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METALURŠKI FAKULTET

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Preface

This booklet contains abstracts presented at the 5th Annual FAMENA PhD Workshop and 2nd joint Conference of Postgraduate Students from the Faculties of Mechanical Engineering and Naval Architecture of the Universities of Ljubljana, Maribor and Zagreb (LMZ Conference). The event was held at University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, on June 28, 2019. The workshop/conference is aimed to provide forum for exchange of ideas among PhD students, to help students to strengthen their presentation skills and to provide a platform to initiate new scientific collaborations.

Contributions in this booklet are divided in two broad groups, abstracts of preliminary PhD topics and abstracts of final PhD topics. Former are mostly presented by the first year PhD candidates, while latter are presented by PhD students of second and higher years. Abstract are structured in a way to encourage students to write clearly and concisely purposes of their PhD theses in order to bring their research closer to the wide community and even to those who are not specialists in the field. This booklet could be a valuable and relevant reference for PhD students and their mentors as it represents kind of milestone in the progress of their PhDs. It will also be useful for all stakeholders of PhD education to evaluate quality and progress of PhD theses. Finally, it can be useful for the industry in both Croatia and Slovenia as it contains in one place many of the research efforts from the involved faculties.

43 participants on the PhD workshop presented preliminary topics of their theses, while 34 participants presented final PhD topics. 8 participants belong to the non-academic sector, while 4 participants are from countries other than Croatia and Slovenia (Bosnia and Herzegovina, Denmark, Kosovo, Mexico).

Editors

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TOPIC NOT APPROVED

APPROVED TOPIC

TOPIC NOT APPROVED

Preparation and Characterization of TiO_2 / MWcnt Composites for Use in Advanced Oxidation Process

PhD candidate: Igor Jajčinović
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Introduction

Industry development, Earth's population growth, ever increasing need for greater pharmaceuticals production causes irreversible changes in the environment. Photocatalysis is a process that leads to complete decomposition of pharmaceuticals to a non-hazardous degradation products under the influence of solar radiation in the presence of a photocatalyst. A photocatalyst, such as titanium dioxide (TiO_2), is required for photocatalysis. The efficiency of using TiO_2 is limited due to the high energy banned zone (3-3.2 eV) so only UV-A light, which makes up 5 % of solar radiation, activates the photocatalyst. In order to overcome the problem of prohibited zones and to shift the light response threshold of TiO_2 into the visible part of the spectrum, different methods can be used. One of the methods showing the potential is the use of multiwall carbon nanotubes (MWCNT).

Aims

The aim of this assignment would be to develop TiO_2 / MWCNT composites with various concentrations of MWCNT. The concentrations of MWCNT ranged from 1.5, 5, 10, 25, 50 and 100 wt. % MWCNT relative to the mass of TiO_2. It was observed that the concentration of MWCNT affects the photocatalytic activity of the composite obtained.

Methods

TiO_2 and MWCNT is applied to the glass mesh using sol-gel method, for the preparation of the immobilized layer. Six different solutions with different concentrations of MWCNT were produced. The concentrations of MWCNT ranged from 1.5, 5, 10, 25, 50 and 100 wt. % MWCNT relative to the mass of TiO_2. After homogenization, tetraethoxysilane (TEOS) was added and further stirred over a period of 60 minutes at a temperature of 50 ° C. Glass mesh is immersed in the prepared suspension and dried. Clean meshes and meshes with TiO_2 / MWCNT obtained by the described procedure were scan by scanning electron microscope (SEM, TESCAN VEGA 5136MM) operated at 20kV. The presence of TiO_2 and/or MWCNT on fiber glass mesh was determined by using energy dispersion spectroscopy (EDX) mapping analysis. For mapping analysis SEM microscope was operating at 20 kV while working distance was set at 20 mm. Mesh for SEM / EDX analysis were previously fixed to the carrier using double-sided self-adhesive carbon-guided stripes and a gold-platinum layer. Photocatalytic activity was followed by a degradation of salicylic acid, in a pilot reactor followed by UV-ViS spectrometry, as a modal solution and an example of a pharmaceuticals present in the water.

Expected scientific contribution

The expected scientific contribution is to find and develop the best possible TiO_2 / MWCNT composites immobilization method on glass meshes for use in advanced oxidation process, photocatalysis in order to purify waste water from pharmaceuticals.

Keywords

Photocatalysis, TiO_2, multiwall carbon nanotubes

The Impact of Artificial Intelligence on Traditional Methods of Corporate Governance

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Introduction

Usage of Artificial Intelligence (AI) is one of the largest research areas in latest decades as well as its impact on different areas: from Industry 4.0 to decision making process within society and companies. The main task of this work is to identify recent researches connected with new technologies that enables collection of different information from company's internal and external eco-systems in real time, data processing, their analysis and conclusions drawn by using AI and machine learning tools. Historical data on production, decision making process and finances in different miscellaneous companies could be processed and patterns of good corporate governance and/or mischievous business praxis identified. IoT and Big data lead to business futurology and predictions.

Aims

The main objective of the work is to identify future impact of new technologies, in particular AI on all business activities within different sectors as well as in different type of companies. Industry 4.0 concept has radically changed production process in wide range of manufacturing companies; however, the goal of this work is to identify how AI and new technologies will impact other activities within companies' value of chain.

Methods

Recent literature on AI impact on technology, economy and society are presented, as well as different researchers' models of good corporate governance based on AI will be identified, presented and compared to traditional methods which involves humans' management skills, education, gained knowledge, intuition and other subjective parameters. Qualitative research will be performed using the Analysing Qualitative Data method, while quantitative data is analysed using statistical methods using Simple Statistical Analysis as well as Identifying Patterns method.

Expected scientific contribution

The concept of Auto Pilot Company will be introduced. This concept does not anticipate any kind of human involvement in any company's activity. In such company, all decisions are made by AI and all actions are performed by technology only. All company's main functions (purchase, sales, production, accounting and finance, logistic) are completely automatized, while human's involvement will remain as shareholder only, not as a manager and decision maker.

Acknowledgments

Development of technology, advancement of AI and machine learning enables less involvement of human work. However, the impact of new technologies will be different in different industries. While in some sectors Auto Pilot Company practically already exists, in some other sectors, there is a less possibility that this concept will be introduced in the near future.

Keywords

Corporate governance, AI, Industry 4.0, Smart Factory, Big Data

Innovative Index for Measuring Digital Transformation Process

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Introduction

Manufacturing companies are currently facing significant challenges regarding disruptive concepts such as the Internet of Things, Cyber-Physical Systems or Artificial intelligence – also referred to as Industry 4.0. Companies can become part of Industry 4.0 by digitally transforming itself. Digital transformation is a phrase which by itself synthesizes many concepts such as a smart factory, big data, and its analytics, services, and IoS, cloud, IoT, artificial intelligence and 3D printing. Lean and digital transformation are potent tools for companies to stay competitive but what can not be measured cannot be successfully implemented.

Aims

In this research, we will synthesize new innovative index which will help companies and countries to measure the progress of transformation.

Methods

Methods used are reviewing already existing indexes and innovating a new one that is going to take all parameters into account instead of using many of them. Furthermore, deep in-person interviews with employees will be used to get a clearer picture.

Expected scientific contribution

The result is a unique, innovative index which takes many different parameters into account and can serve as the only KPI for measuring the digitalization process. By measuring it, we can recognize the weak areas and successfully form strategy for digital transformation.

Keywords

digital transformation, lean transformation, value stream mapping, Industry 4.0.

Islanded Microgrid Optimal Control System to Enhance Small-Signal Stability

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Introduction

Compared to interconnected power grids, islanded microgrids are more sensitive to active power disturbances due to lower specific rotational inertia and lack of spinning reserve. Because of these properties, islanded microgrid control and power quality assurance are challenging tasks. Even small power imbalances can lead to grid blackout, if not addressed in a proper and timely fashion.

Aims

This paper presents a dynamic model based on elastically coupled rotational inertial masses, enabling a simple small-signal stability analysis. The model is linearized in the vicinity of a characteristic operating point and such linearized model is used to develop a linear quadratic regulator (LQR) to control distributed resources' power output.

Methods

Dynamic properties of LQR microgrid control are investigated by means of root locus analysis and comprehensive computer simulations.

Expected scientific contribution

Simulation results illustrate that incorporating appropriate LQR control laws in a peer-to-peer control system enables its use for small-signal stability enhancement without incorporating a traditional droop frequency controller, whereas the root-locus analysis illustrates how LQR input parameters affect closed-loop poles and, thus, the small-signal stability properties.

Keywords

Microgrids, electromechanical model, islanding, frequency control, linear quadratic regulator (LQR)

Issue of Temperature of Stagnation in Polymer Solar Collectors

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Introduction

The temperature of stagnation is the temperature a solar collector reaches during peak hours of sunlight if there is no flow through the collector. The lack of flow may be due to a malfunction, or more commonly, due to the fact that there is no demand for heat during that period. The temperature of stagnation in most collector designs can be very high easily surpassing the glass transition temperature of all commonly used mass produced polymeric materials. Historically, this has severely limited the selection of such materials in collector design and kept the price of the collector relatively high compared to what could be achievable. While some solutions have been suggested, currently none of them have provided a widely acceptable solution, especially if passive overheating protection is required.

Aims

Due to the aforementioned problems, the aim is to find a way to passively lower the stagnation temperature in a flat plate solar collector to the point where it will no longer reach the levels surpassing the working temperature of mass produced polymeric materials. This would enable the use of such materials in all parts of a solar collector and make collectors cheaper for the end consumer.

Methods

Based on the previous research, which included optical simulations as well as experimental measurements, the model was further improved. A new method for optical simulation was applied, which increased precision and simplified the process. Research was conducted into the feasibility of using phase changing materials as overheating protection in solar collectors. Properties of polymer materials were researched in order to determine their long-term behavior. In the following steps a prototype collector will be created, as well as a new CFD model for the potential PCM solution.

Expected scientific contribution

The results of this thesis should provide a guideline to mitigation of the problem of the temperature of stagnation in flat plate solar collectors.

Keywords

solar collector, temperature of stagnation, overheating, polymer

Increasing the Integration of Variable Renewable Energy in a Coal-Based Energy System Using Power to Heat Technologies in District Heating

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Introduction

The use of coal for powering entirely Kosovo power sector has put a heavy burden of lignite coal in Thermal Power Plans to cover the energy demands with electricity. This conventional resource use is one of the main contributors of CO_2 emission released into the atmosphere engendered by the energy sector. In order to tackle the issue of climate change mitigation and CO_2 emission reduction goals, the coupling between synergy sectors of electricity, heating, cooling and transport should happen. Such sector coupling will increase the flexibility of the power sector that can allow a higher share of variable renewable energy sources (RES) penetration.

In this regard, coupling of electricity and heating sector (electrification of the heating sector) has gained increasing attention as an additional source for providing higher flexibility in energy systems.

From the other hand, research has proved the building sector is responsible for around 40% of final energy consumption by end users in energy systems worldwide, the greatest part of which is provided as thermal energy, respectively heat. This shows that the potential use of power to heat technologies for individual and district heating solutions can be significant. In addition to that, the way of heat provided to final end users, by careful selections of available power to heat technologies, can have a significant contribution on carbon dioxide emission reduction and increasing the share of variable RES into energy systems.

Aims

The objective of this work is to identify the influence which utilization of district heating system coupled with the power to heat technologies based on the flexible operation of coal-based thermal power plants and limited electricity system interconnections can have on the maximum integration of variable renewables.

Methods

An hourly deterministic programming tool Energy PLAN will be used for modeling and simulation of Kosovo energy system. District heating with 50% share of total heat demand will be used as input data in the model for analyzing the effect that economically viable district heating systems and power to heat technologies can have in increasing variable RES penetration in coal-based power systems.

Expected scientific contribution

Results will quantify the role which district heating system, electricity transmission line capacities and flexible operation of thermal power plants coupled with power to heat technologies can have for capturing the power curtailed by RES. In addition to that, it will be shown that power to heat technologies will have a significant impact especially for increasing the Wind with less meaningfulness for solar PV power plant penetration, even in very well interconnected power systems.

Keywords

district heating, power to heat, renewable energy integration, coal power plant, interconnections

Implementation and Validation of the Discrete Ordinates Method for Calculation of Radiative Heat Transfer in a Direct Injection Diesel Engine

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Introduction

The radiative heat transfer in the numerical simulations is often not considered due to its additional computational complexity and demanding of computational time. With the development of the computational resources, the radiative heat transfer models within Computational Fluid Dynamics (CFD) are commonly applied to evaluate the impact of the radiative heat transfer on overall temperature field, and then indirectly on the emission formation in the combustion system. Among the many types of research on the topic of radiative heat transfer in IC engines, just a few were carried out by solving the RTE.

Aims

The goal of this thesis is the additional improvement of the radiative heat transfer in participating media through the implementation of Spectral Line-Based Weighted Sum of Gray Gases – 1 (SLW-1) model for calculation absorption coefficient. Specific research goals are the development and implementation of the SLW-1 model for efficient prediction of radiative transfer in high-temperature gases of Solovjov et al. into CFD procedure. Additionally, implementation of turbulence radiation interaction (TRI) model for calculation of temperature fluctuations based on probability density function will be conducted, with a purpose to evaluate the accuracy of the coupled SLW-1 and TRI model. The research hypothesis is that implementation of SLW-1 model which calculates absorption coefficient based on a spectral line of gasses will significantly increase the accuracy of numerical simulations for not significant increase of computational time compared to conventional Weighted Sum of Gray Gases Method (WSGGM) model. Implemented coupled SLW-1 and TRI model could be used in industrial applications.

Methods

If the participation of medium in the radiative heat transfer is considered the Radiative Transfer Equation (RTE) must be solved. Discrete Ordinates Method (DOM) featuring Finite Volume Method (FVM) is implemented by user functions into the CFD software AVL FIRE™ for calculation of RTE. For verification of the results, the absorptivity and emissivity were modelled with an implemented WSGGM based on non-isothermal and non-homogeneous correlations for H_2O, CO_2 and soot. The whole procedure was implemented to work with parallel computing, moving meshes and rezoning process. The implemented models will be first validated with simple geometry cases for which the analytical results are available in the literature, and then on complex furnace geometry where the combustion process is also accounted for. Additionally, this study will be focused on the radiative heat transfer modelling in combination with the combustion process inside an IC combustion chamber.

Expected scientific contribution

The excepted scientific contribution of this work is the implementation of SLW-1 method for the calculation of the absorption coefficient in the CFD code.

Acknowledgments

This work has been fully supported by Croatian Science Foundation under the project IP-2016-06-1488.

Keywords

Radiative Heat Transfer, Participating Media, Finite Volume Method, Engine

Leveraging Product Manufacturing Information

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Introduction

Time available for new product development and its dimensional control is getting shorter with the advancements of manufacturing and information technologies. Concurrently, the complexity of products, required geometric tolerances, and quality requirements are increasing. New approaches to decrease the time to market are required. The technology of 3D-CAD models enriched with additional product information (MDB – Model Based Definition and PMI – Product and Manufacturing Information) is therefore being implemented in all major CAD/CAE and PDM (Product Data Managements) environments. Recording all the crucial information of the product, including geometric tolerances, surface finish, process notes, material specifications, etc. into a native 3D CAD model, reduces the need for an additional step of producing 2D documentation, while shortening development times and reducing the risk of possible errors along product's R&D process. However, currently both, individual and serial control of products requires separately prepared inspection and control documentation, most often in the form of 2D drawings. Furthermore, achieving the products comprehensive information model is one of the requirements for the transition into industry 4.0, which facilitates individualisation and customisation of each particular product.

Aims

The aim of this research work is the development of a procedure model for effective connection and integration of dimensional control procedures with an MBD model, which already consists of information about required tolerances and necessary dimensional control of the product. The procedure model will enable recognition of these requirements and selection of adequate measurement equipment and procedures as well as a definition of adequate measurement protocols. Computer aided quality control is only one of the recognised problems. It is expected that the solution will enable new applications of MBD models to other fields, e.g. recording of knowledge and decisions along the whole product's R&D process.

Methods

Existing technology, protocols and standards in the field of MDB, measuring procedures and the state-of-the-art CAD standards and protocols will be investigated and analysed. Current trends in measurements technology for dimensional control of products (e.g. 3D scanning, Coordinate Measurement Machines) will be investigated in parallel. Gained knowledge will be used to develop a procedure model and development of a solution for the integration of MBD description of a product and the measurement protocols for its dimensional control. Further, a verification of the model is necessary on a practical example along with the definition of the guidelines and development of the methodology for integration of measurement procedures into the products R&D process.

Expected scientific contribution

A new method of improving the products quality control process with leveraging product and manufacturing information in MBD models. Based on the procedure of the models verification, generalised guidelines and a methodology for the integration of measurement procedures into the products R&D process will be developed.

Keywords

model based definition, product and manufacturing information, product data management, smart pro-cesses

Simulation of Diagnostic Systems Inside Iter Tokamak

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Introduction

ITER is an international experimental fusion reactor built in Cadarache, France. Its purpose is to produce large fusion plasmas in range of 500 megawatts while 50 megawatts of power are injected into the reactor, which will result in ten-fold gain of plasma heating power. The goal of the experiment is to prove that it is possible to produce more thermal power from the fusion process than is used to heat the plasma. Plasma is controlled inside a vacuum chamber called the tokamak via a magnetic coil system. Due to the extreme heat environment that can damage the reactor components, behaviour of the plasma must be carefully monitored from the beginning of the plasma operations. That is why different diagnostic systems are present inside the reactor, such as neutron diagnostics, optical systems, bolometric systems and operational diagnostics that aims to help in protecting the machine from heat and includes several wide angle visible/IR cameras that monitor the conditions in the main chamber.

Aims

Research focuses on construction of diagnostic models for a selected set of plasma diagnostics that include visible/IR cameras and bolometers. Construction of diagnostic models will be based on the characteristics of individual diagnostic system. Research aims to improve the performance of simulation models and get an insight of plasma behaviour and its effect on other components in the reactors.

Methods

To provide input data for the diagnostic systems, a thermal model needs to be developed that can map existing power depositions on the plasma facing surfaces. Output of this thermal model are stationary temperatures that serve as an input to our models. Further on, in order to perform ray-tracing, deliver spectroscopy and carry out tomography, different tools and open source packages must be used and possibly extended to fill the needs. Then follows the construction of diagnostic models for a selected set of diagnostics including visible/IR cameras, and bolometers. Full photonic power loading onto complete ITER first wall and divertor stuctures needs to be taken into an account and interactive viewing of results should be enabled with the provided code, such as dust monitoring, bolometers and power loadings. Further on, different synthetic diagnostic physics studies, that deal with evolution of power flux densities on plasma facing surfaces will be explored and will be the basis for the constructed models.

Expected scientific contribution

Expected scientific contributions are plasma diagnostic simulation models and software, that will be used by ITER to provide an insight into plasma behaviour and measurement systems responses. Consequently, the characteristics of plasma properties can be changed in order to increase the efficiency of the reactor.

Keywords

ITER, plasma, fusion, plasma diagnostics, spectroscopy, ray-tracing

Biochemomechanical Finite Volume Model of Dissecting Aorta

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Introduction

The healthy aorta is composed out of three layers: tunica intima, tunica media and tunica adventitia. Aortic dissection (AD) is an injury affecting the innermost layer of the aorta. It enables blood to flow between the layers of the aortic wall, forcing the layers further apart, and thus creating a true lumen and a false lumen. In case the blood-filled channel ruptures through the outside of the aortic wall, AD is often fatal. It is a relatively uncommon disease; the prevalence is approximately 30 cases per million individuals per year. It is also challenging to diagnose and has high mortality rates.

Aims

Aim of this work is to develop and implement incompressible material behavior of biomaterials with blood interaction into finite volume method (FVM) code. In the first stage numerical model will be limited for solid materials only and then adjusted for biomaterials which represents real blood vessel behavior. Additionally, growth and remodeling theory will be implemented to analyze aortic wall structure changes due to external influences. In the end the aim is to see how blood flow impacts the healthy and diseased blood vessel.

