic deformation solver implemented in foam-extend, a community driven fork of OpenFOAM.

Preliminary results

Compressible form of modified Reynolds equation is able to tackle non-physical negative pressures in diverging parts of the contact, while incompressible form of the equation cannot. Wadwalkar's contact model gives better results, compared to FEM simulations of spherical asperity for larger deformations, than Jackson-Green and Peng's model. Wire rolling and drawing simulations will be performed and compared using different contact models.

Discussion

Elasto-plastic contact models should give contact areas and forces which are more physical compared to elastic models (Greenwood-Williamson), in case of metal forming processes. Using compressible form of Reynolds equation enables limiting hydrodynamic pressure in diverging parts of the contact, which are important in wire rolling.

Keywords

Lubricated Contact, Finite Area Method, Reynolds Lubrication Equation, Metal Forming, Fluid-Structure Interaction

Protocol Analysis of Teamwork in Design

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Introduction

Teams are the core building blocks of modern product development companies. Understanding teamwork is essential for both researchers and practitioners responsible for the formation of teams and allocation of project resources. Thus, the number of studies aiming at understanding how designers work in teams is continuously increasing.

To identify regularities in the phenomena of teamwork design, one must observe it at high levels of granularity and abstraction. Presented research is focused on recognising such patterns in team behaviour and correlating them to the team structure and context.

Methods

Of all the varied range of methods for fine-grain investigation of design activity, protocol analysis has been regarded as the most suitable to reveal the cognitive activity of designers. Hence, the presented research is designed in the form of a protocol study.

Methodologically the study follows five steps: identification of available data (video recordings), development of a coding scheme, segmentation and coding of data, analysis of captured protocols, and discussion of the results. Two teams performing idea-generation in conceptual design phase were recorded. Team 1 consisted of three mechanical engineerng students in laboratory environment, and Team 2 consisted of three experienced designers in real organizational environment. The coding scheme was developed to reflect elementary design operations of analysis, synthesis and evaluation (ASE) and the alternation of the problem-solution related discussion. The video recordings were segmented and coded with design operations.

Preliminary results

The distribution of segmented codes shows that Team 1 spent more time formulating and analysing problems while Team 2 spent more time generating, analysing and evaluating solutions. Both teams spent most of the discussion to synthesise and analyse, with evaluation being rarely performed. Additionally, transitions between the coded segments show that for the Team 1 78 % and Team 2 60 % of transitions followed three directions: synthesis to synthesis, synthesis to analysis and analysis to synthesis. In the problem and solution space the most dominant transitions for Team 1 were the cycles of problem formulation related discussion, while Team 2 had cycles of solution generation and analysis.

Discussion

Protocol analysis of both teams revealed patterns of analysis, synthesis and evaluation in the problem and solution space. Proportions of design operation correspond to what has been reported for the brainstorming-driven idea-generation sessions in other studies. Both teams show dominant alternation of synthesis and analysis which is typical for idea-generation sessions. Such cycles are repeated until the current aspect of design entity evolves to a satisfactory level or the topic changes to another design entity aspect. Furthermore, as brainstorming method is perceived as a tool of creative design, the alternation of problem and solution related discussion supports the co-evolutionary models of designing.

Acknowledgments

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Keywords

design process, conceptual design, protocol analysis, teamwork, human behaviour in design

High Temperature Latent Heat Storage Modelling and Validation

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Introduction

Increasing power systems flexibility to allow greater penetration of renewable sources is one of energy transition priorities. Most significant flexibility improvements can be achieved through installation of large scale energy storages. While development of direct electric energy storages in form of large batteries advances rapidly, equal potential for some applications is found in large thermal storages, especially in case of concentrated solar power (CSP) plants. After long period of investments stagnation, huge increase in CSP installations can be observed, especially in Morocco, South Africa, China, United Arab Emirates etc. This renewed popularity is, in large part, result of very effective utilization of large energy storages in such plants. Although sensible heat storages are still dominant storage technology in CSP industry, latent storage has much greater potential and its implementation is only matter of successful mitigation of its disadvantages. Most popular phase change materials (PCM) used in high temperature latent heat storages (HTLHS) are different salts, popularly called "solar salts".

Methods

To improve performances of HTLHS, namely heat rate during charging and discharging, it is necessary to improve heat conductivity of PCM. Scientific efforts to improve heat conductivity of high temperature PCM can be divided in two directions: improvement of physical properties by combination with different high conductivity materials and geometry modifications for higher heat transfer rates. No matter the approach, exact simulations of PCM behavior are necessary for further investigations in high temperature PCM and development of new storage designs.

In this work 2D and 3D numerical models based on enthalpy-porosity method introduced by Voller are developed. Models are further extended to incorporate conjugate heat transfer (CHT) and enable simulations of heat transfer through heat exchanger material and storage medium (PCM).

PCM models are usually validated by shape and position of the phase-change front, however such data for most solar salts, including most popular, $NaNO_3$ does not exist. Therefore, extensive experimental measurements for acquisition of front shape and position are planned.

Preliminary results

Presented mathematical model is implemented in OpenFOAM, an open source CFD tool. First results provide very good agreement with existing experiments, but lack of experimental data limits validation options. Simulations of different shell and tube configurations with multiple tubes and different positioning shows that even small changes in geometry can lead to significantly different heat transfer rates over time.

Discussion

Results can be further improved with implementation of temperature dependent material properties, unfortunately there are large discrepancies between results from different researchers, especially in case of thermal conductivity of solid NaNO3. New experimental measurements should provide sufficient data for model validation.

Keywords

High-temperature thermal energy storage, concentrated solar power, phase change materials, mathematical modelling, heat-exchange enhancement

Numerical-Experimental Suitability Analysis of Using Agricultural Biomass in Hot Water Boilers

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Introduction

Increasingly stringent environmental requirements of the EU require the development of new design solutions of the combustion system for residential hot water boilers fueled by some solid biomass. Emissions are becoming even greater problem if instead of wooden biomass various residues from agricultural production are used, which are becoming more desirable fuel due to their low cost. This work, by means numerical and experimental methods, aims to explore applicability of the agricultural biomass for combustion in the residential burning appliances and mechanisms of pollutants reduction. The goal is to achieve guidelines for design of commercial hot water boiler prototype.

Methods

Information relevant to the combustion properties of agricultural biomass have to be researched via literature survey and laboratory testing. Based on that the appropriate residue will be selected. Selected biomass will serve as a fuel based on which guidelines for the construction of prototype of commercial hot water boiler will be developed. In order to meet all EU emission requirements key places for pollutant generation need to be identified. To do that, CFD model of the hot water boiler will be made. Following this, new design solutions for combustion system that avoids previously detected places, will be proposed and evaluated.

Preliminary results

Low ash melting temperatures of most types of agricultural residues is identified as a crucial problem in achieving an efficient combustion. Rotary combustion chamber burners proved to be particularly suitable for burning of fuels with low ash melting temperatures without the need to manually remove agglomerate or slag. Other essential problems are high content of the volatile mater. This means that combustion is expected to be rapid and difficult to control resulting in high amount of pollutants. For that reason, combustion chamber needs to be constructed in a manner that ensures complete combustion of the volatiles in order to ensure low emissions. This can be achieved by installing various obstacles to flue gas steam flow and insulating the whole combustion chamber. In theory, this solution can also ensure destruction of dioxins temperature in combustion zone. Other mechanisms of dioxin formation can be potentially controlled by porous ceramic media installed behind the combustion zone.

Discussion

In literature, combustion properties of agricultural biomass are only explored in terms of applicability to burn in existing burning appliances. Ash melting temperatures are determined and increase in pollutant emission compared to wooden biomass is quantified. No data regarding dioxin emissions was found, although in Commission regulation (EU) 2015/1189 clearly states that appliances that use non-woody biomass may have significant amount. Also, there is no data that investigates the potential of certain modification to the combustion system to reduce the pollutant emission. New proposed modification should ensure cost-effective low emissions combustion system (and low dioxin emission) that meets EU requirements set for 2020.

Keywords

low ash melting temperatures, dioxin emissions, agricultural biomass

Two-Way Coupled Eulerian-Eulerian Simulations of Drifting Snow with Viscous Treatment of the Snow Phase

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Introduction

The objective of this research is to present a two-way coupled two-fluid model, which models the snow phase as an Eulerian continuum, similarly to the air phase. Besides properly accounting for two-way coupling in the saltation layer, this model is free from all equilibrium assumptions used in other one-way coupled approaches based on the transport of snow density method or the volume of fluid method.

Methods

The new model is implemented in the Finite Volume C++ CFD toolkit OpenFOAM. A purposely developed snow phase viscosity model for high rates of strain is used.

Preliminary results

This new formulation is validated against detailed experimental measurements of snow flux and airflow velocity profiles, at several measurement stations along the working section of a controlled wind tunnel drifting snow experiment . When polydispersity of the snow particle phase is taken into account, good agreement is found between the simulation results of snow flux and airflow velocity profiles, and the experimental measurements. The standard k-epsilon model used was found to overestimate the turbulent kinetic energy compared to experimental measurements. However, the experimental measurements are believed to somewhat underpredict the actual experiment turbulent kinetic energy levels, as stated by the experiment authors.

Discussion

The present novel approach is found to accurately predict snow flux and airflow velocity profiles. It is desirable to replace the k-epsilon model with the more robust and accurate k-omega SST. Moreover, polydispersity is presently simulated by combining the results of several monodisperse simulations. It is desirable to implement polydispersity directly in the formulation instead.

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All simulations were carried out on the Arctur-1 supercomputer, courtesy of ARCTUR d.o.o.

Keywords

Drifting Snow, Eulerian, Multiphase, Viscosity, Gamma Distribution

Model of Integrated System for Monitoring and Increasing Availability and Efficiency of Production Equipment

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Introduction

The purpose of this paper was to introduce a model for monitoring of production time and downtimes with increasing the availability and efficiency of production equipment. Methods and tools for improving efficiency and usability of production equipment are proposed. The description of concept Internet of Things (IoT), total productive maintenance, overall equipment efficiency, and total effective equipment productivity is given, as well as guidelines on collecting the required data to achieve these initiatives. Calculations of OEE, as one of the key performance indicators of equipment effectiveness was also given and explained. Solutions and explanations for faster and more accurate collection of data were proposed. Categories of production losses were listed and explained describing how they affect the actions needed to be done in order to reduce production stoppages. Also, a model was proposed for reducing the performance category of losses in order to increase overall equipment efficiency.

Methods

One of main focuses in the paper was calculating the Overall Equipment efficiency number. Overall equipment efficiency (OEE) looks at the potential production time as a maximum, without calculating time that has been unscheduled. It identifies the percentage of manufacturing time that is truly productive. In order to explain OEE the data collection and OEE analysis was conducted in the company Elektro-kontakt d.d. within a period of 24 hours split between 2 shifts. The measurement of downtimes occurred on the stamping machine for producing metal pieces from raw metal band. It is an example of real OEE analysis. In addition, in order to reduce performance losses, which affects OEE percentage, the integrated wireless paging model is proposed.

Preliminary results

The proposed integrated pager system is in direct relationship with production equipment downtimes and efficiency measured by the OEE analysis. By implementing such a solution, better understanding and overview of production equipment is achieved. Workers responsible for the group of equipment have better understanding of the production equipment state in real time. Analysis can be done retroactively as well since all the stoppages are measured in the database and stored for further examination and data extraction. All of these systems proposed represent a move towards better business production model, and overall efficient way for keeping material input, product output and worker awareness at optimum levels.