Methods

FVM code was made in OpenFOAM which is based on C++ programing language. Model is up till now made for linear elastic solid materials with implemented incompressible model for small deformations and displacements. Incompressible model for large deformations and displacements has to be added to the model. After that stage, growth and remodeling model of aorta dissection will be implemented into code. Models are based on the constrained mixture theory and the theory of evolving configuration. Former means that constituents (e.g. for aorta: elastin, collagen and smooth muscle cell) are bound together and have the same displacement, while each of them can possess different stress state. Latter means that, in the present moment, mixture is comprised of constituents created in different times in the past and each of them can have different deformation gradient. After the growth and remodeling model is verified, fluid – solid interaction (FSI) model will be conducted.

Expected scientific contribution

There is a significant gap in research on aorta dissection with blood flow interaction FSI based on a hearth cycle and fluid – solid growth as a result of longtime changes due to blood vessel illness. Numerical model will obtained detailed aorta dissection analyses and it will broaden our understanding of FSI in biomechanics. Additionally, the model will assess different ways of incompressible formulations. In the future it could assist surgeons in making decision whether to perform surgery or not.

Acknowledgments

This work was supported by grants from the Croatian Science Foundation project IP-2014-09-7382 I. Karšaj and Training of New Doctoral Students (DOK-2018-01-5244).

Keywords

Dissection, Thoracic aorta, Growth and remodeling, Finite Volume Method, Hemodynamics.

Digitalization Era – Robotic Process Automation Implementation Challenge

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Introduction

Digital transformation brings the improvement of everyday business activities. User experience, speed, productivity, and cost-effectiveness are still imperative. To keep the companies competitive, they need to go a step away from implementing ERP software, outsourcing, and digitizing information itself. The center of successful global companies is information – which requires quick access, processing and reaction. The business challenge of today is no longer the digitization itself and the "paperless" concept, but the access to information. Information is most commonly stored on multiple IT systems (including "legacy" applications), as well as on multiple external sources such as websites, portals, or any other external information sources. Integration and automation of data collection activities is extremely difficult and challenging. Robotic Process Automation (RPA) is a technology that, with the help of artificial intelligence and software, enables automation of tasks. Technology is applicable to almost all platforms, whether they are on internal or external IT resources. The basic goal is to replicate human interaction with user software. Regarding employees, task robots perform faster and error-free, and working hours are 24/7/365. In this way, people are disengaged from common tasks and can focus on activities that necessarily require their engagement or emotional intelligence. Traditional IT project management approach can be used but business cases showed that there is a need for a new tailor-made model for RPA. A review on the advances of robotic process automation technology and obstacles in automating processes by giving the roadmap towards RPA implementation has been done.

Aims

The initial aim of the study is to research Lean 6 sigma tools and methods to develop algorithm for deploying robotic process automation. The algorithm should help develop new, and improve existing structures of RPA systems, mapping in both directions, from structural to behavioral domains and vice versa. Conducted research does not include the development of new RPA development methods, but a new algorithm for describing the architecture of complex technical systems and RPA implementation. With the use of existing Lean methods, the algorithm will also enable prediction of behavior in the work environment and process stabilization.

Methods

The research plan can be described by the following steps:

1. Explanation
2. Analysis
3. Synthesis
4. Verification
5. Discussion

Expected scientific contribution

As part of the research conducted, contributions are expected in the theoretical and applied part. The development of a robotic process automation implementation algorithm should help move the processes faster and more efficiently into the production within complex system architectures, which is still an unexplored scientific area, and which is expected to have also an applied contribution. The algorithm would be used in the implementation phase of robotic process technology.

Acknowledgments

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A Journey Trough Digital Transformation

Keywords

RPA, digital transformation, automation, lean, six sigma

Evaluation of Biogas Production from Food Waste and Industry Co-Products

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Introduction

Anaerobic digestion (AD) of food waste is considered as a sustainable waste-to-energy technology, and an economically effective way for waste food disposal. Based on the previous studies in the field of anaerobic (co)-digestion, pretreatment of feedstocks for anaerobic digestion and inhibition of anaerobic (co)-digestion process it was found that they are important topics in studying the efficiency of the AD process. Meat bone meal has been recognized as a valuable source of nutritive elements like nitrogen, phosphorus, potassium, calcium and magnesium. Also, it has shown synergistic effects in terms process stability and higher methane yields in co-digestion with crude glycerol and dairy manure. Research studies in this domain have demonstrated that wastes of slaughter industry, such as sludge produced in wastewater treatment plants of abattoirs as well as residues of livestock and poultry slaughterhouse contain high amounts of fat, protein, and organic matter; which make them a suitable choice for biogas production.

Aims

The aim of this study is to determine synergistic and antagonistic effects of using industry co-products, meat bone meal (MBM) and wastewater sludge (WWS) as co-substrates in the mesophilic anaerobic digestion of pretreated liquidized food waste (LFW). Using the experimental analysis of variables in the liquid and gas phase, the influences of the added co-substrate on the process stability and efficiency are studied and evaluated. Experimental approach in this study will reveal possible limitations of using meat bone meal and wastewater sludge in a large-scale biogas production.

Methods

Liquidized food waste, meat bone meal, wastewater sludge and inoculum were taken from the processing plant of a company Agroproteinka-Energija d.o.o., located nearby the city of Zagreb, Croatia. The entire work has been carried out in a laboratroy using common equipment for biochemical biogas potential test – reactors, eudiometers, heathed bath and levelling bottles. Gas phase composition has been analysed by OPTIMA 7 biogas analyser, and the following gases have been measured: CH_4, H_2S, CO_2 and O_2. For liquid phase, chemical oxygen demand (COD) and ammonia nitrogen (NH_4-N) have been analysed by Hach LCK cuvette tests, while pH has been measured by Hach HQ440d pH-meter. Concentration of volatile fattty acids (VFA) and total anorganic carbon were determined by Hach TitraLab AT1000 Series unit.

Expected scientific contribution

To reveal the synergistics and anthagonistcs effects of using industry co-prodcuts in the anaerobic mesophilic digestion of thermally pretreated food waste with goal to reduce size and the impact of the co-products on the environment and to get benefits in terms of biogas production.

Acknowledgments

The authors acknowledge the financial support from the Competitive funds of Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb (UNIZAG FSB).

Keywords

Anaerobic digestion, food waste, industry co-products

Energy, Environmental and Economic Comparision of Different Waste Management Systems

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Introduction

Nowadays the waste is a huge social problem. In Europe, only 40% of waste is recycled or reused. In some European countries more than 80% of waste is disposed at landfills, and the most expensive waste management option is landfill. The European policy of waste management is based on a „waste hierarchy". It is a preferential order of waste treatment options that aims to reduce environmental impacts by prioritizing prevention, reuse, recycling, and recovery over landfill. Concerning the ultimate goal of this hierarchy, there is a lack of literature on prevention of waste generation as well as its socio-economic analysis. Moreover, this research will provide a comprehensive analysis of two different solid waste management systems „Ponikve eko otok Krk" and „Marišćina". „Ponikve eko otok Krk" is system in which dominates recycling and reuse of products while „Marišćina" is mechanical-biological treatment facility which main output is refuse derived fuel.

Aims

The aim of the study is to compare the data from two different already implemented waste management systems according to energy, economic and ecological criteria. The comparison criteria are the amount of exploitation of primary resources, the amount of consumed energy, overall costs of each system sections and impact of the system on the environment.

Methods

The research plan is collecting data and statistic analysis of measured data for each system sector (amount of waste, costs of a particular sector, quantity of spent fuel, saving of primary materials...), MFA analysis of each waste system, LCA analysis including assessment of human health, ecosystems, resources and climate change by Eco-indicator 99 and IMPACT 2002+, CBA analysis, and comparison of the systems based on the performed analyzes and the criteria.

Expected scientific contribution

This research will contribute to the science as this part of waste management is still unexplored in terms of comprehensive analysis and comparison of such systems. This includes ecological, social, energy and economic factors that will show which system is better. Thus, future users of such systems will have clearer outcomes and expectations when implementing one of these systems and will be able to participate in a better way in choosing of the type of future system.

Keywords

waste management, recycling, mechanical biological treatment

Abrasive Flow Machining of 3D Printed Metal Parts – A Scientific Review with Extension on Industrial Needs

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Introduction

Nowadays, the use of additive technologies is increasing. Despite the exceptional capability to produce complex geometries, additive technologies are unable to produce components or functional surfaces within tight tolerances and integrity demands. With other words, „as build" surface qualities are poorer in comparison to conventional machined surfaces. Therefore, components have to be post-machined. Lately, abrasive flow machining (AFM) is offering improvements in such cases. However, many process parameters, e.g. abrasive media property, temperature, velocity, etc. are influencing the performance of AFM and their understanding is crucial for successful implementation of AFM into the industrial applications. This paper presents a scientific review of AFM, with an emphasis on post-machining of 3D printed metal parts.

Aims

The aim of this study is to present a review on the post-machining of 3D printed metal parts, with an emphasis on the abrasive flow machining (AFM). Furthermore, the state-of-the-art on AFM is presented and the areas that need further research are critically determined.

Methods

In the present article different methods and approaches for post-machining of 3D printed parts are presented. Different AFM processes are discussed, including the hybrid and/or combined processes, based on AFM. A literature review on the latter includes ultrasonic-assisted AFM and a combination of chemical-abrasive machining. Furthermore, the methods for determining the efficiency of AFM processes are presented. These include residual stress measurements using X-Ray diffraction, flow simulations, abrasive medium wear experiments and surface roughness measurements.

Expected scientific contribution

The present article gives the reader a thorough review on the post-machining of 3D printed metal parts. AFM was found to be a very perspective process for the inclusion in the manufacturing chain of 3D printed metal parts. Therefore, a review on the state-of-the-art on AFM is presented and the areas that need further research are critically determined.

Keywords

Abrasive flow machining; complex geometry, additive manufacturing, surface quality

Energy Efficiency and Environmental Eligibility for Ships Engaged in Short-Sea Shipping

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Introduction

Emissions produced by the fuel combustion in marine engines are one of major causes of the marine environment pollution. The most pernicious emissions released from the engines are carbon monoxide (CO), carbon dioxide (CO_2), sulphur oxides (SO_X), nitrogen oxides (NO_X) and particulate matter (PM). The presence of these gases affects the environment and human health with respiratory diseases and global warming. This impact is more pronounced for ships which mostly operate near ports and inhabited areas, such as ro-ro passenger ships. More stringent requirements for environmental protection and the reduction of harmful emissions, as well as oscillating oil prices, are some of the challenges that the shipbuilding industry is facing today. In light of these challenges, International Maritime Organization has adopted new regulation on energy efficiency for ships according to which the International Energy Efficiency (IEE) Certificate should be issued for every new ship of GT=400 and above engaged in the international shipping. In order to obtain it, the ship must comply with the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP) requirements. Air pollution from ships originates from the combustion of heavy fuel oil (HFO) for power generation. However, this fuel is mostly used because it is relatively cheap. In order to comply with strict regulations on energy efficiency and environmental eligibility, HFO needs to be changed with some alternative fuel, such as LNG or hydrogen for fuel cells, or conventional ship power system should be replaced by hybrid power system or integrated power system.

Aims

The aim of the research is to improve the existing design methodology for selecting the optimal configuration of the ship power system in terms of energy efficiency and environmental eligibility. Moreover, in this research analysis of the possibility of using alternative fuels and renewable energy sources on board is going to be performed.

Methods

In order to assess the impact on the environment of different power system design, the Life-cycle assessment (LCA) will be performed and results of each power system design will be compared in order to find out which is the best solution for particular ship. These results will be illustrated on example of ro-ro passenger fleet and the research will include analysis of current fleet and energy-efficient technologies. LCAs are going to be performed by software GREET 2018.

Expected scientific contribution

This research will result with the advanced design procedure of ship power systems for vessels engaged in short-sea shipping with technical, environmental and economic criteria included.

Acknowledgments

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Keywords

ro-ro passenger ship, environmental eligibility, life-cycle assessment, alternative fuel, ship power system

Improving the Absolute Precision of Multi-Axis Revolute Robots with Application in Medical Robotics

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Introduction

In recent years increasing attention in medicine is given to robotic systems with the aim of advancing surgical procedures. Although modern robots are well known for their reliability and repeatability, their absolute accuracy is still lacking precision required for some of the highly demanding neurosurgical procedures, where precision is a crucial demand. These positional deviations can be attributed to imperfections inherent in manufacturing processes, various physical characteristics, as well as serial kinematic linkage found in most common robot configurations. To tackle this issue robot calibration is performed to fit the kinematic model more closely to the real robot and improve positioning calculations.

Aims

The aim of this research is to improve precision of neurosurgical procedures using a calibrated robot kinematic model. The calibrated model implementation is aimed to improve patient localization and registration precision, as well as achieve higher positional precision when using the robot as a Stereotactic navigational tool.

Methods

Modified Denavit-Hartenberg notation is implemented in combination with a simplification of the Newton-Euler iterative dynamic algorithm to describe robot kinematics and static joint elasticity. A commercial software RoboDK is utilized for online robot control as well as model-based kinematic parameter optimization using the least squares method. Calibration and validation measurements are performed with a laser tracker 3D Coordinate Measurement Machine.

The calibrated kinematic model is utilized to acquire more precise localization data for the registration procedure, as well as to provide the robot with corrected positioning when calculating trajectories for Stereotactic navigation. RONNAstereo, a stereovision system developed for the Stereotactic robotic system RONNA, and a special robot tool equipped with three high resolution digital linear displacement sensors are used to validate the results.

Expected scientific contribution

The research is expected to provide information on the effect robot calibration can have on positioning accuracy of a 6R industrial robot. The effect of using a calibrated industrial robot on the overall precision of a neurosurgical system when used in combination with standard medical imaging/referencing equipment will also be established. In addition, linear displacement sensors, coupled with a precisely measured reference phantom, will provide information on the amount of error introduced by the localization and registration algorithms to robot positioning procedures.

Keywords

modified Denavit-Hartenberg, robot calibration, least squares, joint elasticity, RONNA

A Comparative Study of Cost Functions Used in Inverse Identification of Material Parameters by Considering Full-Field Measurements

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Introduction

Numerical simulations of the mechanical response of various structural parts nowadays represent an indispensable tool for engineers. But simulations are useful only as long as the modeled material behavior satisfactorily imitates the behavior of the real material. Inverse identification enables the identification of multiple material parameters from a single experiment. Most of these methods transform identification into an optimization problem, where we search for such values of material parameters, that yield the smallest mismatch between measured and simulated response. The cost function, which is the basis of all optimization algorithms is determined from the amount of mismatch. Researchers use many different kinds of cost functions. The choice of it determines the outcome of the whole identification procedure. Some may enhance the convergence of optimization, and some could greatly influence the propagation of the measurement uncertainty all the way to the identified material parameters.

Aims

The purpose of the work is to analyze the effects of different cost functions on the performance and effectiveness of the inverse identification procedure. Our aim is to determine the best cost function that can be used in the identification of material parameters by considering full-field measurements.

Methods

The effectiveness of different cost functions will be determined with the inverse identification of material parameters from a single tensile test. The material will be modeled as orthotropic (lamina) linear elastic, for which we must identify 4 parameters. Because the experiment itself plays an important role in the outcome of the identification, different specimens that can be found in the literature will be considered in the identification of material parameters. The identification procedure is based on the finite element method updating (FEMU). The desired data will be created with a synthetic numerical experiment in order to observe the effects of different measurement errors. This method primarily uses cost functions based on deformation or displacement of points on the surface of the specimen. The number and choice of used points will also be investigated as well as the influence of different optimization algorithms.

Expected scientific contribution

The most appropriate cost function used in an inverse identification of material parameters considering full-field measurements will be determined.

Acknowledgments

The authors acknowledge the financial support from the Slovenian Research Agency (research core funding No.P2-0263).

Keywords

inverse identification, optimization, cost function, material parameters, full-field measurements

Design Methodology for Product Concept Embodiment

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Introduction

Constant changes in market demands and rapid development of technologies are forcing the companies to search for new methods to improve their product development process. Early phases of product development, namely the conceptual design phase dictate the direction in which the product will be developed, and if defined properly, they can lead to significant cost and time savings. In the conceptual design phase multiple alternative solutions to a given problem are generated. It consists of the ideation process where ideas and working principles are discussed and embodiment design where these ideas are translated into physical parts and mechanisms. As conceptualisation depends greatly on the designer's experience, knowledge and creativity, this phase is often characterized by numerous iterations, which makes it rather complex to automatize. Several tools and methods for the ideation process have already been developed. Regarding the embodiment design, 3D CAD softwares come into use when the initial concept has already been established, but the bridge between the two stages is still widely unexplored.

Aims

The intention of this work is to provide engineers with a structured approach to the conceptual phase of product development process. Research focus will be on the transition from ideas and working principles into product components, concerning their function and design objectives. Research aim is to provide engineers with the support for the exploration of the overall design space, defining the product structure and appropriate components for the products realization, as well as to increase the efficiency of the concept development.

Methods

Existing tools, methods and technologies that could assist conceptual design phase will be explored and their advantages and drawbacks identified. Furthermore, two main problems will be tackled: first, how to efficiently develop and represent engineering design concepts and second, how to automate the concept embodiment process. Potential applications of emerging technologies such as artificial intelligence, search systems and generative design in the field of engineering design, computer aided design and computational creativity will be explored. Based on the findings, a computer tool will be developed, with the aim of assisting engineers with the embodiment design in the conceptual design phase. Research will require the use of several different computer tools and results will be presented on a real life design problem.

Expected scientific contribution

Expectations are that this research findings will contribute to a better understanding of the concept embodiment process. Expectation of the developed computer tool is that it will facilitate the creation of better concepts, in terms of quality, quantity, diversity and innovativeness. This should consequently lead to lowering the number of iterations in the process and overall increase in the efficiency of the product development.

Keywords

Conceptual design, embodiment design, concept re-presentation, component geometry and structure

The Method of Determining Emission Factors of Engines That Propel Non-Road Mobile Machinery

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Introduction

Due to the large variety of internal combustion engines installed in non-road mobile machinery (NRMM), it is very difficult to assess the emission of harmful gaseous and particulate matter (PM) emitted by such engines to the environment. Current Regulation 2016/1628 of the European Parliament and the Council lists many engine categories depending on several parameters, each of which has separate emission limit values and test procedures.

Literature review shows that many factors which influence fuel consumption and engine emissions, such as different fuels and transient conditions, are not taken into consideration while conducting engine tests. A model that will determine the emission factors of engines that are installed into NRMM is thus needed. More accurate emission factors will allow better quality of emissions inventory and more accurate estimation of emissions of non-road mobile machinery than is currently possible.

Aims

The aim of the research is to improve the process of determining NRMM engine emissions factors by grouping emission factors for similar types of engines, which will result in cost savings and simplifications in the process of assessment of emissions of such engines, as well as facilitate developing emission inventories. This will help decision and policy makers to develop better environmental policies. Special emphasis will be put on the determination of NO_x, which are considered as the largest ecological problem of Diesel engines. Apart from emission factors for NO_x, emission factors for PM will be also observed.

Methods

The model will be constructed from theoretical backgrounds, legislative and normative provisions and data provided by field experiments and in the Laboratory for Engines and Vehicles at the Faculty of Mechanical Engineering and Naval Architecture.

For engine emissions from NRMM, apart from the scientific literature, technical standards and the EU Regulation 2016/1628 are of great importance. This will be followed by experimental determination of the emission factors for which various equipment will be used. Equipment for fuel consumption (gravimetric fuel meter), gas emission analyser, engine emissions particle size spectrometer will be used for conducting laboratory tests, while a portable emissions measurement system (PEMS) will be used for experiments in the field. Weighting factors of influence quantities will be determined by regression methods. Checking the model on several engines of different power and workload categories will validate the model.

Expected scientific contribution

During exploitation, fuel consumption and engine emissions differ significantly from those measured in laboratory conditions during official type approval tests. Scientific contribution of the research is a model that will help to determinate the emission factors of engines that are incorporated into the NRMM, so that emission factors of a particular engine can be used to determine the emission factors for several engines. The model will be constructed from theoretical backgrounds, legislative and normative provisions and data provided by field experiments and experiments conducted at the Laboratory for Engines and Vehicles of the Faculty of Mechanical Engineering and Naval Architecture.