Discussion

This concept, in my opinion, stems from the ability to realize problems and concerns early and rectify them 'on-the-fly' rather than using ad hoc methods or time-consuming analyses after a minor or major stoppage of work. Companies that can make in-course corrections are more effective, and needless to say – more profitable, than companies who wait for catastrophic failures to occur before making changes to their management or manufacturing model. The threat of not meeting the required deadlines or fulfilling the required quota can be damaging. And this is exacerbated during times when manpower is at a minimum during vacation periods, holidays, illness, medical leave or what not. Just one or all of these conditions could have negative ramifications on the company's name or reputation, to say nothing of the morale of the workers involved. I believe that all of this can be prevented.

Keywords

overall equipment efficiency, internet of things, production losses

Numerical and Experimental Modeling of Anterior Cruciate Ligament Biomechanical Implant Support of Knee Joint

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Introduction

Since human knee is used in all movements, damage of anterior cruciate ligament is very common. In recent years, the number of people who are exposed to anterior cruciate ligament injuries (ACL) is increasing. The ACL is one of four major knee ligaments which connects the back of the thigh bone with the front of the tibia and provides knee joint stability as well as limits rotation during movement. If there is a major damage of an ACL, in most cases, surgery is the only procedure to be undertaken for the patient's effective return to daily activities. Rehabilitation of an anterior cruciate ligament is very significant for regain the function of this body part in proper condition. Today's technology leads to the development of a range of solutions that enable better way of rehabilitation process during and after surgical procedure or after ACL injury.

Methods

Within this doctoral thesis a new biomechanical support for the ACL reconstruction will be developed. The design solution for the implant will be selected based on computer simulation using the finite element method with 3D models of the knee, created from the reconstruction of the geometry obtained from CT and MRI data. The design solution will also be based on the in vitro experimental testing of a bone-implant set with a displacement measurement using the digital image correlation.

Preliminary results

From CT and MRI data 3D model of a knee joint was created in the Mimics Materialise software package which is an image processing software for 3D modelling. The finite element method was used for a numerical simulation related to the load causing damage to the ligaments. Numerical simulation was provided using the commercially available finite element program ABAQUS. The finite element method is a numerical method for solving problems of engineering and mathematical physics based on cutting certain structures into several elements that are parts of that structure and then re-linking these elements in nodes as if the nodes are made of adhesives that hold the two elements together. The result of this process is the set of simultaneous algebraic equations. Numerical simulation is significant for analysis in medicine to understand for what reason something is happening in body under the influence of forces and stresses and is also a basis for experimental testing.

Discussion

The knowledge and analysis of mechanical and biological properties have important role in better understanding of physical appearance of anterior cruciate ligament and allows better understanding and implementation of the operational process and opens an opportunity for improvement and innovation. Since 3D modelling offers engineers a range of tools that can alter the characteristics of the product to the point where they are satisfied with solutions, followed by prototype or experiment, it can be concluded that such an approach is very educational, as well as desirable in medicine, which further development is associated with further development of technology. Based on previous testing and researches, there is plenty of room for improvement of artificial ACL ligament and replacement of classic surgery with minimally invasive with fast postoperative recovery of a knee. New biomechanical support as a product of this doctoral thesis will not behave destructively to the surrounding tissue and will have good mechanical properties.

Keywords

Biomechanics, medicine, numerical simulation, support, knee, ACL, stabilization

Influence Parameters in Computed Tomography Dimensional Measurement

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Introduction

Period of use of computed tomography (CT) for purposes of dimensional measurements started about 10 years ago and it is still on its beginning. It is a method that has a lot of advantages and can be used for many purposes, e.g. for material inspection, dimensional inspection, in quality control etc. at the same time and with only one scanning of the product. In order to ensure metrological traceability of the method, measurement uncertainty needs to be assessed. Since the CT method has a lot of influencing factors, assessment of measurement uncertainty is a very complicated process. In order to evaluate measurement uncertainty of results according to GUM (Guide to the expression of the uncertainty in measurement), influences of all factors need to be identified and each individual influence on results needs to be specified. Since the CT dimensional measurement is achieved through several stages, influence parameters can be divided according to that criterion into: parameters influencing scanning process, parameters influencing reconstruction process and parameters influencing measurement process. In this research combination of different parameters on measurement results will be investigated and analyzed.

Methods

Method used for the investigation of the chosen parameters was fractional design of experiment (DOE). The method is used to find cause-and-effect relationships and to manage process inputs in order to optimize the output. In total, observed were seven different input parameters, four of them from first stage of CT dimensional measurement process – CT scanning process – and those were: geometrical magnification, source voltage and current and number of projections; two parameters from reconstruction process: beam hardening filter and data size and one parameter from measurement process: object determination by choice of threshold value. Observed outputs were dimensional and geometrical characteristics of inspected polymer cylinder.

Preliminary results

While conducting fractional DOE on measured dimensional and geometrical features of observed object, a correlation between chosen input parameters and output variables was determined. Different combinations of parameters influence results of dimensional and geometrical measurands differently. The parameters that have proved to be significant, both in dimensional and geometrical measurements, are geometrical magnification, threshold value and beam hardening filter.

Discussion

Determination and mathematical expression of dependencies between selected inputs and measurement results (outputs) was obtained by use of design of experiment. However, because of the lack of metrological traceability, obtained results as well as mathematical models need to be further investigated. The next steps in analysis of input parameters, with aim of more accurate determination of influence parameters, should consider comparison of obtained results with reference measurement values achieved with use of traceable measurement method such as tactile measurement method.

Keywords

computed tomography, dimensional measurements, influence parameters, design of experiment

Model of Optimal Maintenance Strategy in Early Stage of Equipment Purchasing Phase

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Introduction

"Model of Optimal Maintenance Strategy in Early Stage of Equipment Purchasing Phase" is an specific tool which gives possibility to select an optimal equipment supplier during Purchasing phase considering Maintenance strategy for production equipment. Basically, model is based on RCM – Reliability centered maintenance. As support for optimal maintenance strategy development, FMECA – Failure mode, effects and criticality analysis will be used. Model will be able, based on the estimated production losses due to the downtime, to define optimal maintenance strategy in order to minimize total costs. Spare parts optimization will be calculated taking into consideration spare part cost, delivery time and downtime costs. Main idea is to collect, calculate or simulate Maintenance costs for both, Preventive and Corrective maintenance activities and after data pass through it, Model will provide optimal Maintenance strategy for particular equipment. It will be possible to calculate strait influence to the total Production costs. In early stage of purchasing equipment, before choosing a specific supplier, it could be possible to perform a cost-scaling analysis in advance, and determine the supplier whose equipment generates lowest maintenance and consequently lowest production cost.

Usually when developing maintenance strategy, only preventive maintenance activities are taking into consideration and corrective maintenance activities are not. Model will fulfil this gap, it will inspect potential failures, analyse failure consequences due to the costs and connect them to economical part of production – production costs.

Model is based on RCM (Reliability Centred Maintenance). RCM is methodology based on Risk assessment through the application of FMECA (Failure mode, effects and criticality analysis) which is used to analyse potential failures. Different authors mostly use RCM to develop maintenance strategy during operational phase usually not taking production losses into consideration.

Methods

An adapted Failure mode, effects and criticality analysis (FMECA) is used to analyse potential failures and downtime costs.

Preliminary results

By reviewing the literature, it is concluded that is possible to develop model for maintenance strategy in early stage of machine procurement phase executing Failure mode, effects and criticality analysis (FMECA). There is a similar method known as RAM – Reliability, Availability and Maintainability modeling which can be applied during equipment construction phase. When RAM is applied, result is equipment designed to meet high production performances.

Discussion

Combining of FMECA and economical aspect of failure, by means of consequent downtime costs, will provide useful data. Those data can be optimized in the way to provide model (selection tool) to select the best equipment supplier due to the compliance to the optimal maintenance strategy. "Model of Optimal Maintenance Strategy in Early Stage of Equipment Purchasing Phase" will also take into consideration some aspects of RAM method.

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Keywords

Maintenance, Maintenance Strategy, Reliability Cen-tered Maintenance (RCM), Failure Mode, Effects and Criticality Analysis" (FMECA)

Distributed Control of Elastically Interconnected Seesaw-Cart Systems

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Introduction

Most of the research activities in the field of distributed control have focused on theoretical aspects, and most of the applications are demonstrated by means of simulations due to lack of experimental research platforms suitable for validation of control algorithms and educational purposes. In order to set up a benchmark example, we present a specifically designed network of electro-mechanical systems as a suitable platform for education, testing and verification of real-life implementation of distributed control solutions. Additionally, the synthesis procedure of a set of distributed controllers has been demonstrated.

Methods

The proposed network consists of physically interconnected seesaw-chart systems. Each subsystem is physically interconnected with its neighbors with elastic link, thereby forming a complex non-linear interconnection of electro-mechanical systems. A structured control oriented model of system's dynamics, which is suitable for distributed control synthesis, is derived by using Euler-Lagrange formalism. Additionally, linear time invariant (LTI) model for relatively small deviations around desired stable equilibrium points is obtained. For the proposed system, we design a set of distributed H_infinity optimal controllers such that interconnection signals between controller subsystems reflect physical interconnections between seesaws and that the closed-loop is stable while achieving the desired performance.

Preliminary results

Performance of the distributed controller is compared to a centralized H_infinity controller which internally stabilizes the system and achieves desired performance of the closed-loop. The response of the closed-loop system with distributed controllers in the presence of external disturbances is simulated and compared with the closed-loop response when centralized controller is used. Similar behavior can be observed in time and frequency responses. As expected, distributed controller achieves somewhat lower performance level, but it is interesting to observe that the difference is relatively low.

Discussion

Our primary aim has been to present a specifically designed network of electro-mechanical systems as a suitable research and education platform for investigating techniques in distributed control. Results of a case study in distributed control are presented, together with comparison with achievable centralized control behavior.

Acknowledgments

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Keywords

Distributed control

Experimental and Theoretical Research of Geothermal Heat Pump

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Introduction

Ground coupled heat pumps utilize the low enthalpy geothermal energy for the purpose of heating or cooling. Commonly, vertical borehole heat exchangers are coupled to the ground used as a heat source/sink. The proper dimensioning of the system requires knowledge of the thermophysical properties of the ground while both, ground properties and borehole heat exchanger design, affect heat transfer rate and the long-term performance of system. Vertically distributed properties of heterogeneous underground cause varying heat exchange rate along the borehole heat exchanger during system operation. Aim of this research is development of borehole heat exchanger model in stratified ground coupled with the heat pump. Hence, characterization of influence of vertical variability of ground thermal properties on efficiency of geothermal heat pump system and resulting temperature field around borehole is possible.

Methods

Research includes experimental investigation and simulation of system for analysis of influential parameters. The heat exchanger is coupled to the propane heat pump used for conditioning of the two computer classrooms. Distributed temperature measurements using fiber optic cables placed in borehole heat exchanger are used for obtaining temperature profiles in the ground during system operation. Heat pump system is equipped with temperature, pressure and heat sensors. Also, electric consumption of main components is monitored. Mentioned set up enables calculation of real seasonal performance factor (SPF) and development of the model of heat pump and borehole heat exchanger in stratified underground.

Preliminary results

Determination of composition and thermal properties of the soil samples is made during drilling procedure. Prior to the thermal response test, undisturbed ground temperature profile is measured and geothermal gradient calculated. Distribution of thermal conductivity and borehole resistance is obtained by application of distributed temperature measurements. Temperature profiles during TRT are used for comparison of common methods for averaging the fluid temperature during data processing. Following the initial measurements of the systems, improvement of heat pump cycle have been performed and operating curves of a compressor have been determined. Seasonal efficiency of the heat pump in cooling and heating season have been compared based on first year of system operation.