Keywords

ICE, emission factor, non-road mobile machinery, EU 2016/1628

Inverse Determination of Johnson-Cook Model Parameters by Using SHPb Test Apparatus

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Introduction

The Johnson-Cook constitutive model (JC) is used to simulate the effects of a dynamic load on the behavior of material within computer simulations. The Split Hopkinson Pressure Bar (SHPB) test apparatus is used to determine the constitutive material law at higher deformation speeds between 10^2 and $8 * 10^4$ s^{-1}. This is done by one-dimensional analysis of elastic stress wave propagation in incident and transmission bars.

Aims

Determination of the Johnson-Cook constitutive model basic parameters for steel S235 JR using analytical calculations and inverse numerical method.

Methods

First, a classic quasi-static tensile test of selected steel material was conducted, followed by dynamic tests at two strain rates using the Split Hopkinson Pressure Bar test apparatus. The main components of the SHPB test apparatus were titanium bars with foil strain-gages, which were calibrates before testing. A numerical model was built in the LS-Dyna system to carry out the necessary simulations of the SHPB test. The inverse determination of JC parameters was done by comparing the measured and computed stress signals on input and output bars and minimizing their discrepancy by searching for appropriate parameters by applying the Nelder-Mead simplex method.

Expected scientific contribution

Experimental results obtained at SHPB test apparatus were compared with numerical results and were found to be in a good agreement, therefore, the use of the JC constitutive model for dynamical characterization is adequate.

Acknowledgments

The authors acknowledge the financial support from the Slovenian Research Agency (research core funding No. P2- 0063).

Keywords

Johnson-Cook constitutive model, SHPB test apparatus, inverse computational determination, Nelder-Mead optimization

Model Predictive Control of an Electric Vehicle Cabin Heating and Cooling System

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Introduction

Electric vehicle cabin heating and cooling system represents the highest auxiliary load in an electric vehicle, which negatively impacts the vehicle's range due to the low system efficiency. In order to increase the system's efficiency in the presence of redundant actuators and multiple energy flows, including the possibility of storing the thermal energy, it is necessary to design a control system which optimally synthesizes multiple control actions. Additionally, the cabin heating and cooling processes are characterized by highly nonlinear and slow dynamics, which makes them a good candidate for advanced predictive control methods based on the system model. Another system which will be considered in the final stage of the research is the advanced automatic transmission of ground vehicles, which is characterized by fast and well-described dynamics. For that application, special care will be given on the proposed control strategy and optimization algorithm computational efficiency in order for the algorithm to be able to solve the optimization problem in real time.

Aims

The aim of this research is to develop a control system for maintaining the passenger thermal comfort in the cabin for a wide range of operating conditions with minimal electric energy demand. In the final stage of the research, the developed methods will be applied to an advanced automatic transmission for a clutch to clutch shift control in order to obtain the good trade-off between shift performance and shift quality.

Methods

The research is based on designing the control system based on nonlinear model predictive control, implementing the system in a simulation environment and detailed simulation-based and experiment-based validation for a wide range of operating conditions., including the tuning and optimization of control strategy parameters.

Expected scientific contribution

It is expected that the developed control strategy based on the system model, which takes into account multiple, redundant actuators and energy storage systems and optimally distributes the control action between the actuator will be beneficial for electric vehicles in terms of increased vehicle range and improved cabin thermal comfort. It is also expected that the proposed control strategy will be transferable to another process type, namely automatic transmission, where it should improve shift performance in terms of good driveability, comfort and shift efficiency.

Acknowledgments

It is gratefully acknowledged that the research work of the author is supported by the Croatian Science Foundation through the "Young researchers' career development project – training of new doctoral students".

Keywords

model predictive control, electric vehicle, heating and cooling, dynamic programming, automatic transmission

Comparison of Parametric and Non-Parametric Calibration

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Introduction

Stereo calibration is a process of determining intrinsic and extrinsic parameters of a stereo camera system. When a stereo system is calibrated, it is possible to calculate points in space, given pixel coordinates from both cameras from a stereo pair.

Parametric and non-parametric methods are used for stereo calibration. The goal of traditional parametric methods is to calculate camera intrinsic and extrinsic parameters, which are then used to transform pixels from cameras to real-world coordinates. Non-parametric calibration, on the other hand, uses methods like genetic algorithms or neural network to obtain the corresponding relationship between pixels and points in space.

Aims

The goal of this research is to develop a neural network which will be able to map pixel coordinates to real-world coordinates.

Methods

The first step in parametric calibration is to record the coordinates of 3D object points and their corresponding 2D projections in each view. This is achieved by using an object with known geometry and easily detectable feature points, called calibration pattern. Multiple images of calibration patterns have to be taken. Zhang's algorithm, which is one of the most common algorithms for determining camera intrinsic and extrinsic parameters, is used. Besides the intrinsic and extrinsic camera parameters, fundamental, essential, and projection matrices are calculated and used for mapping between pixel coordinates and world coordinates.

Non-parametric calibration is done using a neural network with the goal to obtain a mapping function between pixel coordinates and world coordinates. To learn the mapping function, the network needed to be trained with a large set of training data. Training data consist of input-output pairs. In our network, inputs were pixel coordinates of fiducial markers on both left and right images, and output was world coordinates of the same fiducial marker.

Acquiring data was done by using stereo cameras, retroreflective markers, and the CMM machine. RONNAstereo system was attached to the CMM and marker was attached to the touch probe of a CMM. CMM was programmed to move along 3 axes in steps by 1mm and 2mm in front of the stereo system with cameras simultaneously recording. Each CMM position is stored and paired with coordinates of a marker position on the corresponding stereo image.

Expected scientific contribution

In some cases, a stereo camera system can be hard to calibrate using traditional parametric methods, due to the shallow depth of field of the lens and a small volume for the recording of calibration plates. This is why non-parametric calibration can be beneficial. The goal of this work is to show that non-parametric calibration can yield better results that parametric calibration.

Keywords

stereo calibration, parametric, neural network

Performance and Power Consumption Evaluation of Seawater Heat Pump

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Introduction

Heat pumps are an energy-efficient technology for heating and cooling. For calculating their seasonal performance factor (SPF), the measure of how well the heat pump is operating, several computer programs can be used. Nevertheless, some analysis, especially the ones which are studying the effect of heat pumps on the power grid, would have more realistic results if the daily coefficient of performance (COP) would be used.

Aims

The objective of this work is to identify the difference in economic benefits of demand response analysis of a heat pump using realistic daily COP values and SPF.

Methods

The performance of an existing seawater heat pump system was evaluated, studying the measured heating and cooling demands as well as used electricity, in order to calculate the realistic daily COP of the heat pump. Furthermore, a demand response analysis was made using the calculated COP and the difference in the economic benefits of the results compared to a demand response analysis using the SPF will be analysed.

Expected scientific contribution

The work will provide evidence that in energy planning efficiency of the heat pump should not be considered a fixed assumption in order to prevent the wrong forecast and by it, overcapacity and underutilization of the installed technologies.

Acknowledgements

Financial support from the European Union's Interreg ADRION project SEADRION (539 – Fostering diffusion of Heating & Cooling Technologies using the seawater pump in the Adriatic-Ionian Region) is gratefully acknowledged.

Keywords

Heat pump, demand response, seasonal performance factor, coefficient of performance

Influence of Dimensional Accuracy on Pitting Development in Worm Gears

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Introduction

Worm drives are used for achieving relatively high transmission ratios per reduction stage with regard to their small assembly size. They are characterized by silent operation due to dominant sliding motion between tooth flanks of the worm gear and the worm wheel. However, this sliding motion has negative impact on the surface durability, increasing the intensity of wear and probability of pitting occurrence. Pitting is a surface fatigue wear mechanism that mainly depends on contact pressure, lubricating conditions, roughness and quality of the contacting surfaces. It occurs on weaker of the two contacting bodies, which is usually worm wheel. Current research results have accounted for the aforesaid factors, but the results have demonstrated uneven pitting initiation and propagation with regard to the number of load cycles and, more important, initial location on the surface of the wheel teeth. Pitting formation areas can vary up to 50% among teeth of the same worm gear without proper explanation. During mesh, due to manufacturing imperfections, worm and worm gear may produce localized contact areas with high contact pressures that favor pitting development, which can potentially explain uneven distribution of pitting on worm wheel teeth.

Aims

The aim of the research is to improve current understanding of pitting formation and development, enabling more accurate predictions of pitting location and propagation. Moreover, experimental results should point out if dimensional accuracy influence is to be considered as significant factor among other contributing factors in pitting development. Defining how and which dimension inaccuracies influence pitting development will be presented. Additionally, influence of running-in will be observed as it can greatly influence final worm wheel geometry.

Methods

Worm gear and worm wheel will be optically measured before and after running-in. Further inspection will be carried out using geometric dimensioning and tolerancing (GD&T) software to accurately define dimensions of the manufactured pieces. In addition, worm reducer housing will be optically measured to define position of the worm gear and worm wheel axes. Housing measurements will help in defining possible assembly errors that might influence gears meshing. The collected data will help in determining locations on the worm wheel teeth surface which will be monitored for pitting development during the experiment.

Expected scientific contribution

Differentiation between dimensional inaccuracies with considerable and negligible impact considering pitting development will be possible. Furthermore, proposed research will indicate which dimensions should be inspected with greater care during worm pairs manufacturing. The aforementioned will contribute to better understanding of pitting development on worm gear pairs.

Keywords

Worm gears, dimensional accuracy, pitting development, optical measurement

Aerodynamic Loads on Wind Turbines Situated in Complex Terrain

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Introduction

Wind turbines and offshore platforms are exposed to extreme weather conditions including various effects of wind and coastal terrain topology. Improving the fatigue life and energy yield of wind turbines is one of the main topics in renewable energy industry. To enhance those issues, it is necessary to analyze in detail all the relevant effects of the environment on wind turbines and platforms.

Aims

The aim of the present work is to experimentally, on small-scale models, investigate the aerodynamic loads of an alone-standing wind turbine and an offshore wind-turbine platform. They are both studied when situated in the flat terrain as well as in the complex terrain and subjected to various atmospheric boundary layer (ABL) characteristics. The focus is on the distance between the wind turbine and the platform from the hill, the hill shape, the flow incidence angle and the effects of those parameters on the structural aerodynamic loads. In addition, the wind turbine is studied for the rotating blades as well as in the parking position when the blades do not rotate.

Methods

Experiments will be carried out in the Vincenc Strouhal climatic boundary-layer wind tunnel of the Institute of Theoretical and Applied Mechanics in Prague, Czech Republic. This wind tunnel consists of the aerodynamic and climatic test sections. It is possible to simulate the thermally stratified ABL. Experiments will be performed in the aerodynamic test section using a High-Frequency Force Balance (HFFB) to measure aerodynamic loads experienced by the structural models. Flow velocity will be measured using a Prandtl-Pitot tube, Aeroprobe sensor and Dantec Particle Image Velocimetry (PIV). Downscaled wind-turbine model is similar to the Siemens Sapiens 6.0 MW wind turbine.

Expected scientific contribution

A systematic and detailed insight will be gained into aerodynamic loads experienced by wind turbines and offshore platforms that operate subjected to the ABL winds in complex terrain. This original data will provide an important input for further studies attempting to reduce structural loads and enhance energy yield of those superstructures. Moreover, the experimental results may well serve as a validation tool that is required for Computational Fluid Dynamics (CFD).

Acknowledgments

The Croatian Science Foundation HRZZ-IP-2016-06-2017 (WESLO) funding is gratefully acknowledged.

Keywords

Wind turbine, Offshore platform, Complex terrain, Aerodynamic loads, Wind-tunnel experiments

Optimization of Contact Calculation Algorithm for Finite Volume Metal Forming Simulations

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Introduction

Metal forming simulation is challenging task due to presence of highly non-linear effects such as mechanical contact and plasticity. Although the existing numerical algorithms for contact calculation are mostly based on the Finite Element (FE) method, Finite Volume (FV) method has become a viable alternative. In contrary to FE formulation, where various approaches for contact constraint enforcement are available, in FV framework the contact force is successfully calculated only using penalty method.

The contact calculation algorithm currently implemented in the FV framework shows good stability and accuracy in solving complex contact problems. However, some limitations related to efficiency are still present, thus opening the possibility for further research and improvement.

Aims

The aim of this work is to describe and test performance of the current FV contact calculation algorithm. Through the set of metal forming simulations, drawbacks of the current method will be investigated and potential improvements will be tested. Further enhancements will be mostly based on increasing of algorithm's efficiency in order to make the method more appropriate for industrial applications.

Methods

The computer code is implemented in foam-extend, a C++ library for computational continuum mechanics (the community driven fork of OpenFOAM). The methodology allows for calculation of large strain elasto-plastic deformations with second order accurate discretization in space. The assembled system of equations is solved in segregated manner whereas contact boundary condition is treated explicitly. Contact surfaces are specified in advance as slave and master patches. The contact traction is calculated on slave patch and interpolated to master patch using strongly conservative general grid interface (GGI). The point distance and contact search algorithms are implemented inside GGI interface.

Expected scientific contribution

The new contact calculation algorithm is expected to be developed and tested in order to improve some drawbacks of currently used ones. Although, it is difficult to improve the efficiency, robustness and accuracy in the same time, it is expected that the developed method will be more suitable for further application in metal forming industry.

Acknowledgments

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Keywords

Metal Forming, Contact Mechanics, Contact Search Algorithm, Finite Volume Method, OpenFOAM

Adaptation of Established Mhd and Sol Plasma Codes to Imas Data Model

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Introduction

The Integrated Modelling & Analysis Suite (IMAS) infrastructure is a modular set of components enabling collective development and execution of integrated modelling plasma applications and plasma codes describing plasma operations and research activities on the ITER tokamak experiment. IMAS is being actively developed and used by the ITER Organization, the EUROfusion community and other ITER Members. The IMAS is based on an underlying Physics Data Model (PDM) that allows the coupling of codes via standardized database structures, named IDS (Interface Data Structures). The list of codes adapted to use the IMAS Data Model is gradually increasing with examples including SOLPS-ITER and JINTRAC. One of the next plasma codes which are to be adapted to IMAS are JOREK, a non-linear magnetohydrodynamic (MHD) code and EMC3-Eirene, three-dimensional edge transport plasma code.

Aims

The main goal of the integration of JOREK and EMC3-Eirene with IMAS is to enable interaction with the plasma scenarios stored in the IMAS databases in the form of Interface Data Structures (IDSs): input conditions can be read from the databases and plasma states determined by JOREK or EMC3-Eirene stored. IDSs provide a uniform way of representing data within the IMAS framework and allow to transfer data between codes and to storage within larger integrated modelling workflows.

Methods

In order to integrate JOREK and EMC3-Eirene within IMAS it is therefore necessary that transformation tools are developed to facilitate the reading and writing of the relevant IDSs with its underlying Generalized Grid Description (GGD). The tools are going to be validated through execution of a series of confirmed benchmark computations and data analysis (with developed software utilities) of the final case results.

The code development is going to be done mainly in Python3, C++ and Fortran90 programming languages.

Expected scientific contribution

Expected scientific contributions are the provision of IMAS adapted JOREK and EMC3-Eirene plasma code, tools for IDS data management, and software utilities for direct comparison of different case scenarios and scenarios computed by other plasma codes. Consequently, supporting the knowledge gathering on plasma behaviour and its properties, and contribute to overall IMAS versatility.

Keywords

ITER, Interface Data Structures (IDS), plasma, fusion, Integrated Modelling & Analysis Suite (IMAS)

Design Procedure for Energy Saving Device in Ship Propulsion

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Introduction

Enforced rules and regulations on the ship-building industry to promote „green" and environmentally friendly design has influenced the improvements in ship propulsion systems. One of the possibilities, in order to reduce the fuel consumption and consequently the environmental footprint, is by installing the Energy Saving Devices (ESDs) near the ship propeller. In general, the aim of any ESD is to favorably alter the flow in order to increase the propeller efficiency. Despite the proven performance while interacting with the propeller, in practical use, ESDs suffer from design uncertainties. Subjected to nonstandard impact loads, combined with the lack of straightforward classification rules, structural safety and reliability of ESDs represent an insecurity which ship owners tend to rather avoid. Given the context, a clear design procedure incorporating ultimate limit state and fatigue limit state is definitely needed.

Aims

The research is focused towards a definition of a design procedure for the ESD, specifically the pre-swirl stator. For the approach to be consistent three different steps must be clarified. First, from the potential linear wave theory a large set of different conditions is evaluated to identify the critical points in the structural response. Second, for the obtained critical conditions, a more sophisticated viscous flow solver is employed with all non-linearities included in the solution. Third, the computed pressure distribution is consistently interpolated from the fluid mesh to the structural Finite Element (FE) mesh in order to calculate the actual stress which can later be used for additional structural design evaluation.

Methods

In the first step, for the potential linear wave theory a commercial HydroStar software is used with the additional investigation into the definition of the relevant dominant loading parameter and the design wave. In the second step, the solution for viscous flow is obtained by means of OpenFOAM which is an open source Computational Fluid Dynamics (CFD) solver based on the Finite Volume (FV) discretisation. In the third step, regarding the fluid-structure interaction, an interface will be developed to handle the communication between the CFD and FE mesh. For the FE analysis, commercial NASTRAN solver package is deemed sufficient.

Expected scientific contribution

Key aspects of the research are following:

- identification of dominant loading parameter and the definition of the relevant design wave,
- consistent and conservative load transfer from the CFD mesh to the FE mesh.

Acknowledgments

This research was supported by the Croatian Science Foundation under the project Green Modular Passenger Vessel for Mediterranean (GRiMM), (Project No. UIP-2017-05-1253).

Keywords

Energy Saving Device, CFD, potential flow, FEM, fluid-structure interaction

Non-Contact Optical Measurements in High-Series Automotive Industry

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Introduction

Dimensional measurements in automotive industry represent critical point in sustaining product quality. With narrow tolerance fields of dimensions and specific functionality of every product, bearing rings production requires high level quality control. Due to high possibility of human mistake in 100 % product control, a new approach in terms of quality control is needed. Reducing human factor is of great importance and can be achieved through automation of control and measurement process. Replacing product control with dimensional measurement provides the possibility for monitoring of production process making it more efficient and predictive. Considering high level demand for accuracy of measurement, contact methods represent reliable and proven way of measurement but also highly customized solution for specific product

Aims

In order to reduce the measurement customization to specific products, contactless measurement methods represent best solution for mentioned problem. However, current contactless methods cannot provide sufficient accuracy for production that is taken under consideration. Considering implementation of the measurement system into production environment, temperature stability and product surface roughness are one of the most influential factors for achieving sufficient accuracy.

Methods

The paper shows the idea for innovative contactless measurement system using laser diode and PSD (position sensitive detector). Basic (mentioned) components and other equipment like laser diode driver and temperature stabilizer, beam aligner, neutral density filters and diaphragm will be used and mounted onto experimental setup to examine the functionality of method.

Expected scientific contribution

The result from discussed work is development of innovative non-contact optical measurement method based on laser light reflection. The biggest scientific contribution and difference from already existing contactless measurement methods is achieving sufficient accuracy in production environment, reducing the customization of measurement system to specific product and easier automation of measurement system contrary to contact measurements.

Keywords

dimensional measurement, laser diode, PSD

A Two – Dimensional Small Strain Finite Element Formulation Employing Gradient Elasticity

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Introduction

Heterogeneous microstructure is present in all engineering materials, and accurate description of microstructural behavior is necessary in order to correctly predict behavior of the entire constructions. Classical continuum theory uses local approach at a material point which cannot describe the effect of the microstructural size. Thus, higher order continuum theories were developed, such as gradient theory. The theory includes microstructural parameter in its formulation and allows for development of finite elements able to accurately describe behavior of heterogeneous materials. In literature, there exist finite elements employing gradient theory. Fully displacement based finite elements for gradient theory found in literature have large number of degrees of freedom and very complex interpolation polynomials, and as such have high computational cost. Mixed formulation finite elements satisfy gradient requirements only in weak sense, and kinematic equilibrium is maintained by means of Lagrange multiplier or penalty method. Such elements show poor behavior in comparison to fully displacement based finite elements. In this work, a new two – dimensional finite element for gradient elasticity will be presented.