Discussion

Vertical variability of ground thermal properties have been investigated in literature in terms of its influence on procedure for determination of effective thermal properties. Based on the results obtained by distributed TRT, modelling of stratified underground is possible. When coupled to the heat pump model, based on the experimental monitoring of the system in use, influence of the vertical variability of ground thermal properties on resulting efficiency of geothermal heat pump system can be observed. Model will be used to analyze effect of different parameters of borehole heat exchanger design and ground properties on the resulting temperature field inside and outside of the borehole, the heat exchanged with the ground and seasonal efficiency of the system.

Acknowledgments

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Keywords

Geothermal heat pump, ground thermal properties, borehole heat exchanger

Effect of Zinc Oxide Nanoparticles on Structure and Properties of Poly(Vinyl-Alcohol)/Chitosan Blend

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Introduction

Nanocomposites encompass a large variety of materials made of distinctly dissimilar components and mixed on a nanometer scale. Their properties depend on the properties of their constituents, their morphology and interfacial characteristics. This research focuses on relating structure and mechanical properties of nanocomposites with antimicrobial activity. Organic nanoparticles of chitosan (CS) and inorganic nanoparticles of ZnO, both with cumulative antimicrobial activity are added in a non-toxic poly(vinyl-alcohol) (PVA) matrix. PVA is biocompatible and biodegradable, water-soluble synthetic polymer with good mechanical properties and excellent chemical resistance which is widely used in biomedical field. Chitosan is the second most abundant natural polymer. It is non-toxic, biocompatible and biodegradable natural polymer with antimicrobial activity mostly used as a functional biopolymer in food industry and biomedical applications. Since CS contains hydroxyl and amine groups, it is miscible with flexible PVA due to the formation of hydrogen bonds. CS in the mixture reduces the crystallinity of PVA inducing degradation of mechanical properties. However, the properties of the polymer matrix can be improved by chemical crosslinking with glutaraldehyde (GA) and by adding ZnO nanoparticles. At the interface of polymer blends (PVA/CS) and ZnO it is expected that interphase with reduced molecular mobility will be formed. This will improve the mechanical and barrier properties of the mixture and reduce the negative effect of CS on PVA properties.

Methods

Polymer solutions with ZnO NPs are casted and then dried in oven in order to prepare flexible films. A solution of low molecular CS in dilute acetic acid is mixed with fully hydrolyzed PVA dissolved in water. The blend is cross-linked by means of the glutaraldehyde. ZnO NPs are synthesized by precipitation method from zinc sulphate. The molecular dynamics of these one-, two- and three component system and its effect on the mechanical properties are studied by means of dynamic mechanical analysis (DMA).

Preliminary results

Preliminary results showed that in the tan δ vs temperature graph the a relaxation peak that is attributed to the glass-rubber transition increases both when CS is added to the PVA and when PVA is chemically crosslinked with GA indicating an increase in free volume amount. However, a slight drop and shift to higher temperatures is observed when GA is added into the PVA/CS mixture. CS reduces the crystallinity degree leading to the higher amount of the amorphous phase contributing to a relaxation, but the mobility of the amorphous phase can be restricted with crosslinking.

Discussion

DMA is an excellent tool for mechanical spectroscopy. From relaxation processes visible in mechanical spectrum, information about structure and mechanical properties depending on temperature can be obtained. It is necessary to perform additional DMA tests, in combination with FTIR spectroscopy, to obtain detailed insight into the nanoparticles influence on the structure and properties of the polymer matrix. An analysis of the barrier properties will also be performed by means of time lag method, in order to show nanoparticles influence on the permeation of small gas molecules through the obtained composite films.

Keywords

Polymer nanocomposites, ZnO nanoparticles, dynamic mechanical analysis

Design of Hydrofoils for Small-Scaled Hydrokinetic Turbines Using Genetic Algorithm

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Introduction

The hydrokinetic turbines represent an emerging technology for the harnessing of a mostly untapped renewable energy contained in river streams, waves and tidal currents. This technology can generate electricity from the flowing water without the use of large dams and reservoirs with a less harmful impact on the environment, which makes it applicable to sites where conventional hydropower technology cannot provide suitable technical, economic and environmentally acceptable solutions. However, the main barrier to their commercialization is relatively low efficiency. The majority of literature focuses on the design improvements of large-scaled hydrokinetic turbines for tidal applications which may be the reason for delayed widespread utilization of kinetic energy contained in rivers and canals.

Methods

The objective of this study is to provide an efficient approach to the design of small-scaled hydrokinetic turbines with improved hydrodynamic performance by using specially designed hydrofoils. In order to design hydrofoil, characterized by high lift to drag ratio and delayed cavitation inception in the considered operating range of the turbine, the genetic algorithm optimization technique is incorporated in the rotor design procedure. Instead of using multi-objective optimization techniques, that can be quite complex, in this work single objective approximation has been used to meet both criteria by assigning weighting factors. High computational efficiency of the proposed approach is achieved by using B-spline representation of hydrofoil that reduces the number of required control variables in the optimization process, while at the same time keeps wide variety of different hydrofoil shapes that can be obtained.

Preliminary results

The optimized hydrofoil was compared with other commonly used profiles for hydrokinetic turbines. The new hydrofoil has the highest lift coefficient, as well as low drag coefficient. In addition, minimum coefficient of pressure is high enough which means that cavitation will not occur. Preliminary results, obtained using Blade Element Momentum theory model, show that new hydrofoil can enhance hydraulic efficiency at the rated water speed of 1 m/s.

Discussion

To validate the results obtained using BEM theory based model, three-dimensional computational fluid dynamics analysis of the turbine will be performed in the future work. The next step will also include an investigation of the impact of enchasing turbine blades in different shroud geometries. Improved hydraulic efficiency, relative to the efficiency of bare rotor design, is expected as a result of increased flow velocity at the rotor plane.

Keywords

Genetic algorithm, Design improvements, Hydroki-netic turbines, Hydrofoil optimization, Blade Ele-ment Momentum theory

Preliminary Research on Robust System of Autonomous Agents

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Introduction

In a variety of applications the presence of humans is to be avoided and their work replaced by the work of robust systems of autonomous agents. Such activities include dangerous, dull and dirty tasks for humans. Examples of the use of autonomous agents are transport of loads and people between multiple locations, non-destructive and irreversible searches of the area, monitoring of natural phenomena, underwater research, traffic control, implementation of communication networks in adverse environments and others. The most commonly used autonomous agents for such tasks are stationary or mobile robots, underwater vehicles, aircraft, agents in a virtual environment, and other types of agents that perform a smaller number of simpler operations, including collecting and processing directly or indirectly measured data on the environment.

During the performance of tasks agents constantly measure their internal and environmental parameters. The capabilities to assess system performance based on the known or estimated agent parameters could enable coordination between the necessary and available use of the autonomous agents system in the early planning stages.

Preliminary research is done on the system of load transport by two rotocopter unmanned aerial vehicles (UAVs) in a static atmosphere. The goal of research is to use a cooperatively flying group of UAVs, each of which is non capable to carry the load solitary.

Methods

In the first part of the research data was collected on the existing systems of autonomous agents and computed statistical distribution of the parameters. According to the statistical parameters a theoretical framework of model of a system of autonomous agents was developed and analytically solved.

Preliminary results

The model of a system of unmanned aerial vehicles consists of two rotocopters transporting load in static atmosphere. Rotocopters are represented with their generic aerodynamic characteristic. Flight is conducted in atmosphere with constant density and other thermodynamic properties. Configuration of the rotocopters and the load is fixed during load transport and relative distance between rotocopters is unique. Load is connected to the rotocopters with two identical non-extensible ropes and negligible masses, one rope for each rotocopter. All four ends of the ropes are taken to be in the centres of gravities of the corresponding bodies.

The solution of the theoretical model for stationary flights of two rotocopters carrying one load in a static atmosphere is fully solved. The corresponding power and energy consumption and other characteristics of that form of the rotocopters was determined, validated and compared with same characteristics of a single rotocopter carrying the same load.

Discussion

The use of a group of UAVs is better in cases when a loss of one or a several UAVs has non negligible probability, as well as in cases in which the flight path passes through the non characterised or rapidly changing environment, or cases in which the flight path cannot be tracked. This approach, in principle, could utilise simpler, thus cheaper UAVs.

Keywords

unmanned aerial vehicles, load carrying, measure-ment, numerical simulations, system of autono-mous agents

A Model of Innovation Evolution in the Development of Technical Systems

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Introduction

The development of new technologies is one of the main objectives of today's scientific and industrial development. The companies that are operating in a competitive global environment are trying to improve their development processes, develop new products or to offer new services to the market based on improved or new technologies in order to attain a dominant and advantageous position in the market. Accordingly, current research trends focused on emerging technologies, and their development based on technical inventions, represent an increasingly important part of research and systematic efforts in both academia and the industry. Determining the direction of technology development is an approach used in the industry to support strategic and long-term planning of the development of products, processes and services.

Methods

Data mining is used to extract patent data from online databases. A series of data analysis methods, such as graph theory, statistics, semantic analysis and complex data visualization are employed on the retrieved data set.

Preliminary results

One conference paper has been published while another has been accepted. These papers explored the evolution of an example technology using graph theory, semantic analysis and data visualization as well as other statistical metrices.

Discussion

The purpose of gaining a precise understanding and description of the dynamic relationship between technical invention evolution, their implementation in physical systems and services and market development for such innovation, is to determine (predict) the future direction of technology development. The purpose of this research is to provide insight into the evolution of technology and attempt to predict its future evolution. Patent analysis is used as the basis of developed models.

Acknowledgments

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Keywords

innovation management, technology forecasting, patent analysis, data analysis

Modeling of Product Development Process Using Petri Nets

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Introduction

New product development process is mostly a geographically dislocated teamwork. In such conditions, coordination and communication between stakeholders become complex problems of primary interest. Even with the support of today's digital systems, one question remains silent: are we sure that the systems for information management are using updated product information in its operation?

Methods

Several authors argue that PLM systems in the industry do not sufficiently address this question. They do not adequately support communication and exchange of information and knowledge between team members, especially in the case of low granularity of engineering information such as design parameters. The aim of this study is to analyze the possibilities for improvements of design parameter management in teamwork development of complex products. In order to achieve defined objective of this study, a preliminary case study was made. Colored Petri Nets were chosen as a method for process modeling. The question discussed here is about limitations of Petri Nets and how will those limitations affect everyday usage.

Preliminary results

After the analysis of complex assembly design process, suitability of Coloured Petri nets for modeling dynamics of design parameters was demonstrated. The main focus was on coupled parameters, what means that more than one engineer have an interest in that parameter and engineers have to collaborate and make an agreement about parameter value.

Based on the presented preliminary case study we got the answer to the question. It can be concluded that "classical" (ordinary) Petri nets showed some significant drawbacks in modeling the design parameter dynamics because for any serious industrial application the generated nets would be too large. Coloured Petri nets, due to their concepts of data, time and hierarchy proved to be a much better method for modeling, simulation and visualization of design parameter dynamics.

Discussion

The models in Coloured Petri nets are sometimes too abstract and difficult to read and understand. This fact should not be neglected if we want to develop a method and tool which will not burden designers additionally. Based on results of the presented case study we believe that it is worthwhile to continue with the approach where repetitive patterns of communication situations and parts of the design process will be extracted by analyzing information processing and information flows in complex product development environment.