Aims

The aim of the research is to develop theoretical and constitutive model of a fully displacement based two – dimensional triangular finite element employing theory of gradient elasticity. Finite element will be used in modeling of advanced material behavior in order to more accurately compute material properties. Future research includes expansion of the finite element formulation with large strain assumption. Finite element will be modified for solving dynamic problems by inclusion of mass and inertial effects. Final goal is development of a novel three – dimensional C1 finite element on the basis of the previously developed two – dimensional finite element.

Methods

Finite element will be developed on the premises of the virtual work principle. Finite element formulation will be programed into commercial software ABAQUS using FORTRAN based user subroutines. Preliminary calculations of shape functions will be performed using MATLAB or MATHEMATICA software. Two dimensional finite element will be based on an unit triangle shape, with 4 nodes, 3 in vertices and 1 in centroid of the triangle. The degrees of freedom in vertices will be displacements and first derivatives of the displacements, while degrees of freedom in centroid, necessary for completeness of interpolation polynomial, will be only displacements. Element stability and convergence will be tested using benchmark and „patch" tests, and validation of the element will be performed by comparing results from experimental testing with numerical simulation. Method used will be of mathematical, numerical and experimental nature.

Expected scientific contribution

This research will increase knowledge of modeling of advanced material responses, and enable more accurate computation of material properties of such materials. Developed finite elements will be implemented into multiscale procedures, and will be used in atomistic to continuum scale, as well as on micro to macro scale transition problems. This will enable more accurate modeling of such phenomena as material damage, fatigue, crack opening and fracture propagation in material.

Keywords

FEM, C1 Continuity, Strain Gradient, Multiscale modelling, C1 Finite element

Possibilities of Mathematical Modelling on the Fixed Bed Gasification Process

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Introduction

Development of renewable energy resources recorded significant growth in the past decades due to climate changes caused by the combustion of fossil fuels. Conversion of biomass into the syngas suitable for further exploitation is recognized as a valuable energy resource because of the wide distribution and availability of raw materials. Biomass gasification is the thermochemical process of partial combustion in the oxygen-free environment with a final product of hydrogen-enriched gas. Development of mathematical models for describing physical and chemical behaviour of gasification process significantly replace expensive experimental investigations with an aim to optimize the process. There are four different modelling approaches for the mathematical description of biomass gasification: thermodynamic equilibrium models, kinetic models, computational fluid dynamics (CFD) and artificial neural network (ANN) models, each with its advantages and flaws.

Aims

In this work, possibilities of using thermodynamic equilibrium models and applying the neural network modelling approach on the fixed bed gasification process are shown.

Methods

Thermodynamic equilibrium models are based on the assumption that reacting species are left for an infinite amount of time, where consequently the results may vary considerably from a real-life scenario. ANN models are presented as a novel modelling method of biomass gasification using an unphysical approach based on experimental input and output data.

Expected scientific contribution

The results showed that both modelling approaches can be used for predicting the syngas composition from the gasification process, although further improvement of the models is mandatory. Developed models could be used for a better understanding of the complex thermo-chemical process and for the optimization of the biomass gasification.

Keywords

Biomass, Gasification, Mathematical modelling, Thermodynamic equilibrium model, ANN

Possibilities for Efficiency Improvement in Heat Supply Steam Turbine

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Introduction

The approach of „Total Energy Usage" which is at disposal, contributes to increase of energy efficiency which assumes usage of total heat energy in a energy system at different temperature levels. Such approach can be found in cogeneration cycles for simultaneous generation of electrical and heat energy (Combined Heat and Power – CHP). The increase of efficiency (economics), resulting in reduction of fuel consumption and flue gas emmission, could be obtained by usage of waste heat or ventilation steam heat from the exhaust part of the low pressure housing of a Heat supply steam turbine. Furthermore, to investigate the effect of energy reciprocity, that is energy exchange within the CHP facilities at the location and to propose a design solution and adequate equipment which would be installed (heating stations, built-in heat exchangers, heat storages, heat pumps, solar systems, low temperature heat exchangers etc.), in order to fulfill the requirements of a higher generation DH system.

Aims

Using a developed mathematical model with a computer aided numerical approach will simulate various operating regimes of a Heat supply steam turbine with and without utilization of waste steam heat entering the condenser on a low temperature DH system. The calculation results obtained with the mathematical model for various operating regimes shall serve for an energy and exergy analysis of a Heat supply steam turbine operation and finally for a complete techno-economical analysis. Based on the conducted analysis the possibilities shall be evaluated and recommendations shall be given to increase efficiency (economics) of Heat supply steam turbines.

Methods

By numerical modelling a mathematical model shall be developed which represents an energy characteristic of a Heat supply steam turbine, which shall enable a calculation of variable operating regimes. The experimental part of the research shall comprise measurement of relevant variables on various operating regimes of the Heat supply steam turbine T-100/120-130-3 in the TE-TO Zagreb district heating power plant. The calculation results obtained with the mathematical model for various operating regimes shall serve for an energy and exergy analysis of Heat supply steam turbine operation and finally for a complete techno-economical analysis.

Expected scientific contribution

Getting familiar with the scientific methods and solutions that lead to increased efficiency in the existing CHP plant of TETO Zagreb and the associated DH system is a benefit to the wider scientific community and energy companies. The resulting mathematical models and energy characteristics will serve to create a mathematical model and program for other Heat supply steam turbines in the power range from 25 to 150 MW. It will also strengthen scientific cooperation between Hrvatska Elektroprivreda and the Faculty of Mechanical Engineering and Naval Architecture. acknowledgments The knowledge to be applied relates to energy, mathematics, heat science, numerical modeling and programming.

Keywords

Energy efficiency, sustainable development, district heat power plant, combined power generation, Heat supply steam turbine, waste heat utilization, low temperature district heating

System for Management and Control of the Public Passenger Transport

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Introduction

Implementation of public passenger transport as a public service obligation (PSO_PPT) is based on concession contracts between the concedent, i.e. the Public Transport Authority (PTA), and the concessionaire, i.e. transport operators. For the successful and efficient allocation of public funds, the competent PTA should monitor the implementation of PSO_PPT and also encourage the use of vehicles that are most suitable for use in terms of sustainable development.

Therefore a model of monitoring and evaluation of the implementation of PSO_PPT lines is set up. The input parameters in the models are: the number of passengers carried, the travel times required, the price suitability, the number of passengers entering the stations, the time accuracy, the diversity of lines, the possibility of extension of lines, the possibility of transferring to other forms of public transport, and others.

The input data for the second model to calculate the potential energy savings when using vehicles (buses) on alternative vehicle propulsion technologies are: slope inclination, vehicle speed, itinerary segment, fuel rate, brake switch activation, efficiency in energy transfer.

Aims

The aim of this work is to carry out research in the field of setting up the line optimization model, as well as the system for collecting the necessary input data into the model. The tool can be used for direct monitoring of the PSO_PPT implementation, as well as in analysing the bids of concessionaires before the new concession period.

Methods

The tool for optimizing the implementation of lines was developed in a pilot area of PSO_PPT covering 28 bus lines. We set up a model for evaluating these lines by using objective function. The model consists of 8 criteria, to which we added correction factors and weights. Subsequently, this tool was upgraded with optimization procedures based on linear regression calculations and non-linear GNG algorithms. In the final phase, we compared the values of the implementation of 28 lines by using three methods: the objective function method, the two variants of linear regression method and the non-linear GNG algorithm. The results showed that lines that have higher value functions are more efficient.

In the continuation of our research, a tool was developed to determine the potential energy savings in the case of using a bus with serial hybrid drive technology. The results showed possible energy savings with a 7% and 20% reduction gas emissions.

Expected scientific contribution

The contribution of science is reflected in an innovative system of data preparation, collecting, analysing and evaluating the results of the implementation of lines. The results of the described methods serve as a tool for monitoring and increasing the efficiency of lines implementation. A mathematical model was developed and adapted to evaluate the implementation of lines, as well as to monitor the efficiency of energy consumption and reduce gas emissions.

Keywords

Public Service obligation of Public Passenger Transport, Public Transport Authority, Objective function, Optimization method, Vehicle hybrid propulsion technology.

A Gis Based Approach for Evaluating the Spatial Distribution and Seasonal Variation of Biogas Production Potential

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Introduction

Anaerobic digestion technology (AD) for biogas production offers numerous benefits as it may not only recover the energy contained in the biomass but also contribute to nutrient recovery and reduction of greenhouse gas emissions. The EU Commission has recognised the role of AD in achieving circular economy goals and set the biogas and digestate production at the highest rank in the hierarchy of waste-to-energy operations. The expansion of the biogas production promotes the need for the assessment of energy potential of biomass, which is available for the biogas production (technical potential) and not in the competition with the other purposes.

Aims

The assessment of the technical potential at the high spatial resolution is a necessary precondition for identification of the optimal location for biogas plant sites, techno-economic studies of biomass supply chains and managing the supply risks. This work presents a GIS (Geographical Information System) based approach for the spatial distribution of the energy potential for biogas production by taking into consideration the seasonal variation of biomass production.

Methods

Statistical information, land use maps and previous research were used for the estimation of the energy and technical potential of agricultural residues, livestock waste and biodegradable municipal waste for the biogas production. Here, GIS tool was used to obtain the spatial distribution and seasonal variation of the potential. The presented approach was tested on Croatia as a case study. The final results are presenting the seasonal and spatial distribution of the energy potential for biogas production at the spatial level of 1 km x 1 km.

Expected scientific contribution

Up until now, biogas potential was assessed at an annual basis. However, generation of agricultural residues is not continuous during the year and since those feedstocks have low energy density, there is the need for significant storage capacities in case of large time gap between supply and demand. For that reason, the integrated assessment of spatial and seasonal variation could give better insight into the biogas potential and feasibility of its utilization.

Acknowledgments

This work has been financially supported by the RESFLEX project, funded by Programme of the Government of Republic of Croatia for encouraging research and development activities in the area of Climate Change.

Keywords

biogas, GIS, agricultural residues, seasonal variation

Scattered Data Interpolation and Approximation Techniques as a Basis for Meshless Methods

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Introduction

A meshless method is a method used to establish system algebraic equations for the whole domain of a problem without using a predefined mesh for the domain discretization. Meshless methods use a set of scattered nodes to establish the problem domain and boundary, and do not require any prior geometrical information on the relationship between the nodes for the interpolation and approximation of the unknown functions of the field variables. According to formulation procedure, meshless methods fall into two categories: strong-form and weak-form methods. Both formulations have their own limitations, applications and advantages. In seeking for an approximate solution to the problem, without mesh generation, the unknown fields need to be obtained by using shape or basis functions. Different basis functions e.g. polynomials, or radial basis functions such as multiquadrics, inverse multiquadrics and Gaussians can be used. A linear combination of these basis functions provides the scattered data approximation. These basis function are locally supported, because only a set of data points of a small local subdomain are used in their construction. To construct the meshless shape functions, and to interpolate or approximate values of unknown field variables, several interpolation and approximation techniques are being used.

Aims

Research focus is to analyse these interpolation (collocation) and approximation (least squares approximations) techniques for 1-dimensional and 2-dimensional datasets. Accuracy, fitting behaviour and smoothness capability of all these techniques are compared.

Methods

Numerical solution will be provided to construct the basis functions and to obtain the unknown field variables. Interpolation techniques of Shepard type collocation, point interpolation collocation and collocation by radial basis functions will be described. While ordinary least squares, weighted least squares and moving least squares types of approximation techniques will be illustrated. To elaborate the concept of these techniques, several numerical examples will be performed for different datasets. For numerical computation of data, MATLAB R2018b will be used. Polynomial basis function will be used and weight will be applied by using Gaussian exponential function. To show the numerical stability of these techniques, root mean square errors will be calculated and compared. Fitting capability of the approximate functions of these techniques will be evaluated graphically.

Expected scientific contribution

Meshless methods have achieved a remarkable progress over the past few years. The techniques discussed here have been successfully applied to many of the meshless methods. Consequently, this comparison study will provide a strong theoretical foundation for meshless solution of solid mechanics and fluid mechanics problems.

Keywords

Meshless methods, basis function, strong-form, weak-form, subdomain, interpolation, collocation, least squares approximation, root mean square error.

Surrogate Modeling of Ship Structural Adequacy Based on the Sensitivity Analysis

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Introduction

The main goal of a ship structural design process is to obtain a satisfactory structural arrangement, i.e. an arrangement that meets all the criteria required by the regulation authorities. These criteria are given in the form of the so-called adequacy parameters that represent a ratio of the required parameter (e.g. stress) value and the parameter value obtained from the structural response calculation of the structural arrangement.

During a typical ship structural design process the structural arrangement is generated and its response is calculated by means of the finite element method (FEM). The obtained parameter values are used to calculate adequacy parameters. When all the adequacy parameters are fulfilled, the design process ends with a satisfactory but a non-optimal structural design. To obtain an optimal solution, one can employ structural optimization methods. However, this might be challenging because the optimization problem could include several design objectives, hundreds of the design variables and thousands of the design constraints. Bearing in mind that it is usually necessary to analyze hundreds or even thousands of the design alternatives, it is obvious that a critical task in the development of a new procedure is to reduce computational time needed for the structural analysis of the design alternatives.

Aims

The main goal of this work is to obtain ship structure's adequacy parameters in a more efficient way, i.e. less computationally demanding and faster. This could be achieved by reducing the number of structural response FEM calculations. However, because we still need structural response data for every generated design alternative in order to assess it in the optimization procedure, it is important to provide a less computationally demanding way of obtaining the data.

Methods

A numerical research will be used. A new surrogate model for the calculation of the ship structural adequacy will be developed. It will be verified on a series of models ranging from the simple models of the ship substructures such as ship panels and grillages to the partial ship models. To gain access to all the data about ship structural response needed by the surrogate model, an open source software, the Object-Oriented Finite Element Method (OOFEM), is selected for structural response calculations.

Expected scientific contribution

The scientific contribution comprises the development of a surrogate modeling method for the calculation of adequacy parameters based on the sensitivity analysis of ship structural response displacements. The new method will enable an efficient prediction of ship structures' adequacy criteria near the initial state point, which will further on make the ship structural optimization by means of mathematical programming methods, such as sequential linear programming (SLP) and sequential quadratic programming (SQP), more applicable in the timeframe of a typical ship structural design process.

Keywords

Ship structural optimization, ship design process, surrogate models, structural sensitivity analysis

Machine Learning Application in Estimation of Ship Motions

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Introduction

The wave-induced ship motions and the accompanied loads have been studied for several decades, due to their relevance in successful design and operational life of the ship. Their stochastic nature has been recognized long time ago, thus implying application of probabilistic models in mathematical modeling of this phenomenon. The description of sea waves and theoretical predictions of ship responses are based on mathematical models which have different degrees of accuracy depending on the assumptions on which they are based. Based on the full-scale seakeeping and wave measurements, a hybrid approach, so called physics-based machine learning (ML) method will be applied to model ship response function depending on the sea state. Instead of using raw data and only generalized ML models, numerical seakeeping calculations will be used as intermediate between input data and ML algorithm enabling greater accuracy while lowering data dependency (lowering necessary training data). The proposed model will utilize benefits of already well tested and for some range of applications perfectly good physical model empowering it with knowledge from measured data.

Aims

The presented research is focused on improving uncertainty assessment of wave-induced responses of ship sailing in the Adriatic Sea, including comparison of transfer functions of wave-induced responses calculated by different numerical methods, and their comparison mutually and with experimental results. In order to investigate an alternative approach for reduction of modelling uncertainty of wave-induced response, machine learning will be investigated within proposed research as an upgrade or a substitute to conventional seakeeping approaches.

Methods

The study is based on combined application of machine learning algorithms and numerical methods for ship response calculation. The transfer functions of the ship seakeeping responses will be calculated by different numerical methods, including strip theory, 3D panel method, and closed-form expressions. Different ML approaches will be tested, and the most suitable algorithms will be chosen with respect to studied phenomena and available database. The development of the method will be carried using MATLAB and Python.

Expected scientific contribution

A novel physics-based machine learning method for seakeeping analysis of ships will be developed and tested. The research is intended to improve understanding, quantification, and reducing of modelling uncertainties in prediction of short- and long-term stochastic responses of ship in seaway that may be used for different practical applications. Modelling of seakeeping responses using ML is necessary prerequisite for successful design of autonomous ships. Therefore, present research is expected to contribute to the long-term strategic objective of European Union in the field of waterborne transportation.

Keywords

physics-based machine learning, ship responses, full-scale seakeeping measurements

Safety Principles in Cognitive Robotics Integration in Industrial Environments

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Introduction

Research shows that collaborative robotics is taking it's share of market and that it is allowing to combine the precision, speed and repeatability of an industrial robot with cognitive abilities of a human worker. This research will revolve around technologies such as assembly, material handling, welding etc. In order to achieve the collaboration some necessary steps must be taken. Most of industrial workplaces involve robots working behind the fences which prevents humans to approach the position. This brings to the first and one of the most challenging problems- making the workplace safe for human co-workers. Along with the human co-worker safety there is a problem of safe interaction with the robot, the human-robot-interaction (HRI). While there are numerous methods for ensuring the worker safety already on the market, visual perception is still an unexplored area in terms of ensuvalgorring the human safety in industrial environments and might be considered somewhat unreliable. In collaborative environments human co-workers will work closely with the robot on numerous tasks where safe interaction is imperative. One of the tasks might include robot programming which should be of a natural character, meaning the human co-worker must be able to teach the robot what to do using natural interfaces such as speach and body language. The promising area of research tends to be emotion recognition which would enable another source of information about the human co-worker. Emotion estimation is well known area of research in terms of face recognition and tracking. The basic suggested emotions (happiness, sadness, disgust, fear, surprise and anger) are estimated with a certain amount of confidence using machine learning algorithms and require large amounts of data while some fo them tend to be unreliable due to poor data (emotion such as fear is hard to record and use for learning). Using additional modalities such as body language could boost the confidence of the algorithms which appear to have reached its performance peak.

Aims

The aim of this research is to develop an effective multi-modal algorithm that boosts the output confidence of the existing emotion estimation models. Further work will include deadlock event detection and removal, present in the process of reinfored learning, using the afore mentioned algorithm.

Methods

The research methods that will be used include both theoretical and experimental. The first part consists of data collection and validation. For this part, the open-source database will be used. When the models are trained, specific situations will be recorded for retraining and validation. The second part will include creating a virtual environment that would simulate an industrial workplace that includes robotic manipulators. The V-Rep software package will be used for that part. After the setup algorithm synthesis will take place and validation will be carried by comparing experimental results with the available state-of-the-art results.

Expected scientific contribution

The expected result is a novel algorithm for emotion estimation confidence boosting and a reliable dead-lock removal method.

Acknowledgments

The research is supported by Visage Technologies AB by providing the state of the art face tracking software development kit (SDK).

Keywords

collaborative robotics, active safety, industrial environments, face tracking, body language recognition

Properties of Wood-Polymer Composite Gears

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Introduction

Gears are the most used machine elements for power and motion transmission. They are mostly made of steel because of its good mechanical properties such as high strength, hardness, modulus of elasticity etc. Given that the mechanical properties of the polymer materials are inferior to steel, their use in gear manufacturing is mainly reduced to the production of gears used for the transmission of motion and limited power. One way to improve the mechanical properties of polymer gears is to make them out of a composite with a polymer matrix. The most commonly used reinforcements are glass and carbon fibres. Gears made of such composite materials have much better load capacity than polymer gears. Alternative to polymer composites with carbon, glass and other similar fibres are wood-polymer composites. In these composites cellulosic fibres, which are obtained from natural sources, such as wood, are used as reinforcements. Fibre reinforced polymer composites have particularly good properties, and since wood-polymer composites use wood instead of artificial fibres, they represent an environmentally acceptable alternative.

Aims

The aim of the research is to determine whether the gears made of wood-polymer composite can achieve mechanical properties equal to or better than the gears made of pure polymers and to conclude whether such gears are more cost-effective than the polymer gears. The research should provide insight into the properties of the gears made of wood-polymer composites and the impact of different parameters of the material itself on the load capacity and lifetime of the gears.