Keywords

product development, dynamic process, Colored Petri Nets

Energy Analysis of Heat Exchanger in a Heat Exchanger Network

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Introduction

For many years now, heat exchanger optimization has been a field of research for a lot of scientists. Aims of optimization are different, having in mind heat exchanger networks with different temperatures of certain streams. In this work mathematical model in dimensionless form has been developed, describing operation of one heat exchanger in a heat exchanger network, with given overall area, based on the maximum heat flow rate criterion. Under the presumption that heat exchanger is part of the heat exchanger network, solution for the given task is resting in a possibility to connect additional fluid stream with certain temperature on a certain point of observed heat exchanger area. The connection point of additional fluid stream determines the exchanging areas of both heat exchangers and it needs to allow the maximum exchanged heat flow rate. In other words, within this mathematical model a criterion for existing of the maximum heat flow rate, as a local extremum, needs to be obtained. This needed heat flow rate amounts higher than heat flow rate acquired by either of streams.

Methods

This is a theoretical research and the algorithm is given in a dimensionless form. Relevant dimensionless properties of the physical (dimensional) parameters are formed, which appear in a formed algorithm and at the same time represent the parameters describing operating states of the counterflow heat exchanger. Those parameters are: overall disposable heat exchanger area, area of both heat exchangers, their mass flow rates, specific heat capacities of the streams, inlet temperatures as well as overall heat transfer coefficients. Those parameters are used to form the dimensionless model, which is used for analytical obtaining of the local extremum (maximum heat flow rate) existence or non-existence criterion. Thus obtained dimensionless criterion is therefore universal for it covers all of the operating regimes of such defined counterflow heat exchanger.

Preliminary results

General criterion is derived, which needs to be fulfilled in order for maximum heat flow rate of the counterflow heat exchanger in a heat exchanger network to be achieved. This criterion is valid for whole interval of ratio of heat capacities. Also, criteria for which maximum heat flow rate will not be achieved are obtained. Results of the research are presented by the adequate diagrams and interpreted, with emphasis on cases which fulfil and those which do not fulfil the given condition for achieving the maximum heat flow rate.

Discussion

Understanding the needed criterion has a significant importance in design of new heat exchangers as well as in design modifictions of existing heat exchangers in actual facilities. It has been shown, when interventions in existing heat exchangers with given overall areas are undertaken, that, to achieve maximum heat flow rate, there is a certain connection point on heat exchanger area for the additional stream. Of course, this concerns design of the new heat exchangers as well.

Keywords

Heat exchanger network, energy analysis, dimensionless analysis, maximum heat flow rate

Numerical Simulation of Blood Flow

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Introduction

Research and development of heart pumps is focused on achieving greater hemocompatibility. Besides stagnation zones and recirculation zones, wall shear stress is parameter that is used to predict pump hemocompatibility i.e., amount of mechanical damage caused by pump on blood cells. Blood is biological non-Newtonian fluid with shear-thinning behavior (viscosity decreases under shear strain) affecting wall shear stress values. In order to calculate wall shear stress and blood flow in heart pump, blood as non-Newtonian fluid has to be numerically modeled.

Methods

Hemodynamic simulation using OpenFOAM was performed on two-dimensional backward-facing step geometry under laminar incompressible flow conditions. The geometry of two-dimensional backward-facing step is modeled in Salome software package and exported in form of a STL file describing its boundaries (inlet, outlet and wall). After defining computational domain, finite volume mesh of model is created. Idealistic volume flow rate with parabolic velocity profile, based on data presented in Gijsen et al., is defined on inlet boundary. Blood is modeled as incompressible (ϱ = 1060 kg/m3) non-Newtonian shear-thinning fluid described by Carreau–Yasuda model. Flow downstream of a backward-facing step contains a reattachment point and flow reversal. Hemodynamic simulations are used to obtain velocity, wall shear stress distribution and location of the reattachment point for different volume flow rates on inlet.

Preliminary results

Numerical and experimental results of wall shear stresses and location of the reattachment point for different volume flow rates are shown. Numerical investigation of the wall shear stress distribution downstream of a backward-facing step is carried out and compared with experimental results. In general, the non-Newtonian Carreau–Yasuda model provides an accurate prediction of the measured wall shear stress distribution and the location of the reattachment point is predicted accurately for all the flow rates.

Discussion

The aim of this study was to calculate wall shear stress in a backward-facing step of blood flow and to assess the ability of Carreau–Yasuda model to predict the wall shear stresses. Backward-facing step flow was studied extensively in the past (e.g., Halmos et al., Armaly et al., Pak et al.), enabling detailed validation of the results. The good agreement between experimental and numerical results indicate that the implementation of non-Newtonian shear-thinning Carreau–Yasuda model in OpenFOAM is valid. Research showed that Carreau–Yasuda model in OpenFOAM can be used on steady laminar flow conditions in heart pumps.

Keywords

Computational fluid dynamics, blood flow, wall shear stress, non-Newtonian fluid, backwards-facing step

The Developments of the Harmonic Balance Method

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Introduction

The Harmonic Balance method is a quasi-steady state method developed for simulating non-linear temporally periodic flows. It is based on the assumption that each primitive variable can be accurately represented by a Fourier series in time, using first n harmonics and the mean value. Such assumption leads to transformation of a single transient equation into a coupled set of steady state equations, each for a different time instant. The benefit of the method, compared to steady state methods, is the ability to capture the transient effects of periodic flows, while providing significant speed-up compared to transient simulation. The Harmonic Balance method will be presented on two turbomachinery test cases and compared to conventional steady-state and transient solvers.

Methods

The method solves incompressible turbulent periodic flows, while special attention is given to development of turbomachinery applications. It is implemented and tested in foam-extend, a community-driven fork of the open source software OpenFOAM. The Harmonic Balance model is used for accurate and efficient simulation of incompressible turbulent periodic flows, and therefore validated using ERCOFTAC centrifugal pump case and KP505 propeller test case. Results are presented and compared with conventional transient and steady-state simulation. Furthermore, obtained convergence with increase in number of used harmonics is presented.