Methods

Gears made of wood-polymer composites would be produced using injection molding. Polymers used as matrices would be polyethylene and polyamide, while beech and oak fibers would be used as reinforcements. Four different gear pairs would be produced from these materials (PE/beech fibers, PE/oak fibers, PA/beech fibers, PA/oak fibers) and they all would be submitted to examination. Experimental examination of mechanical properties of produced gears would be carried out on a closed-loop testing rig. This test would also give insight to gear's behavior in working conditions, working temperature, load capacity and material fatigue properties. Additionally, test specimens would be produced from different types of wood polymer composites and static tensile tests would be carried out to determine tensile strength and elastic modulus.

Expected scientific contribution

The research should study gears made of wood-polymer composite in working conditions to determine main cause of gear failure (tooth flank damage, tooth root fracture, overheating) and their cost effectiveness when compared to polymer gears in same operating conditions. The findings obtained through the research could serve to better understand the behavior of the gears made of wood-polymer composites, which would result in the improvement of the gear design itself with respect to the specific properties of the composite material.

Keywords

Composite, gear, polymer, wood

A Computational Study of a Small Scale Biomass Boiler: the Influence of Process and Geometry Parameters Related to Air Staging

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Introduction

Air staging is characterised as a combustion method where the combustion air supply is spatially separated into two or more streams in order to create specific reaction zones (i.e. fuel rich and fuel lean zone). Air staging acts in such way to form a fuel rich reduction zone in between air supplies for an effective reduction of nitrous oxide emissions. Furthermore, more efficient mixing can be achieved meaning that less combustion air is needed for a complete burnout resulting in an increase in thermal efficiency due to potentially lower flue gas losses. Influential parameters determining air staging effectiveness are associated with the boiler geometry (e.g. orientation of air supply nozzles) and process parameters (e.g. primary to secondary air ratio and total amount combustion air supplied).

Aims

In this work the influence of different combustion air geometry and process parameters on the combustion process in the freeboard region of a small-scale wood pellet boiler, operating under air-staging conditions is investigated. The aim of this work is to study the link between geometry and process parameters regarding air staging in small scale biomass fired boilers.

Methods

A parametric numerical simulation is performed in order to acquire results of the combustion process when operating under different geometric and process parameters. A two-part simulation method was chosen: The goal of the first simulation is to determine the effect of the geometric parameters in the form of orientation of secondary air supply nozzles on the combustion effectiveness. Secondly the secondary air mass flow was lowered for one best case of the first simulation to study the effect of process parameters on combustion effectiveness and thermal efficiency.

For the means of describing the combustion process an empirical 1D bed model is used. The input parameters are: feeding rate, properties of the fuel, primary air mass flow from beneath the grate and the incident radiative heat flux at the top of the fuel bed. The bed model provides profiles of temperature, species concentration and velocity of the gas leaving the fuel bed into the freeboard, which serve as the inlet boundary condition for the freeboard 3D CFD simulation.

Expected scientific contribution

Results of the simulation give insight into the process of solid fuel combustion inside a small scale wood pellet boiler operating under air staging conditions. It was found that increasing the secondary air injection angle reduces the CO mass fraction in gases leaving the combustion chamber. Decreasing the secondary air injection nozzle diameter also reduces the CO mass fraction in gases leaving the combustion chamber. Moreover, it was shown that optimal (i.e. better suited) geometric parameters offer the possibility to reduce the supplied amount of secondary air whilst increasing the thermal efficiency due to lower mass flow.

Acknowledgments

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Keywords

Solid fuel combustion, Computational fluid dynamics (CFD), Air staging, Parametric simulation

Virtual Reality Supported Transition Processes in Teams Developing Products

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Introduction

Product development (PD) organisations often employ teams whose activities can be divided into action and transition episodes. During action episodes, teams are engaged in acts that contribute directly to goal accomplishment. On the other hand, during transition episodes, teams' primary focus is on evaluation and/or planning activities as a guide to accomplish the team goal. Transitions serve as critical mediators through which team inputs influence team outcomes; however, they are still not well understood and require further examination. In the context of PD, common manifestations of transitions are design reviews which are most often conducted between the phases of the process. In design reviews, teams commonly use 2D interface (e.g. paper, screen) to share information about the product (e.g. requirement list, 2D drawings, 3D models). However, with the recent proliferation of virtual reality (VR) technologies, researchers often point out the implications of new technologies such as VR for supporting design reviews. VR technology may potentially decrease the time for manipulating objects, improve spatial awareness, help in identifying design issues. VR might also improve collaboration, especially in settings where teams do not share the same physical space, but rather work virtually. Given the importance of transitions in PD and the implications of VR for design reviews, bridging these two perspectives seems to be a necessary research step.

Aims

This work aims at developing an experimental research framework for studying VR supported teamwork within transition processes in PD, and a theoretical model of team transition processes in the same context.

Methods

The research is divided into three cycles of activities: Relevance, Design, and Rigour cycle. Within the Relevance cycle, a literature review will be conducted to identify the requirements which will define the problem space. In the Design cycle, insight from the literature review will be used as a basis to design the experimental framework and the theoretical model which will be implemented through the series of experiments. Finally, in the Rigour cycle, validation criteria will be identified from the scientific literature to ensure scientific rigour of the presented research.

Expected scientific contribution

With successfully conducted research, several scientific contributions are expected. The first contribution is a theoretical model of team transitions within PD. Next, an experimental framework that enables the study of the VR supported teamwork for transition processes in PD will also be proposed. The third contribution is manifested through design review case study with the aim to validate the proposed model.

Acknowledgments

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Keywords

virtual reality, team, transition processes, design review, product development

Development of a New Alloying System for Tool Steels Based on Thermodynamic Parameters

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Introduction

Tool steels for hot work are designed for tools, which are heated during operation to a temperature higher than 200 °C. In such conditions, this group of tool steels is exposed to sudden temperature changes, high mechanical and impact loads, so extremely good properties are required from tool steels for hot work. Tool steels are alloyed with carbide forming elements (Typically: vanadium, tungsten, molybdenum and chromium). Addition of alloying elements serves primarily purpose to improve the hardenabillity and to provide harder and thermally more stable carbides than cementite. Assuming proper heat treatment, the properties of a tool steel strongly depends on which alloying elements are added and their respective concentrations.

Aims

The most important property of tool steels for hot work is tempering resistance. Also high impact strength, good shape and dimension stability, high wear resistance, good tempering resistance and high-temperature corrosion resistance are also required from tool steels for hot work. In addition to the above-mentioned requirements expected from this group of steel, it is very important to know the influence of medium in which they are exposed. If used in various metal treatments, they are most often exposed to oil and water based emulsions. Also, it is of great importance to explore the additional capabilities of these materials, such as corrosion resistance testing in various media, to which these tool steels could be exposed in practice.

Methods

Experimental material analysis techniques will allow the obtaining of thermodynamic parameters that are necessary for the application of the material. The research would include the design of the chemical composition, calculations and thermodynamic parameters of the equilibrium phase diagram. Thermo-Calc method would provide certain thermodynamic parameters that are suitable for describing the system and predicting the phase diagrams. For the purpose of preliminary research, by the electrochemical measurements corrosion resistance of tool steel for hot work in medium of emulsion, water and 3.5% NaCl was investigated. The metallographic analysis of the tool steel exposed to the emulsion medium showed no microstructural changes. However, corrosion products on the surface of the tested tool steel were observed in the medium of water and chloride media.

Expected scientific contribution

The research would be based on the connection of thermodynamic parameters and phase changes in the investigated tool steels, and then would be predicted the development of the microstructure with reference to the relevant thermodynamic parameters. By choosing an appropriate chemical composition, the proportion of elements involved in the production of tool steel can be balanced, thus achieving the highest quality properties. All the results obtained will be compared with the analyses that will be made on industrial samples of tool steel.

Acknowledgments

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Keywords

Tool steels, metallurgical processes, thermodynamics, alloying elements, corrosion

The Influence of the Process Parameters of the Nanosecond Fiber Laser System on the Ablation of Steel and Brass

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Introduction

Laser milling became widely accepted as an alternative to conventional methods of material removal. Fiber lasers based on master oscillator power amplifier (MOPA) architecture allow for a fine control of pulse characteristics and thanks to its high efficiency and low prices already supplant classic solid-state lasers. The utility of laser milling for industrial purposes is mainly conditioned by the material removal rate (MRR) and the quality of the ablated surface. We aim to maximize those two demands, but in practice they are mutually exclusive. The determination of working parameters is usually a matter of compromise. In order to optimize the ablation process, it is crucial to know the impact of individual process parameters.

Aims

The aim of the research is to determine the influence of different parameters on the results of laser ablation with nanosecond laser sources and to deepen the understanding of the light-matter interaction. This will enable the optimization of the process in the processing of industrially interesting materials and increase its applicative value.

Methods

We designed an experimental study to determine the influence of the selected process parameters on the quality of the ablated surface and the MRR for the selected materials (brass CuZn37, stainless steel AISI 316L). The MRR was quantified by the amount of material removed in a unit of time, while the quality of the ablated surface was determined by its surface roughness (S_a). A 20 W Yb fiber laser source based on the MOPA architecture operating at 1064-nm wavelength was used. We investigated the effects of the pulse repetition frequency (f_{las}), pulse length (t_p), pulse overlay ($\eta_{p\text{-}p}$), spacing between scanning traces ($d_{l\text{-}l}$), and scanning techniques. We also studied the effectiveness of sample processing in an inert atmosphere and evaluated the relevance of introducing intermediate polishing phases in the ablation process.

Results

The MRR increases to a certain extent with both t_p and f_{las}. If the fluence of the laser pulses does not exceed a certain limit value, we get a maximum MRR at a f_{las} where the energy of an individual pulse (E_p) and the average power of the laser are the highest. Otherwise, the maximum is moved to higher f_{las}. The optimal MRR is achieved at cca. 50% overlap of the craters formed by a single pulse, while the use of the inert atmosphere significantly reduces the MRR. The quality of the treated surface is influenced predominantly by the $\eta_{p\text{-}p}$, with the higher overlap resulting in lower S_a. The influence of the f_{las}, which defines the degree of surface oxidation, and the scanning technique, which determines the amplitude of the surface relief, are also significant. S_a of steel increases with the number of laser passes, while it stays the same when ablating brass. The use of an inert atmosphere also influences the quality of the surface, but further research is needed. Based on the experimental findings, we achived MRR of 5.9 and 3.2 mm^3/min and S_a of 1.0 and 6.8 μm while laser milling brass and stainless steel, respectively.

Expected scientific contribution

Determining the influence of individual process parameters on the ablation results will enable the improvement of laser ablation with regard to the quality of the treated surface and the rate of ablation. The research results will further increase the applicative value of the studied process.

Keywords

Laser ablation, nanosecond Yb fiber laser, MOPA architecture, brass CuZn37, stainless steel AISI 316L

APPROVED TOPIC

The Impact of Personal Attributes on Increasing the Success of Complex Projects

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Introduction

Number of complex projects is increasing in many sectors and the challenges for such projects are significant. The project manager is meant to, in the beginning of the project, select the framework and tools that best suits the defined project. Research shows that frameworks and project management methodologies do not have a direct link to achieving project success, but that for achieving project success experience as well as adaptation of existing frameworks and methodologies to the current project are an important factor. Project team working on the project is equally important for the success of the project. Collaboration within the team and the success of each team member are critical factors for project success. However, the impact of the project team and project managers personal characteristics on the project success was not, until now, further explored.

Methods

The starting point of this research was the research of the existing literature and the definition of the hypothesis. Qualitative methods of collecting data in form of a questionnaire have been used to prove the set hypothesis. Semi-structured interviews will be used during 1:1 interview with project managers as well as selected members of project teams, while the questionnaires were used for the whole project teams. The conducted research can be validated by testing and re-testing or using an independent equivalent measurement, or by both. In this case, both approaches will be used to achieve different validity goals, including data triangulation approach. A re-examination will be used to determine if the responses were biased. Data collected through the questionnaire will be analysed using descriptive, analytical statistics and data collected through interviews will be analysed using analytical statistics and content analysis. To form a distinctive benchmark, the research will be conducted on both successful and unsuccessful projects, as well as in multiple countries.

Preliminary results

Preliminary results based on the segment of the research focusing on project teams, project managers, project frameworks and tools and project success indicate that there is a significant relationship between all mentioned areas and project success. Personal attributes that were under consideration were those of the project manager and the project team. These results are ensuring a solid starting point for further research and are in accordance with the outcome from the existing literature review.

Discussion

The research in project management is recognized but not further explored, when considering the personal attributes of project team members and project manager and their impact on project success of complex projects. Creation of a project team consisting of members with the predefined and specified personal attributes capable of realizing and increasing the success of complex projects is expected to move the limits of existing project management practice. The research approach, where the human factors are recognized as one of the critical success factors and the comprehension of personal attributes which need to be present in the project team together with establishing novel framework for tracking project success will be described and defined, will acknowledge the importance of detailed human factors studies, when educating the new generation of project managers.

Keywords

Project management; Complex projects; Project Management Framework; Project Success; Personal Attributes

Consideration of Al-2,2 Mg-2,1 Li Alloy's Equilibrium and Non-Equilibrium Solidification

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Introduction

Density reduction, stiffness increase, increase in fracture toughness, fatigue crack growth resistance and crack propagation behaviour are considered to be the benefits of aluminum-magnesium-lithium (Al-Mg-Li) alloy application. The mechanical properties result from microstructure development during solidification. The solidification sequence is manly influenced by chemical composition and thermodynamic parameters. The investigation was conducted in order to estimate the influence of Li and Mg additions, as well as different heating and cooling rates on solidification of Al-2,2Mg-2,1Li alloy.

Methods

The alloy was synthesized in induction melting furnace under vacuum and cast into a permanent steel mould without protective atmosphere. Solidification sequence under equilibrium and non-equilibrium conditions was identified using Computer Aided Thermodynamic Diagram Calculation (CALPHAD). Equilibrium calculations covered processes in liquid and solid state. Calculations in non-equilibrium conditions, based on Scheil-Gulliver solidification, included only liquid state processes. The solid state processes were not influential due to the low diffusion rate. The influence of heating and cooling rates on solidification sequence was determined by Differential Scanning Calorimetry (DSC). Microstructural constituents were identified by different techniques of metallographic analysis. The solidification sequence under non-equilibrium conditions was considered by correlating the results of CALPHAD, DSC and metallographic analysis.

Preliminary results

Equilibrium solidification begins with transformation of α_{Al} dendritic network followed by diffusion based solid state precipitations. Stable Al-Li (δ) phase precipitates first as a result of reduced solubility of Li in α_{Al} and a high Li/Mg ratio. Ternary Al_2LiMg (T) phase precipitates from Mg rich bulked α_{Al}. Equilibrium solidification ends with the precipitation of Al_8Mg_5 (β) phase. Predication under non-equilibrium conditions covered the transformation of α_{Al}, and solidification of stabile δ and ternary T phase directly from the Liquid. Precipitation of β phase was not expected. Solidification sequence under non-equilibrium conditions begins with transformation of α_{Al} dendritic network followed by the precipitation of metastable Al_3Li (δ′) phase inside the grains of α_{Al}. Metastable precipitation is caused by reduced solubility of Li in α_{Al}. During the rest of solidification, δ′ phase is used as a nucleus for precipitation of both δ and T phase. Nucleation and growth of δ and T phase causes the formation of precipitation free zones (PFZ) near grain boundaries. Solidification ends with the precipitation of irregular and course β phase at grain boundaries.

Discussion

The Al – 2,2 Mg – 2,1 Li alloy investigation indicated a significant influence of chemical composition and thermodynamic parameters on the solidification sequence. This correlation caused variations between equilibrium and non-equilibrium solidification.

Acknowledgments

Investigations were performed within the research topic „Design and Characterization of Innovative Engineering Alloys", funded by UNIZG, scientific-research project within Croatian-Slovenian collaboration "Design and Characterization of Innovative Aluminum – Magnesium – Lithium alloy funded by MSE and infrastructural scientific project: Center for Foundry Technology, KK. 01.1.1.02.0020 by ERDF.

Keywords

Al-2,2 Mg-2,1 Li alloy, solidification, equilibrium and non-equilibrium solidification, microstructure.

Heat Affected Zone Micro-Structure of Weld Joint Preparation in Artificial Manner

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Introduction

This paper presents two possibilities of martensitic (fine grain and coarse grain) microstructure preparation. Fine and coarse grain microstructures are present as sub-zones in the heat-affected zone of welded joints, but due to the narrow region of HAZ in a real weld, only a few tests are possible to perform such as micro-hardness. The material used in this study was a Nickel Molybdenum alloy steel (18CrNiMo7-6), which is a case hardening steel with high toughness. This type of steel is mostly used in the automotive industry for heavy load capacity components. To investigate the mechanical properties of sub-zones of the HAZ of this particular alloy steel, specimens with entire microstructure (fine and coarse grain) were prepared by applying proper thermal cycles. Thermal cycles were conducted in the welding simulator and laboratory furnace. Hardness and diameter of grain size were measured, Tensile test and Charpy instrumented test of both microstructures were performed in room temperature. The difference in Impact toughness was markable due to the difference in microstructure, energy for initiation and propagation were calculated by comparing (F-t and E-t) diagrams for both microstructures. The study revealed that the preparation of specimens with microstructure as at welded condition is possible, and it could lead to prepare samples for investigation of other mechanical properties such as fatigue crack growth and fracture toughness test.

Keywords

Weld joint, laboratory furnace, welding simulator, fine grain HAZ, coarse grain HAZ.

Learning from Demonstration Based on a Classification of Task Parameters and Trajectory Optimization

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Introduction

Learning from demonstration involves the extraction of important information from human demonstrations and the reproduction of robot action sequences or trajectories with generalization capabilities. Task parameters represent certain dependencies observed in demonstrations used to constrain and define a robot action because of the infinite nature of the state-space environment.

Methods

We present the methodology for learning from demonstration based on a classification of task parameters. The classified task parameters are used to construct a cost function, responsible for describing the demonstration data. For reproduction we propose a trajectory optimization that is able to generate a simplified version of the trajectory for different configurations of the task parameters. As the last step before reproduction on a real robotic arm we approximate this trajectory with a Dynamic movement primitive (DMP) – based system to retrieve a smooth robot trajectory.

Preliminary results

Results show that the system is able to extract multiple task parameters from a low number of demonstrations. Based on this we are able to generate collision free trajectories that encode task parameters for new situations.

Discussion

Learning and reproducing a task from human demonstrations is difficult because of the high dimensionality of the robot operation space. For now, virtually two main choices exist. Learning the demonstration data with respect to certain task parameters and constructing a statistical model, or providing interesting features occurring in the demonstrations and learning a reward/cost function with respect to them. We use ideas from both concepts to construct methodology to analyze human demonstrations and generate generalizable task constrained trajectories.

Acknowledgments

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Keywords

Learning from demonstration, Task parameterized movement, Trajectory optimization

Machine Learning Algorithms for Modelling Consumption in District Heating Systems

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Introduction

The building sector in the EU spends about 40% of the total final energy, from which a further 80% is energy for space heating and domestic hot water preparation. In recent years, there is an extensive development of the Data science and Big Data sciences and the wider application of machine learning methods to the analysis of the various areas.

Methods

In this research machine learning algorithms and statistical methods were implemented together with comparative analysis and identification of the most appropriate algorithm to model and plan consumption in district heating systems. Several machine learning algorithms where implemented, namely multiple linear regression, logistic regression, decision trees, random forest and support vector machines. Each of these algorithms was implemented over a dataset of approximately 1,750 district heating substations in 600 buildings in two towns in Croatia. The focus of the analysis is the comparison of the consumption in the years prior and after to instalment of heat cost allocators. as well as the overall modelling of the consumption in district heating sectors taking into consideration both technical and behavioural influential parameters.

Preliminary results

Results of modelling and predicting consumption in district heating systems using above mentioned five machine learning algorithms are presented and interpreted while each of the algorithm is evaluated accordingly.

Discussion

The influence of non-technical parameters should beaccessed in more details in further research.

Keywords

district heating, heat cost allocator, energy efficiency, machine learning, support vector machines

Fatigue Modelling in Tooth Root of Surface Hardened Gears

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Introduction

Gears are one of the most commonly used components for power transmission. During power transmission, variable stresses occur in the tooth root region of the gear. Since gear mesh occurs once per full rotation, the stresses in the tooth root region are also of cyclic nature. The aforesaid results in bending fatigue of the gear, which may cause fatigue crack initiation and, consequently, complete fracture of the tooth. For surface hardened gears, in addition to surface initiation, subsurface crack initiation is a possibility. Hence, to prevent rapid crack growth and possible complete failure of the gear, proper gear design for both surface and subsurface initiation must be ensured. Through employment of different fatigue crack initiation criteria, a computational model will be developed for predicting location and number of cycles for fatigue crack initiation in the tooth root region of surface hardened gears. Surface and subsurface fatigue crack initiation parameters will be distinguished.

Methods

The research is theoretical with an emphasis of computer simulations and will be conducted by using test specimens and gears made of low-alloy steels suitable for surface hardening processes. Bending fatigue life of surface hardened gears will be determined by employing the multilayer method and strain-life approach. At the same time, the applicability of different fatigue crack initiation criteria will be investigated. Due to complex geometry of the gear, finite element method (FEM) will be used to obtain nominal tooth root stresses and strains. The research itself is divided into phases, starting with relatively simple geometries and loading conditions such as surface hardened specimens under pure bending loading. With gradual increase in the complexity of the geometry and loading parameters, bending fatigue of surface hardened spur gears by simulating actual operating conditions will be investigated.

Preliminary results

Preliminary research of the investigation conducted on surface hardened specimens has yielded with a proposition of analytical approach used to predicted bending fatigue life and location of the failure initiation. Two types of specimens with different case hardening depths were investigated. Bending fatigue life predictions have shown good correlation with the experimental results from the literature, with 93% of data falling within the scatter factor of three. Rough agreement of predicted failure location was observed with the reported shift from surface to subsurface failure.

Discussion

Preliminary investigation will be used for the following phases where actual gear geometry will be considered. Due to relatively complex gear geometry and loading conditions, FEM and critical plane method will be employed. The effects of friction and centrifugal force will also be investigated.

Keywords

bending fatigue, strain-life approach, finite element method, surface hardening, multilayer method

Numerical Modelling of Multi-Component Dense Sprays

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Introduction

The development of alternative fuels, such as lower cost refinery fuels, solar fuels, heavy fuel oils, represents one of the main directions of internal combustion engine research. These modern fuels require a new modelling framework capable of predicting their multi-component behaviour in engine-like conditions since droplet evaporation of such fuel involves physical processes which are significantly more complex than in a fuel that can be approximated by one component. Therefore, the topic of this research project is the development of a numerical model capable of predicting the dynamic behaviour of multi-component fuels in dense sprays.

Methods

In the current method, the poly-dispersed nature of the spray is handled using the method of classes in the Euler-Euler framework, where each dispersed phase is characterised by its droplet size and velocity. This approach treats every droplet class as a different phase in the calculation. Therefore, every size class has its momentum and continuity equation, but the mixture pressure is shared among all phases.

In the next phase of the research, the individual size classes will undergo breakup and coalescence, acting as mass source/sink terms in phase continuity equations via breakup and coalescence. Also, the fuel species concentration equations for each size class will track the concentration within the liquid. In the gas phase, equivalent species concentration equations will be implemented to track the gaseous fuel components.

The evaporation will be modelled with a combination of multi-species diffusion within each droplet class and the actual evaporation process on the outside surface of the droplet. To adequately initialise the spray in the near-nozzle region, the droplet properties (droplet position, size and velocity) on the inlet boundary of the computational mesh will be inherited from the direct numerical simulations of the primary atomization.

Preliminary results

The implemented Eulerian multi-fluid model is initially tested for a monodispersed bubbly air-water upward flow which forms a mixing layer inside a square duct. The test showed that the current implementation of the basic Eulerian multi-fluid model gives stable and consistent results which are in good agreement with the available experimental measurements.

Discussion

The implemented Eulerian multi-fluid model shows good agreement with available experimental measurements. The addition of the breakup and coalescence model will enable the model to predict dense spray flows. Furthermore, the implementation of the multi-component evaporation model will contribute to the accuracy of modern fuel spray dynamics simulations.

Acknowledgements

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Keywords

multi-phase flow, Eulerian multi-fluid model, dense spray, OpenFOAM

Numerical and Experimental Investigation of Anisotropic Material Behavior in Crimping Process

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Introduction

The wire crimping process is a solderless procedure of making an electrical connection between wire strands and terminal. It is one branch of the metal forming process where the terminal is drastically deformed to the new shape. Due to the minimization of all parts in the automotive industry and new demands on reliability and safety, together with the applications of new materials and new production technologies, new studies must be made. For terminal production, thin sheets of copper alloys are used. Due to metal rolling process of copper and its alloys, severe anisotropy of mechanical properties may occur

Methods

In order to describe material anisotropy and define the constitutive module, experimental investigations are unavoidable. Tensile and compression tests on specimens, along with wire crimping process are performed. For investigation purposes, two non-contact approaches are used. With optical measurement system ARAMIS 4M, which is based on digital image correlation (DIC), detection of local strains and displacement on complete specimen surfaces is achieved. Accompanied with DIC method, infrared (IR) thermography measures temperature changes on specimen surface during the specimen load. Within the framework of numerical investigations the two and three-dimensional simulations are performed using implicit and explicit finite element methods in the FE program ABAQUS/Standard and ABAQUS/Explicit.

Preliminary results

Experimental results show severe differences in material behaviour at different rolling directions, tensile strength, elongation and elastic modulus are changing. With increased strain rate, tensile strength and elongation are increased while elastic modulus maintains constant. When a material is stressed up to yield point, IR camera detects small temperature drop, but after material passes the yield point and starts to deform plastically, temperature will rise. With numerical simulations, all three types of tests are performed and compared to the experimental results.

Discussion

Copper alloys plates which are produced with rolling process have severe anisotropy due to changes in grain morphology. After rolling, grain size is reduced and stretched in rolling direction. New grain pattern leads to differences in elastic modulus, tensile strength, yield point and elongation of material in different rolling direction. In order to have accurate numerical results, a new constitutive model must be made and numerical simulations must be validated with experimental results.

Acknowledgments

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Keywords

Wire crimping, material anisotropy, strain rate, copper alloy,

First Obd Test Results of Passenger Cars Collected During Periodic Technical Inspection in Croatia

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Introduction

Due to resolution or measurement precision limitations, existing emission testers used in periodic technical inspection (PTI) stations often cannot measure neither the CO volume fraction of Euro 6 petrol engine vehicles, nor the opacity of the Euro 6/VI diesel engine vehicles. Therefore, the application of these devices to the Euro 6/VI vehicles becomes less important. For vehicles complying with emission classes Euro 6/VI, OBD systems are becoming more effective in assessing emissions. According to the Directive 2014/45/EU, for roadworthiness tests the OBD test can be used as an equivalent to standard tailpipe emission testing for vehicles of emission classes Euro 6/VI. Effective from 1st January 2019 OBD testing methods are implemented in Croatia. An OBD connection is required in vehicles belonging to emission classes Euro 3 and newer wherein the following data are collected: MIL status, Readiness-code status, number of DTCs, coolant temperature and engine speed. In addition to the OBD test, the classic tailpipe test is also performed on vehicles of all Euro classes.

Methods

During the PTI, the emission tester and OBD diagnostic tool should be connected to the vehicle. Tailpipe and OBD test results are collected and stored on the OWR17 device. Then all the collected data is transferred to CVH database using RFID card.

Results

The lower the Euro emission class is, the higher is the percentage of PCs with MIL status ON. The number of OBD tests with MIL ON is directly proportional to the average annual vehicle mileage. The higher the mileage is, the higher is the percentage of PCs with MIL status ON. The majority of vehicles meets the following requirements: MIL OFF, Readiness OK and DTC counter = 0. There is a certain number of PCs that, despite passing the OBD test, did not pass the tailpipe test. The data also shows the following: The lower the Euro emission class is, the higher is the percentage of PCs which did not pass the tailpipe test. All Euro 6 vehicles with OBD status MIL OFF and Readiness NOT OK passed the tailpipe test.

Discussion

Before the implementation of OBD tests, an inspector could check the MIL status only visually on the dashboard. This is why owners whose MIL would turn on would often thinker with the system so as to conceal the MIL status. Using the OBD test, the amount of unprofessional tinkering has been greatly reduced because the necessary information is gathered straight from the ECU, regardless of the MIL status on the dashboard. The ECU is also used to gather the VIN, which makes it easier to ascertain whether it matches with the VIN in the documents and on the chassis itself. The OBD system can also show the vehicle's Readiness-code, according to which it is possible to establish which of the vehicle's systems were checked during the diagnostics procedure. Furthermore, the DTC counter shows the total number of faults in the system. This research is a part of my PhD thesis entitled "An Advanced Road Transport Emission Model".

Keywords

Euro emission class, DTCs, MIL, OBD test, Readiness-code

Application of Numerical and Experimental Methods in the Development of a Polymer Solar Collector

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Introduction

Flat plate collectors used for domestic hot water production have already reached high values of thermal efficiency. This is mainly due to excellent thermal, optical and mechanical properties of used materials in the production of FPCs and its design. On the other hand, by using these materials FPCs still, have a relatively high price preventing their wider use. As a result, the development of solar technology is increasingly directed towards application of polymeric materials for the production of solar thermal collectors. Application of cheaper materials and simpler manufacturing process (e.g. extrusion of material or 3D print) would allow the production of solar thermal collector at significantly lower costs, which would eventually lead to further increase of installed collectors. All polymeric materials have poor thermal, optical and mechanical properties compared to materials traditionally used in the FPC production. Therefore, a major challenge to solve is how to prevent degradation and deformation of polymeric materials that occur at relatively low temperatures maintaining low production cost.

Methods

Numerical part of the research will be done within program package FLUENT. 2D numerical simulations of the section of polymer solar collector will be performed in the first part of the research to obtain preliminary results. Based on the findings a prototype of the polymer solar collector will be designed and experimentally tested according to relevant EN standards. Afterward, 3D numerical simulations will be performed to further analyzed proposed prototype design.

Preliminary results

Preliminarily results obtained with 2D numerical simulations show that polymer solar collector has 30% lower efficiency at typical summer operating regime. In the stagnation regime, there is an indication that temperature will rise above 100°C which will cause degradation of the low-cost polymeric materials. Different cover plate configurations are tested in ordered to increase thermal efficiency and reduce stagnation temperature. Results indicated that proposed configuration will increase both thermal efficiency and stagnation temperature. Cooling methods based on natural convection are also examined. Some reduction of the stagnation temperature is expected, but values are still above 100°C.

Discussion

Major issues to be solved before polymeric materials can be successfully used in the FPC production is how to preserve high values of thermal efficiency with low stagnation temperature while maintaining low manufacturing cost. Proposed design of polymer FPC has lower thermal efficiency which can be compensated with proportionally larger installed collector area. Stagnation temperature needs to be further reduced to prevent degradation of the material. Proposed cooling methods are not able to reduce temperatures inside collector below 100°C and other methods must be analyzed, along with others in order to increase thermal efficiency.

Keywords

Numerical modeling, FLUENT, polymer solar collector, heat transfer, experiment

Low and High Strain Rate Loading of Auxetic Cellular Structures

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Introduction

Auxetic cellular materials are modern materials with unique mechanical properties. They exhibit a negative Poisson's ratio due to their internal structure, i.e. they get wider when stretched and thinner when compressed. Their complex internal structure necessitates the fabrication with additive manufacturing technologies.

Methods

This work is concerned with analysis of 3D auxetic cellular structure build from inverted tetrapods. The analysed samples were fabricated from Ti-6Al-4V powder using the selective electron-beam melting (SEBM) method at the Institute of Materials Science and Technology (WTM), University of Erlangen-Nürnberg, Germany.

The mechanical behaviour of the analysed auxetic samples with three different porosities was determined in two different orthogonal directions by low and high strain rate compressive testing. The effects of the fabrication procedure on the compressive mechanical response of auxetic cellular structures were studied by means of micro computed tomography and microscopy. The deformation patterns occurring during the low strain rates were additionally observed with infrared tomography. The high strain rate compression testing (strain rates up to 10000 s^{-1}) was performed by using powder a powder gun experimental device.

Preliminary results and discussion

The results show that the strain rate effect on analysed auxetic samples is significant when the shock deformation mode is achieved, i.e. when most of deformation occurs at the impact front. The change in the loading orientation changes also the deformation mode of the auxetic structure from crushing in shear planes to layer-by-layer crushing, regardless to loading velocity.

The computational models in LS-DYNA were validation based on the results of the experimental testing. The computational models were then used for an extensive sensitivity study of the geometry and additional parametric mechanical testing of auxetic composite panels under different loading conditions.

Keywords

cellular materials, auxetic materials, negative Poisson's ratio, blast loading

Control of Direct Driven Electrohydraulic Systems

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Introduction

In the last decade, energy efficiency is one of the most important research topics in hydraulics which lead to a compact electro-hydraulic system. Such systems are controlled with valve or pump and they can deliver powerful linear movement. The charac-teristics of these systems are their small-to-power ra-tio and ability to achieve very large forces and tor-ques. The main drawback of valve-controlled hy-draulic system is their low energy efficiency due to constant fluid throttling process. An alternative to valve-controlled systems are pump controlled sys-tems which are directly driven by servo motor. These systems have superior efficiency and compact struc-ture then conventional systems. Additionally, speed control is directly done by the servo motor thus al-lowing a wide range of speed control, high accuracy and energy efficiency. Within this work, control of Direct Driven ElectroHydraulic (DDEH) system is being investigated and compared to a conventional hydraulic system.

Methods

The methodology of the proposed research consists of five phases: literature review, mathematical mod-eling, numerical simulations, experimental research and integration of IoT technologies in the proposed experimental setup. Detailed literature overview showed that the focus of research is the construc-tion, thermal analysis and implementation of DDEH systems while from the aspect of control theory such systems are insufficiently explored. Two nonlinear dynamical models are derived, first one for the DDEH system and the second one for a classical electrohydraulic system. Numerical simulations are carried out in Matlab program using a nonlinear state space representation of the derived models. In this research the proposed DDEH setup is designed and manufactured for the experimental validation of re-sults. Both the DDEH system and the classical sys-tem will be experimentally verified through multiple tests. Comparison of both systems will be done for the same working conditions enabling their mutual comparison of the experimentally obtained results. In the final phase, some possibilities for the integration of IoT technology in the proposed system will be further explored.

Preliminary results

The first stage results showed that the further inves-tigation of DDEH system from the aspect of control theory offers promising results. Nonlinear dynamic model of the DDEH system was tested with initial conditions of 0.25m for a piston displacement and showed expected results in gravitational field while input variable was kept at zero. Simulation results for PID controller showed a small steady state output error for a step input signal, while phase shift of out-put signal occurred for a sinusoidal wave input sig-nal.

Discussion

Preliminary results showed that the system was cor-rectly modeled, but further experimental results are certainly needed to verify that assumption. The next step will be the practical construction of an experi-mental DDEH setup and verification of preliminary results. Furthermore, nonlinear control algorithms will be tested and conclusion on dynamics, precision and energy efficiency of the system will be given.

Acknowledgments

The research was partial enabled by the financial support of PhD "Experimental research" found of the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb.

Keywords

hydraulics, direct driven hydraulics, control theory, system modeling

A Phase-Field Model for the Prediction of Brittle Fracture

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Introduction

The phase-field approach to fracture modeling introduces a scalar field which separates the broken and unbroken material phases and can be physically perceived as a damage variable. It thus avoids the problem of numerical tracking of the crack surface, inherent to the discrete crack modeling approaches, and enables a simple extension of the model to the 3D settings. Moreover, it overcomes the non-physical behavior of the classical „local" continuum fracture and damage mechanics models by the incorporation of an internal length scale parameter, similar to the „non-local" damage models. That way, the loss of ellipticity of the system's governing equations on the onset of the deformation localization and material softening is prevented thus solving the problem of the mesh density and mesh orientation dependent results within the framework of finite element method. The phase-field fracture model presented in this work is based on a variational principle of the energy minimization as an extension of Griffith's brittle fracture theory. As such, it is thermodynamically consistent and able to predict complex fracture phenomena, e.g., crack initiation and propagation with merging and branching, without any additional fracture criteria. For the stated reasons, the phase-field approach to fracture has gained a lot of popularity in the last decade.

Methods

The phase-field brittle fracture model is implemented in the finite element framework via the commercial software ABAQUS. Due to the non-convexity of the initial phase-field free energy functional, a robust staggered solution scheme based on the operator split is employed by the means of the UEL and UMAT subroutines, together with the improved residual based stopping criterion of the staggered iterative scheme. The phase-field parameter is introduced in the formulation as an additional degree of freedom whose evolution is driven by the elastic deformation energy.

Preliminary results

The presented model implementation is tested on the standard benchmark examples for the mode I and II fracture problems as well as on the arbitrary porous geometries resembling the heterogeneous microstructure. The obtained results are compared with the experimental and numerical results from the literature in terms of accuracy, robustness and computational costs.

Discussion

The results obtained by the presented model match the experimental data and the numerical solutions from literature very well while demonstrating an improvement in the computational efficiency compared to the existing ABAQUS implementations of the phase-field fracture modeling.

Acknowledgments

This work has been fully supported by Croatian Science Foundation under the project Multiscale Numerical Modeling of Material Deformation Responses from Macro- to Nanolevel (2516).

Keywords

brittle fracture, phase-field model, staggered algorithm, ABAQUS

Modelling of Divertor Target Plate Heat fluxes During Intense Plasma Transients in Tokamaks

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Introduction

The plasmas of interest here in this context correspond to the Scrape-Off Layer (SOL) region in fusion devices of the tokamak-type. These devices rely on controlled thermonuclear fusion processes appearing in sufficiently dense high temperature Hydrogen plasmas. This work is devoted to the transport coefficients in ITER under high confinement regimes (H-mode) when the potential structure/barrier, establishing at LCFS known as pedestal (which is essential feature responsible for the H-mode) crashes, so that the core-plasma is suddenly expelled to the SOL throughout large-scale filament-like structures known as Edge Localized Modes (ELMs). The collision-free contribution enters the corrected transport coefficients throughout the weighting factors named the flux limiters. In addition to the transport coefficients the kinetic effects must be know also for the boundary conditions, such as the potential drop between the plasma-sheath edge (PSE) and the divertor surface, the directional ion velocity at PSE and the sheath transmission coefficients. Together with the flux limiters these expressions make a set of kinetic factors (KFs).

Methods

Resolving the spontaneous appearance and dynamics has to be done via the analytic-numerical approach combined with fluid computational simulations. The input data which are either improved analytic formulation or improved raw-data arrays containing the spatial-temporal kinetic factors (limiters and boundary conditions) will be obtained by combining the kinetic simulations for ITER scenarios, with the experimental data extrapolated to ITER from existing tokamaks. Besides theoretical method (attempting on semi-analytic results) the particular kinetic and fluid algorithms for the plasma simulations (BIT1 and SOLPS-ITER) will be updated and/or upgraded and applied.

Preliminary results

The time-dependent KF-profiles from BIT1 i.e sheath heat transmission coefficients and kinetic heat-flux limiters will be implemented to SOLPS-ITER and applied for simulating the ELMs under critical power load conditions. The transient heat flux coefficients will provide answers on how the energy is distributed in time, through the transient. As a results, thesis will provide more realistic estimates of what the ELM target loading might actually be. The focal point of the first ELM simulations will be mitigated Type I ELMs.

Discussion

The transient heat loads on divertor targets by the ELMs represent one of the greatest threats for target lifetime, which can lead to serious unwanted consequences in the next generation fusion reactors such as ITER. The first step towards solving this research problem is understanding and characterising the underlying ELM physics corresponding to the demanding discharge scenarios, such as mutual charged and neutral particles with fields and material-surface interaction taking place in tokamak devices. The work is based on the hypothesis that understanding and description of uncontrolled ELMs.