Preliminary results

Presenting the two turbomachinery cases, the accuracy and simulation speed-up of the Harmonic Balance method will be demonstrated. A choice on the used number of harmonics n should be made in order to obtain the optimal accuracy with as few harmonics as possible, therefore keeping the simulation time low. The presented cases were run with up to 7 harmonics, although the significant level of accuracy was achieved already with 4 harmonics. Geometries used are the well established 2D ERCOFTAC centrifugal pump geometry and a KP505 propeller 3D test case. Steady-state solution with MRF and transient solution will be compared against several Harmonic Balance solutions.

Discussion

The Harmonic Balance method offers an efficient compromise between accuracy and efficiency as it is capable of capturing transient flow features, while still providing a significant CPU time decrease. Steady state methods lack transient effects, but provide reasonable CPU time savings. On the other hand, transient simulations usually require unacceptably large computational resources in order to achieve periodic steady-state solution, which was demonstrated with the presented test cases.

Keywords

Harmonic Balance, periodic flow, turbomachinery, CFD, Fourier series

Primary Energy Return as LCA Based Sustainability Indicator of Waste Management Systems

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Introduction

Inappropriate waste management and poor resource efficiency are two of the biggest problems which European Union is trying to solve by increasing recycling and reuse and reducing waste disposal. In these circumstances, decision makers need to analyse which of the considered waste management systems leads to higher overall benefits. In this part of research, environmental impact of a waste management system is addressed. The aim of this study was to develop a framework for life cycle energy usage comparison of local waste management systems, which are time dependent, and enable easier decision-making.

Methods

The framework for life cycle energy usage comparison of local waste management systems is developed by using Cumulative Energy Demand (CED) assessment to display total Primary Energy (PE) consumption for product production, taking into account all relevant front-end processes and provides a useful energy-related screening indicator for Life Cycle Assessment (LCA). Because CED correlates with the majority of environmental impacts assessments it can be used as an indicator for identification of environmentally preferable product and/or system. For this purpose, based on collected empirical data and literature research, estimation inventory data for location-specific conditions have been developed. Starting from the mandatory EU waste management legislation goals this study was performed to analyse and compare different MSW systems, which could be implemented and lead to the fulfilment of EU legislation goals, from the perspective of life cycle energy usage. As the path to legislation compliance is lengthy, this analysis examines time changes in primary energy consumption and return. For easier comparison and decision-making a Primary Energy Return Index is formulated which is the CED based index calculated by using the LCA-like framework.

Preliminary results

Results show that time and legislation dependent changes have great influence on decision making related to waste management and interconnected systems. Scenario analysis showed that material recovery scenario saved larger amounts of PE compared to energy recovery scenarios. PERI Index results showed diminishing returns of increasing efficiency of primary waste separation in later years.

Discussion

Even thou material recovery showed better results, by implementation of AD results could be even better. Also, building of WtE incineration based plant made implementation of AD plant in the urban areas easier. Following this, it was concluded that the best results in the field of PE sustainability of WMS could be achieved by combining material and energy recovery of waste.

Acknowledgments

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Keywords

Decision-making, municipal solid waste systems, cumulative energy demand, sustainability analysis, energy and material flow tracking,

Developing an Al-Fly Ash Composite Suitable for Equal Channel Angular Pressing

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Introduction

Fly ash appears as a side-product of coal combustion in thermal plants. It is a low density material that consists of hollow spherical micro particles, which are basically metal oxides. Previous researches of the composite materials have shown that it's possible to improve the characteristics of aluminium alloys by adding fly ash as reinforcement. Applying Equal Channel Angular Pressing (ECAP) on primarily casted composites, their characteristics are additionally improved. The aim of this research is to develop a casted Al based composite with highest fraction of fly ash, that is suitable for ECAP. Thus achieving: a) resolving the problem of disposal of the fly ash, waste harmful to health and environment, and b) providing a lower price material for the production of light components which are usually made of Al or Al alloys.

Methods

Composite samples obtained by casting have been cut and subjected to ECAP. This method means that previously prepared material is extruded through an L shaped die. Therefore significant shear forces and reduction of micro grains occur in the material deformation zone, which causes improvement of material characteristics.

Fly ash was sifted and only particles smaller than 45 microns were used. Determination of fly ash components was provided by EDXRF and ICP-OES methods. Samples with 4, 8 and 12 % fraction of fly ash will be extruded four times, with a rotation of 90° in the same direction after each extrusion. Porosity will be inspected on all samples as well as quantitative and qualitative analysis of microstructure by an optical and Scanning Electron Microscope. Micro and macro hardness will be measured by Vickers method. Tribological characteristics of the samples will be determined by solid particles (SiC) erosion.

Preliminary results

Two different Al alloys were used in this study: A356 and 2024 as metal matrix. During the casting, 4 % of fly ash was added. Casted samples were subjected to ECAP, where problems with the material as well as the tool occurred, caused by severe plastic deformation. The first ECAP die was a multiple part tool. In some of the tests relative movement of certain parts appeared, creating too much clearance and wedging the material between the punch and the die. Hence, a simpler, more durable tool has been made. The A356 alloy, that was primarily intended for casting had shown as a better composite base for ECAP.

A corrosion test has been conducted on the extruded samples, by exposing them to a 3.8 % NaCl solution. Mass variation was measured and the microstructure analyzed. A thicker oxide layer has formed on the samples with fly ash. Deformation had no influence to the process – the results of casted, extruded and pressed samples were similar.

Discussion

Preliminary results present foundation for further research in purpose of quantification of influence of significant plastic deformation degree at ECAP process and reinforcement fraction to physical, mechanical and tribological characteristics of Al + fly ash composite.

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Keywords

Fly ash, Equal Channel Angular Pressing, Metal Matrix Composite