Keywords

Scrape-Off Layer, Edge Localized Modes, Kinetic factors, ITER, Flux Limiters

Transition from Individual to Lean and Agile Mass Production

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Introduction

Customers require short delivery times and high quality products.We can fulfill both customer requirements if the company moves from classical organized production to lean and agile production.The goal of lean production is to eliminate all types of wasting and to do as much business as possible in as short a time as possible,using as little space as possible,with as little human effort as possible,with fewer machines and with as little material as possible,and at the same time deliver quality products and services to the buyer in good time in the agreed quantities,place and price.The agility of production enables successful adaptation of the company to the requirements of customers in a rapidly changing market environment, based on four criteria:flexibility,innovation,productivity and profitability.The latter can be regarded as one of the main goals of agile production.Ensuring productivity is the starting point,and flexibility is a method for achieving agility.Innovation is a prerequisite for introducing leanness as well as agility.An agile manufacturing system enables quick and efficient response of the production process on changing demand of the customers. Lean and agile manufacturing is most often considered in connection with serial and mass production.SME,with predominantly individual and small-scale production,are very important for the Slovenian and European economy.

Methods

Case study method:With VSM we will create a current state map and the ideal state map.

A method of action research(research and action) to identify various factors that hinder or support the implementation of lean and agile manufacturing.

Method of analysis and synthesis(analysis of the current state, synthesis and generalization of conclusions that will enable the creation of the ideal state map of the production process).

The method of expertise, which, based on the conclusions of the previous three methods, enables the creation of the general model for transition from individual workshop production to lean and agile series production of cellular and/or line type.

Preliminary results

Research focus is to consider a combination of lean and agile manufacturing in SMEs with an emphasis on the transition from individual production to lean and agile serial production.

Discussion

The research and the generalized process of transition from individual to serial lean and agile production will enable SMEs to introduce lean and sgile production, thereby increasing the flexibility and agility to the customer requirements while reducing the flow time of orders,lower costs,higher product quality and higher added value.

e research and the generalized process of transition from individual to serial lean and agile production will enable SMEs to introduce lean and agile production, thereby increasing the flexibility and agility to the customer[KT1] requirements, while reducing the flow time of orders, lower costs, higher product quality and higher added value.

Keywords

Lean manufacturing, agile manufacturing, generalized model, VSM

Effect of Carbon Nanotubes on Behavior of Polymeric Materials

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Introduction

Carbon nanotubes (CNTs) present revolution on the area of material science, since they are capable to establish CNT network within matrix material and therefore profoundly enhance physical properties and tailor new functionalities of material at very low concentrations. Currently they represent one of the leading directions of research programs within EU, i.e. Graphene flagship, when using them in composite materials, sensors, etc. Although CNTs are designated as an ideal representative among nano fillers, there is still a lot of unexploited potential in terms of improving physical properties and functionality of nano composites.

Aims

In the first step (improvement of physical properties) we want to use "alternative" approaches, i.e. the growth of crystals in a CNT bundle, which could influence the formation of the CNT network within the material (interconnected tree structures). It has been proven that with similar approaches (by adding decorated CNTs) we can improve physical properties for several orders of magnitude

In the second step (improvement of functionality) we want to determine their time-dependent electro-mechanical responses. By using a time-temperature super-positioning principle (serves as a tool for predicting time-dependent mechanical properties), we want to predict time-dependent electrical responses over a long period of time.

Methods

Within the first part of the research, two partially crystalline polymers will be used for the matrix material into which the single-wall carbon nanotubes (SWCNT) of various concentrations will be mixed by twin-screw extruder. Information on the morphological structure, rheological properties, thermal properties will be carried out with SEM, rheometer and DSC respectively.

Within the second part of the research time-dependent electro-mechanical responses will be determined at different temperatures within the experimental window (from 10 to 10000 s) by using the advanced modular rheological system together with the digital multimeter. Isothermal segments will be assembled into a master curve, which will determine the time-dependent electro-mechanical behavior of the material over a long period of time.

Expected scientific contribution

The presented study is in line with current and future directives within EU research programs, i.e. Graphene flagship. The research is divided into two parts (improvement of physical properties and functionality), presenting the corner stones for generation of multifunctional elements (future emerging technologies), which should exhibit structural integrity as well as capability of sensing external loads over longer period of time.

Acknowledgments

The authors acknowledge the financial support from the Slovenian Research Agency (research core funding No. P2-0264).

Keywords

carbon nanotubes, nanocomposites, rheological properties, mechanical properties, thermal properties, electrical properties

Development of a Numerical Model for the Evaluation of the Ship Added Resistance in Waves

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Introduction

Evaluation of the ship added resistance in waves has increased in importance, especially from the economic as well as from the environmental point of view. Ship added resistance in waves causes a reduction in ship speed and has an impact on the increase in the fuel consumption as well as on the emission of harmful gases, which is subject to the increasingly stringent regulations. The determination of the ship seakeeping characteristics and added resistance in waves requires rather complex hydrodynamic calculations. Therefore, it would be beneficial to develop a model that would allow for a simple but sufficiently accurate and reliable evaluation of the added resistance in waves at an actual sea state. One of the possible tools for the establishment of such a model are artificial neural networks, which have the ability to learn from examples and to identify relationships between the input data and solutions to the multivariable problems.

Methods

Within this research, a large number of hull forms will be generated and the influence of mass characteristics and hull form parameters on ship added resistance in waves will be investigated. Feedforward neural network with static neurons and error-back propagation algorithm will be generated, and input parameters will be evaluated and proposed. The results of added resistance obtained using panel method will be used to train the neural network and define the optimum architecture and learning parameters. Ship added resistance in waves for actual sea states will be determined based on the results for regular waves and by means of irregular waves energy spectrum. The numerical results obtained by hydrodynamic calculations and the output of the proposed neural network will be validated against the available experimental data.

Preliminary results

A database of hull forms that represent typical forms of modern containerships is established. Hull forms are modified by the Lackenby method within the limits established using the data of the regression analysis and the restrictions of the method itself. A sufficient number of the hull forms, required for hydrodynamic calculations, is generated and prepared as an input for potential flow solver. Additional analysis is performed regarding the appearance of the irregular frequencies in the calculations of the ship motions and second-order forces. In addition, the influence of ship mass characteristics on added resistance in waves is investigated in order to establish the crucial parameters for the seakeeping calculations. The results obtained at higher wave frequencies are further improved using the correction method. Basic form of feedforward neural network with error-back propagation algorithm is generated as well. The influence of the hull form parameters on ship added resistance in waves is investigated and input parameters for neural network are evaluated and proposed.

Discussion

Validation of the potential flow solver showed satisfactory accuracy of the results regarding ship added resistance in waves for slender hull forms in the range of moderate and long relative wavelengths and the correction for short wavelengths significantly improved the obtained results. In the future work, the optimum architecture of neural network as well as learning parameters will be set based on the numerical results.

Acknowledgments

I wish to thank professor Degiuli for her constant encouragement and support.

Keywords

Added resistance in waves, Computational Fluid Dynamics (CFD), neural network, seakeeping characteristics

Effect of Fatigue Loading of Aluminum Alloy 7075-T6 on Surface Roughness and Residual Stress

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Introduction

One of the most versatile and most widely used metals in different sectors is aluminum. It is the second widely produced metal after steel. Its alloys are widely used in many modern industries. About 20% of aerospace and aeronautical parts are made of aluminum alloys. These industrial applications frequently imply a combination of mechanical loading and corrosion, which leads to stress concentration and failure of the material. Pitting corrosion is one of the most damaging effect on materials, turned very difficult to predict the damage and the failure in materials. Previous theorical investigations found that the orientation of the corrosion pits regarding the applied load, plays a significant role on the stress concentration under the fatigue life on the material. This motivated authors to conduct experimental investigation.

In this research, low and high frequency fatigue tests were carried out on AA7075-T6 alloy in order to evaluate the effect of the proximity and orientation of the pits regarding to the applied load, in the stress concentration and in the fatigue life. Two different sets of tensile-compression specimens were tested; one with two hemispherical pits and one with smooth surface. The specimens were tested in the high cycle fatigue region (10^7-10^{10} cycles) at frequency f = 20 kHz, and low cycle fatigue region (10^5-10^7 cycles) at frequency f = 20 Hz. Two different load ratios were applied; R= -1 in ultrasonic high cycle fatigue tests and R=0.1 in low cycle fatigue test. It should be noted that testing devices used to perform the low cycle and high cycle fatigue tests were developed and manufactured in our laboratories.

Residual stresses induced by the work-hardening machining process and the surface roughness were addressed in the analysis of experimentally obtained results. Additionally, analysis of fracture surface and location of failure origin was carried out.

Experimental Investigation of Asperity Interaction in Multi-Asperity Contact

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Introduction

Contact area plays a major role in many engineering applications. In the recent past, most research in the problem of real contact area have been studied using theoretical modelling which began in 1967, when Greenwood and Williamson published the Greenwood-Williamson (GW) statistical model for characterizing contacting surfaces statistically. The model described the contact between a rough surface and rigid flat. It used many assumptions to simplify the calculations. One of the assumptions, is that the asperities are far apart, therefore, have no interactions between them. The ramification of that assumption is that it is widely believed that the GW model overestimates the real contact area. This is because it is believed that interactions between the asperities will result in them merging and growing together allowing them to carry more load at a lower surface separation.

Aims

Is to understand the deformation behaviour in statically contacting surfaces. In other words, to identify the important surface features and material properties that affect the real contact area between 2 surfaces.

Methods

To investigate the extent of asperity interactions and coalescence, an in-situ real contact area experimental test rig was used to measure the contact area between specimens prepared from different materials (Al6026, 11MnPb37,100Cr6 & 42CrMoS4) and a sapphire plate at 3 roughness R_a = 0.1 μm, 0.6 μm & 1 μm to the yield tensile strength limit (yts) of each material. Individual images from the beginning of the test (0yts), middle of the test (0.5yts) and end of the test (1yts), were then overlaid in order to observe how the asperities grow and interact with each other. From these images, the number of asperities that coalesced, the circumferential distance at which they interacted and the combined total coalesced area was measured.

Expected outcomes

The material deformation behaviour at the micro-meter scale will be studied. In order to further the understanding of contacts, friction and wear behaviour, the deformation of materials in contacts is important to be understood. As of now, most models for asperity deformations are based on theoretical descriptions and are not validated experimentally

Keywords

Real Contact Area, Asperities, Asperity Inter-action, Greenwood and Williamson model

Composition Optimization of Alumina Suspensions Which Contain Waste Alumina Powder

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Introduction

Green machining of alumina green bodies generates a certain amount of waste, unused alumina powder. Waste alumina ceramics powder should be disposed of as non-hazardous waste in legally prescribed manner. The study is focused on the investigation of the influence of different amounts of the commercial dispersant Tiron, binder PVA – poly(vinyl alcohol) and the magnesium aluminate spinel as additives for the stabilization of highly concentrated alumina suspensions with 20 wt. % of waste (or secondary) alumina powder. Suspensions with different amount of dispersant, binder and sintering additive were prepared based on the response surface methodology design to optimize the suspension viscosity. The viscosity was used for the suspension stability estimation because it is very simple, rapid and accurate method. The lowest viscosity value of all suspensions was achieved with the addition of 0.05 % Tiron, 0.1 % PVA and 0.2 % magnesium spinel expressed on dry weight basis. The obtained results suggest the waste alumina powder is appropriate for shaping new ceramic products by slip casting method.

Keywords

Alumina suspensions; Waste alumina; Response surface methodology; Slip casting

Multiaxial Loading of Chiral Auxetic Cellular Structure

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Introduction

Auxetic cellular structures are modern metamaterials which exhibit a negative Poissson's ratio [1], [2]. The negative Poisson's ratio is a consequence of rotating cells in the geometry of the auxetic structure when an external load is applied [3]. In this study a mechanical behaviour of the three-dimensional chiral auxetic structure under multiaxial loading conditions was studied. In the computational analyses seven different geometries of chiral auxetic structures are considered. The difference between geometries is in the amplitude of the unit cell which affect on the Poisson's ratio of the chiral structure. The shape of the investigated unit cell corresponds to a shape where the struts take shape of the sines, whose turning points meet in the nodal points [4]. The unit cell's geometry parameters are nodal distance in vertical and horizontal directions, amplitude and strut thickness. A 3D computational model was built using finite element method code LS DYNA. The discrete computational model of chiral auxetic structure was built with beam finite elements. The beam model of the analysed chiral auxetic structure was positioned between rigid plates and assembled in a way to simulate a multiaxial loading conditions. Between the touching surfaces interactions in normal (contact) and tangential direction (friction) with the node-to-surface approach were simulated. The contact between the beam finite elements in the structure was taken into account with the general automatic contact algorithm. The computational models were used to study the geometry effect of the unit cell on the Poisson's ratio and mechanical response of the analysed chiral auxetic structure. A developed computational model offer insight in the mechanical behaviour of chiral auxetic structure and help to better understand their crushing behaviour under impact multiaxial loading.

Acknowledgments

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Keywords

computational analysis, multiaxial loading, chiral auxetic cellular structure, fracture behaviour

The Effect of Diffuser Augmentation on a Small-Scaled Hydrokinetic Turbine for River Application

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Introduction

Hydrokinetic turbine technology gained attention as a good complement to the variable renewable energy sources such as solar or wind. This is due to generation predictability which means that energy supply can be easily predicted in advanced, with fairly high accuracy. In addition, space requirements and environmental impact are negligible when compared to conventional hydropower generation. These are just a few reasons to motivate energy markets to extend the use of small-scaled hydrokinetic technology. However, the main barrier to wider commercialization is relatively low efficiency limited by so-called Betz limit.

Methods

The idea of this work is to investigate the influence of casing turbine rotor on the generated power. The generated power is proportional to the cubic power of the incident water speed. In order to increase water speed locally at hydrokinetic turbine blades, shroud or duct can be used. The investigation on the effect of diffuser angles on increase of velocity and generated power is also performed to find the shape that best meets the specified design requirements. The turbine rotor is modeled as rotating immersed frame with an angular velocity and average steady state solution is sought. To solve governing equations commercial package ANSYS Fluent is used.

Preliminary results

The present work proposes design of horizontal axis hydrokinetic turbine that can increase power coefficient up to 2 times when compared to simple bare rotor design. The turbine design is improved by using additional stator element and CFD result for power coefficient prove that use such a modification of a design can highly influence generated power in the same water conditions.

Discussion

In general term, diffuser augmentation found to be beneficial to turbine performance, ensuring relatively high hydraulic efficiency while keeping simplicity in the design. In order to gain deeper insight into the influence of stator geometries on the hydrodynamic performance further investigation of different diffusor shapes is required. In the future work, empirical model for initial prediction of power extraction will be developed, based on the simulation results of different augmentation geometries.

Keywords

Design improvements, Shrouded turbines, Hydrokinetic turbines, Small-scaled turbines, Diffuser augmentation

Measurement Uncertainty for Conformity Assessment

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Introduction

It is common that measurement uncertainty plays crucial role in the quality of measurement results. The purpose of the evaluation of the measurement uncertainty is because the measurements are not perfect, and for the intent of unambiguous expression and comparison of measurement results gained in various calibration and testing laboratories to compare the measurement results with the manufacturer's specifications or tolerance interval. The impact of measurement uncertainty on the acceptance or rejection of a product in line with its specification and measurement results is considered. Decision rule based on simple acceptance and decision rules based on guard bands are described. In order to determine whether specified requirements relating to a product, process or system are met, the different methods for uncertainty evaluation are discussed. We can conclude that measurement uncertainty is an indispensable factor for proper decision-making and risk assessment in the conformity assessment approach.

Methods

The proposed research is related to ensuring the harmonized approach for estimating measurement uncertainty following the international guidelines and reliable decision-making on the compliance of results with specifications. The uncertainty evaluation is performed by using the GUM principle. The measurement uncertainty model will address the issues that have not been considered in the process of conformity assessment of products such as the correlation effects and their impact on final results. Finally, the conformity assessment will be determined by using knowledge of distribution functions and displayed by using the error functions. The model for conformity assessment and reliable decision-making will be given at the generic level, and the model will be implemented by using the appropriate software for modelling.

Preliminary results

The results show that neglecting the correlation effects in the process of estimation of measurement uncertainty on the compliance process has implications and can lead to false decisions in the process of conformity assessment. The false decisions may have an impact on the rejecting of products that meet specifications or the accepting of products that do not meet the specifications.

Discussion

The impact of the measurement uncertainty on the conformity assessment procedure with specifications is unambiguous. Therefore, the measurement uncertainty must be adequately estimated by considering all the contributions and correlation effects between the input quantities in order to make the proper decisions related to the conformity assessment of the product with its specifications. Adopting false decisions in the process of product conformity assessment procedure with specifications may have significant consequences for both, the end user of the product and the manufacturer that placed it on the market. For this reason, the measurement uncertainty plays significant role in the product conformity assessment procedure with its specifications.

Keywords

measurement uncertainty, distribution function, error function, decision making, correlation effect

Complex Objects Measurement by Using an Optical 3D Measuring System

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Introduction

Due to the emergence of new production technologies, and an increase in product complexity, it is necessary to rely on new sophisticated measuring systems. Optical methods for measuring three-dimensional shapes have, in the last ten years, rapidly increased their market share. Optical 3D measuring systems have simple control procedure, high density of data and the possibility of integrated reverse engineering and inspection. With these systems it is possible to get a significant amount of information about the object – in a short time. The result of the optical 3D measurement system is a digitalised geometry which takes the form of a thick point cloud – or a polygon mesh which describes the surface geometry of the measured object. Using an optical 3D measurement system, it is possible to measure objects with complex geometry and to carry out a comparison of the geometry with the CAD model. The research that was carried out indicates that many influential variables exist in the measurement process which utilises the optical 3D system. Sources of uncertainty are divided into five groups: environment, measuring object, operator, scanning hardware, and scanning software. The aim of this research is to identify and determine the significance of each influential factor.

Methods

The Design of experiment (DOE) methods are being applied in the study of factors influencing the characteristics of processes and products. Seven influential factors (temperature, humidity, illumination, measurement object, coating, interpolation and polygonization) were included in the experimental design. All measurements were obtained using the ATOS Core 300 measurement system. In order to determine the significance of influencing parameters, the analysis of variance (ANOVA) was conducted.

Preliminary results

The analysis of variance points to 3 factors which have significant influence on measurement results. These factors are: measurement object, interpolation and polygonization. Furthermore, the results show that the measurement object has the largest influence on measurement results. The deviation from the model is not significant and there is no systematic error, so the results can be accepted.

Discussion

This research investigates influential factors. The next step in the research is to develop a mathematical model of the measurement process and a calculation of measurement uncertainty. Additionally, it is necessary to determine which of the measurement object characteristics has a significant level of influence on the measurement results.

Keywords

Optical 3D Measurement system, Influential factors, Measurement uncertainty

Cognitive Model of Closed Environment of Mobile Robot Based on Measurements

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Introduction

One of the main challenges in operation of today's mobile robots is their management inefficiency in an unstructured environment, within which they have to perform certain tasks. To perform a task, robot necessarily needs to map the environment, but to accomplish this it needs to move in a environment which is yet unknown. This is the main paradox of the so-called Simultaneous Localization And Mapping (SLAM) problem: how to simultaneously build a map and plan a motion in an unknown environment? Initial research on this topic was based on pure mathematical models (configuration environment, potential fields, equidistance path) and has resulted in exact models. However, due to the large limitations in the practical application of such methods, they have been abandoned and today the focus is on methods where the multi-system measurement fusion comes with probable character models.

Aims

The aim of the research is to build a cognitive model of the closed environment of mobile robot. The environment model would be built of robots position and orientation data, data about objects in environment, which are detected with camera mounted on robot, and data collected with distance sensors mounted on the robot. Fusion of this data would produce new data which is more than a simple sum of data parts before mentioned.

Methods

The research methodology will include the definition, analysis and placement of an appropriate interactive cognitive model of the closed environment of a mobile robot. Validation and verification of the model will be performed by a series of simulations of simpler problems. By shaping the work segments in whole, the entire model of interaction between the mobile robot and the environment will be gradually defined. The environment model will be built from position and robot orientation data, object data, which are detected with the robot camera, and data collected from the distance meters/sensors. The research segments will be implemented on a real system consisting of a mobile robot and a test polygon, equipped with sensors and vision systems. By interacting with the data collected, new data will be obtained that will help robot to know, after an acceptable time interval, that the environment is now known to it. Also data gives acknowledgement, with use of the basic cognitive elements, where robot is in environment and what it sees/detects.

Expected scientific contribution

1. Fusion of different types of data from different sources for the purpose of constructing more complex data suitable for the construction of the cognitive model of the closed environment in which mobile robot is positioned. 2. Data and methods selection for construction of closed environment model for execution in real-time. 3. Construction of the cognitive model of closed environment in which mobile robot is positioned. 4. Experimental test of given cognitive model of environment, with use of the mobile robot positioned in test polygon.

Keywords

mobile robots, cognitive model, closed environment, sensors

Application of Diamond-Like Carbon Coating in Orbital Hydraulic Motor

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Introduction

Tribology has been recognized as a very important discipline in different branches of industry within recent years as almost every mechanical system has some moving parts. Due to the relative motion between different mechanical parts, different contacts are formed. They are very often lubricated with oil. Presently, environmental protection and ecological awareness is becoming increasingly important, which in turn has resulted towards the direction of a low-carbon society, therefore, water has gained interest over the years. On the one hand, water is less environmentally damaging as a lubricant than oil, but on the other hand, water has very bad lubrication properties, as its viscosity is 100 times lower compared to the viscosity of oil. Limitations may be overcome with an appropriate surface engineering (i.e. Diamond-like carbon-DLC). Tribological tests were performed in oil and water for two different contacts. Steel/steel and steel/DLC were investigated. DLC was recognized as a very promising solution, which ensures low friction and low wear. DLC was deposited on real hydraulical part in orbital hydraulic motor and tested under real industrial conditions. The overall efficiency of hydraulic motor was measured.

Keywords

friction, wear, hydraulic motor, water, Diamond-like Carbon

Smart Sheet Metal Forming Tools Strip Layout Analysis Method

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Introduction

The differences in the design process of smart and conventional sheet metal forming tools are recognized in the practice and literature, so the goal of the research is to propose and evaluate a new applicable design process model. This paper present method for smart sheet metal forming tools strip layout analysis and presentation as an upgrade of conventional sheet metal forming tools strip layout analysis and presentation methods. Smart sheet metal forming tools are a specific segment of smart products. Controllable actuators in the direction different from the press opening direction and sensors that give information about workpieces, tools and processes regulate the production process parameters in real time. In comparison with conventional, smart tools enable production without bad products, without tool damage and without production breaks or with significantly less of them. They also allow the production of more complex products. In another hand, smart tools include more complex components in tools design, which conventional tools is not, or include them significantly less and more straightforward kind of them.

Methods

Smart sheet metal forming tools can have many kinds of actuators, sensors and another smart component. Conventional strip layout analysis and presentation methods with only work pieces shape and geometrical place of it in tool don't give enough information in this new situation. This paper present new method for analysis and presentation of smart sheet metal forming tool strip layout. Main characteristic of new method is that except shape of work pieces and geometrical place of a particular stage in progressive sheet metal forming tool include component of information infrastructure predicted in tool in different level of finishing from initial idea to final selection.

Preliminary results

Multidisciplinary information presented with this method increases quality of communication between members of multidisciplinary development team which kind is necessary for smart product development and enabled more effective organization of team work. Presented method by clear presented information in early phase of tool development that control and computer engineering specialists needed enable that they can be included in development team in such early phase of tool development. This method also communication with customer make easier.

Discussion

This paper present method for smart sheet metal forming tools strip layout analysis and presentation which have potential to be used in all smart product development process. In this purpose method should be completed with two more presentation. First one which describes function of each information infrastructure component with expectation of working range and setup parameters as well as selection of component and its control elements. Second one that present principle diagram of control software function including user interface. Completing of this method is current work in progress of this research and should be presented in future papers.

Acknowledgments

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Keywords

Smart product design, smart sheet metal tools, strip layout analysis

The Impact of Manufacturing Errors on Dispersion of Hits for Unguided Projectiles

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Introduction

For ammunition manufacturers of today, demands for ever higher manufacturing quality are being set. It is because of the need to avoid or at least to minimize collateral casualties that are common during urban conflicts. At the same time, there is a need to accept a certain level of manufacturing errors so to keep production costs acceptable.

Methods

Because of two aforementioned conflicting demands, i.e. one for precision and the other for lowering production costs, it became necessary to determine which requirements imposed on manufacturers are really justified and which only increase expenses, but do not contribute to a significant reduction of dispersion of hits. This paper shows how it is possible to combine a series of analytical methods to analyze the impact of particular manufacturing error, or more than one error at the same time, on projectile's flight. Methods include: 3D CAD model of rocket with geometrical and inertial characteristics adjusted to the real rocket; 6DOF model of flight showing the motion of rocket during the active and the passive phase; methods for statistical processing of results – Monte-Carlo simulation, regression analysis, worst-case scenario etc.

Preliminary results

Preliminary results show strong connection between changes of rocket's tensor of inertia and its trajectory. In case of dynamic unbalance, principal axes (depending of manufacturing errors, simulated in 3D CAD model) deviate from axes of geometrical symmetry, and center of mass is no longer positioned on longitudinal axis of symmetry. Since manufacturing errors are non-deterministic by nature, points of hit for a series of projectiles are being dispersed. Model shows that there is (among all factors influencing projectile's flight) an especially strong correlation between angle of deflection between principal axes and axes of geometrical symmetry, and an overall dispersion of hits.

Discussion

Using a set of methods and models, logically connected in such a way that each provides the input values for the next one, a comprehensive method is developed demonstrating how to set manufacturing tolerances for certain phase of production. Results show that it is really necessary to insist on extremely high precision for some parts of overall production, but also that less strict tolerance can be implemented for those manufacturing errors that have only limited impact on the projectile's flight or its dispersion of hits.

Keywords

unguided projectiles, manufacturing errors, 3D CAD model, 6DOF model of flight, Monte.Carlo simulation

Residual Stress Effect on Fatigue Crack Propagation

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Introduction

Forming induced residual stress (RS) plays a signifficant role in predicting fatigue life of a product. They are induced by inhomogeneous plastic flow which is exempt only in simply shaped geometry. In product service, RS takes a new equilibrium configuration which is based on deformation hardening that originates in cyclic loads especially in low cyclic fatigue where large plastic deformations are present. This new state of RS has a similar effect as mean stress on fatigue life. Classical fatigue calculation concerns in predicting the number of load cycles that nucleate the initial macro crack and stops here. Fracture mechanics is the current standard for crack propagation until complete fracture of product under study. This poses a severe obstacle in practical application of both methods, because each method requires different material properties which are gained after a series of time consuming and expensive laboratory work. We would like to push the boundary of classical fatigue calculations beyond the current scope of validity and develop a holistic approach for both, prediction of micro crack nucleation and its growth until fracture. Continuum damage mechanics (CDM) will govern our approach in describing the degrading material properties under cyclic loads. The scope of CDM is based on representative volume element (RVE) which describes the growth of intrinsically discontinuous micro cracks and voids as integral effects on nominal stress-strain response on RVE subjected to cyclic loads. Growth of discontinuities is postulated as damage and has a similar effect as a reduction of load bearing surfaces inside RVE.

Methods

A series of strain and stress fatigue testing will be conducted in order to build a reliable material damage model for low carbon structural steel. Inhomogeneous plastic flow will be introduced, via bending load, in a specimen to induce RS. Contour method for measuring RS will be applied after a series of increasing number of cyclic loads to gain insight into RS relaxation. As mentioned before, CDM postulates a RVE as its elementary object of study. RVE is by its principle similar to a volume element used in final element analysis (FEA) which will be used as central method for application of combined approach in fatigue. Node splitting between final elements will be used to simulate crack nucleation and growth in a specimen subjected to bending cyclic load, which is predominately uniaxial and proportional . Node splitting will be governed by the increasing damage of surrounding final elements and will occour when critical damage of fracture is reached. This is the basis of a united approach for modeling fatigue and fracture. Results obtained in this numerical fassion will be compared to experimentally driven fatigue and crack propagation.

Contribution

The before mentioned method will lend a hand in calculating or predicting complete fatigue life by using only one governing approach. A special insight will be given in crack growth under the influence of RS present deep below the surface of a product. This could reveal crack growth retardation in a field of compressive RS thus prolonging the product usability. Current focus is based on low carbon steel under proportional uniaxial loading.

Keywords

fatigue, residual stress, damage mechanics, fatigue crack propagation

Analysis of Thin-Film Lubrication Using Openfoam

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Introduction

In this work a thin film lubrication model implemented inside OpenFOAM framework is presented. Four lubrication regimes are considered: thick and thin film hydrodynamic regime, mixed regime and boundary regime. In hydrodynamic regime two surfaces in contact are completely separated by the lubricant. In thin film hydrodynamic regime surface roughness influences lubricant flow, while in thick film regime surface roughness can be neglected. In mixed regime contact pressure is shared between the lubricant and surface asperities. In boundary regime almost the whole contact pressure resides on asperities in contact, with the lubricant found in traces in asperities' valleys. The implemented model is able to calculate all three regimes continuously. As lubricant flows between two surfaces in relative motion heat is generated due to film shearing effects and due to traction between asperities in contact. Thermal effects are more evident in case of significant sliding between two surfaces in contact. Due to temperature changes lubricant transport properties can vary significantly. Also, in addition to temperature dependence, viscosity and density of the lubricant depend on pressure values. All these effects need to be accounted for when analyzing lubrication between two sliding engineering surfaces.

Methods

Lubricant flow is modelled using Reynolds equation, a partial differential equation governing pressure distribution in thin film flows. Reynolds equation is discretized using the Finite Area Method (FAM), a two-dimensional counterpart of the Finite Volume Method discretized over a curved surface. The film energy equation is also discretized using FAM assuming parabolic temperature profile across the lubricant film. Surface temperature increase is calculated using Carslaw and Jaeger model and FFT method. Surface deformation is modelled using elastic deflection principle where convolution integrals are calculated with FFT method, which significantly increases computational efficiency. Pressure and temperature dependent transport properties are implemented with respect to the type of lubricant oil.

Preliminary results

The model is validated using two test cases, where friction and film thickness values are compared to numerical results and experimental measurements from the literature. Case geometry considers ball-on-disc test rig where a rotating steel ball is in contact with a rotating glass or steel disc. Contact between the surfaces is lubricated. Two lubricants are considered: Turbo T9 and Turbo T68. Test case with T9 oil is calculated for hydrodynamic regime. Film thickness and friction coefficient results show very good agreement with the experimental measurements. Test case with T68 oil is calculated for the hydrodynamic and mixed regime. Friction coefficient results show good agreement with the experimental data considering that the transport properties of the lubricant are partially known.

Discussion

The developed model is able to calculate lubricated contact between two realistic rough surfaces giving very good results when complete information regarding lubricant properties is available. In case of mixed regime, surface roughness profile is also necessary in order to ensure good results.

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Keywords

OpenFOAM, lubrication, ball-on-disc, Reynolds equation, thin film thermal equation

Implementation of Fiber Dispersion in Finite Element Model of Abdominal Aortic Aneurysm

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Introduction

Abdominal aortic aneurysm (AAA) is a local and irreversible dilatation of the abdominal aorta caused by an imbalance in production and degradation of the extracellular matrix. It is an asymptomatic disease until complications occur, which can lead to rupture and death. Numerical growth and remodeling (G&R) models of AAA are developed for better understanding of the disease and to predict the likelihood of rupture. Aorta is considered as a multilayered fibrous composite with collagen fibers and smooth muscle cells embedded into a ground matrix. Experimental and imaging studies have shown that collagen fibers are dispersed within the aortic wall which has an effect on the mechanical response of the aortic tissue. Although G&R models take into account microstructure of the aortic wall, so far none of them has modeled collagen fiber dispersion. The aim of this work is to implement a fiber dispersion model into a current constrained mixture G&R model. Additionally, the influence of the fiber dispersion on the aneurysmal growth and the distribution of stresses inside the aortic wall will be analyzed.

Methods

G&R model of the aortic wall combined with the collagen fiber dispersion model was implemented into the finite element analysis program FEAP via subroutines for the user-defined material model. The G&R model is based on the constrained mixture theory and the theory of evolving configuration. The dispersion model is based on the generalized structure tensor approach and it can describe a non-symmetric fiber dispersion (i.e. different dispersions in the tangential plane and out-of-plane).

Preliminary results

After verification of fiber dispersion implementation, the influence of the collagen fiber dispersion on the evolution of an aneurysm was analyzed. For that purpose, an axisymmetric model of a fusiform aneurysm was used. The aortic wall was comprised of three layers and each layer had different mean fiber direction and fiber dispersion. The preliminary results show that an increased fiber dispersion (i.e. a higher degree of isotropy) in the intima and the media lead to a slower growth rate, while increased dispersion in the adventitia resulted in a faster growth rate. Moreover, an increase of fiber dispersion tends to level the circumferential and axial stresses throughout the wall thickness, while the more aligned fibers increase the axial stress in the adventitia and circumferential stress in the intima and the media.

Discussion

Verification has shown that the fiber dispersion model is correctly implemented. Furthermore, obtained results indicate that the fiber dispersion has a significant influence on the aneurysmal growth and on stress distribution in the aortic wall. Therefore, we suggest that the fiber dispersion should not be neglected in future G&R studies of AAA. Additionally, the inclusion of fiber dispersion is a valuable expansion of our current AAA model.

Acknowledgments

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Keywords

Abdominal aortic aneurysm, Finite element method, Fiber dispersion, Growth and remodeling

Modelling and Optimal Control of a Parallel Plug-In Hybrid Electric Vehicle

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Introduction

The thesis proposes an extension of a parallel Plug-In Hybrid Electric Vehicles (PHEV) powertrain backward model with a sub-model describing realistic transient effects while maintaining computationally efficient quasi-static structure. The extended backward model and a dynamic programming algorithm will be utilised to optimise PHEV powertrain control variables. The optimisation results will be used for synthesis and verification of a control strategy that considers powertrain transient effects. The control strategy can also extended by an algorithm that generates an optimal profile of battery state-of-charge (SoC) reference trajectory considering varying road grade and the presence of low emission zones.

Methods

Powertrain characteristics of a PHEV with parallel configuration can be described by the computationally efficient quasi-static (backward) vehicle model while the dynamical behaviour of PHEV powertrain can be described by more computationally demanding and more precise dynamical (forward) vehicle model. The effects of PHEV powertrain transients in terms of fuel and SoC consumption can be modelled with an appropriate static model based on the results of extensive forward model simulations. An expanded backward model is proposed which will include powertrain transient effects in dependence to a wide variety of transient scenarios with the aim to reduce computational load while maintaining precision of a forward model. Dynamical programming (DP) can be used for control variable optimisation of both backward and expanded backward models. The insights gained from optimal results analysis will be used for control strategy synthesis which will consider previously modelled transient effects with the aim of minimising energy consumption while maintaining acceptable levels of driving comfort and battery degradation. Optimal results gained by the DP can also be used for reference SoC trajectory synthesis for PHEV control strategy in the cases of blended operating regime and varying road grade and existence of low emission zones.

Preliminary results

The method for SoC reference synthesis in the case varying road grade and low emission zones for blended regime has been proposed and verified.

Discussion

The thesis is expected to result in: (i) computationally efficient backward PHEV model which includes effects of powertrain transients described by the static regression model, (ii) optimal energy management control strategy which will achieve additional fuel savings and driving comfort by taking powertrain transient effects into account and (iii) reference SoC trajectory synthesis in the case of varying road grade and low emission zones for the blended operating regime

Acknowledgments

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Keywords

Control, energy management, optimal battery state-of-charge, plug-in hybrid electric vehicle, expanded backward model

Multiagent System for Distributed Control of Cyber-Physical Systems

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Introduction

The number of sensing and actuating devices used for production control is growing rapidly. Advanced connectivity technologies and protocols enable integration of physical and computational devices into cyber-physical systems (CPS), focusing on integration of computation with physical processes. As CPS grow in size and complexity, traditional centralized control often fails to provide adequate response times and management of computational complexity. Researchers work on enhancing flexibility, robustness, adaptability, and reconfigurability of CPS by employing concepts of distributed and autonomous control in dynamic environments of cyber-physical production systems. A way to implement distributed control is by using autonomous computational entities called agents. Agents acquire information about their environment and take actions to influence the environment. In some applications, multiple software agents are used to collectively solve problems by interacting with each other and reaching mutual agreements through negotiations, bidding, and othercommunication mechanisms, enabling reconfigurability and scalability. Agents acting in parallel results in the system's global behaviour that may include emergent phenomena and is often difficult to predict in advance. Adaptiveness can be provided by intelligent capabilities of the agents.

Methods

In the first phase, the general model of the agent will be proposed. Experiments of the implementation of the agents in a CPS will be performed in software simulation. In the second phase, real demonstrators will be assembled using hardware with embedded computers to run the software agents and enable data connection and communication between agents. In the demonstrator, experiments on expansion/reduction of the system scale as well as experiments involving disturbances will be simulated. Through the measurement of selected key performance indicators during normal activity and in case of disturbances, scalability, robustness, and resilience of the system will be assessed.

Preliminary results

The model of the learning agent was implemented in a software simulation where a CPS with agents coupled with valves and switches was used for distributed control of industrial compressed air system. The agents use machine learning to learn the model of their environment and to adapt to disturbances. In the process of action selection, the agents communicate with other connected agents. The observations of the performance of the system in simulated experiments show that the system is scalable, and that the communication structure influences the robustness and the resilience of the system.

Discussion

The focus of the research work is to design the structure and the decision model of a learning autonomous agent for realization of distributed control of CPS by coupling agents with physical actuating devices. The model will be implemented and tested on demonstrators for two industrial use cases: an industrial compressed air system and an automated guided vehicles system. They will be used to show that a CPS with distributed control is more scalable, robust, and resilient than a centralized control system.

Acknowledgments

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Keywords

multiagent system, cyber-physical system, distributed control, production control

Information Support Framework for Processes in Manufacturing Systems Based on Big Data

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Introduction

Due to the intensive development of information and communication technologies, large amounts of data are being generated. Many new approaches, methods, techniques, and tools for advanced data analytics are being developed and, consequently, additional possibilities of using large amounts of complex data – also referred to as big data, are emerging. However, the application of advanced data analytics in the production domain lags behind in penetration and diversity in comparison to other domains, and the data available often remains unexploited. This study develops and demonstrates the use of a framework for information support for processes in manufacturing systems. The framework is a conceptual tool that facilitates the introduction of big data analytics into manufacturing systems. It provides a step-by-step procedure for introducing big data analytics into manufacturing systems and systematically shows what knowledge and skills, reference models, software and hardware tools, etc., are needed.

Methods

The framework is based on the development and research of several data-analytics solutions developed and implemented in the course of this study, as well as on other existing applications and conceptual solutions from literature and practice. The feasibility and wide applicability of the framework at all manufacturing-system levels are demonstrated and validated. For the development and validation of data analytics solutions, real industrial and internet data are used. Developed solutions for data analysis enable either new ways of using the data, a more effective reduction of the incompleteness of information, or more efficient discovery of new knowledge in comparison to conventional approaches in academia and industry.

Results

Results are the following: (1) a conceptual framework for the development and implementation of big data analytics solutions; (2) a method for identifying faulty operating conditions in cyclic manufacturing processes; (3) a data-driven approach to fault prognostics in cyclic manufacturing processes; (4) discovery of the possibility for data-driven prediction of unplanned machine stops in the plastic injection molding process; (5) a method for testing the possibility of data-sharing between similar machines for improving the data-driven fault-prediction model; (6) the identification of the possibility for improving the data-driven fault detection model through the sharing of data between injection molding machines; (7) an algorithm for data-driven prediction of the work-systems work overload and a visualization method of work-systems work overload in large-scale manufacturing systems; (8) the method for identifying the business and social networks in the domain of production by merging the data from heterogeneous Internet sources; (9) a data-driven method for predicting changes in the sequence of work order's operations based on MES data.

Acknowledgments

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Keywords

manufacturing systems, data analytics, big data, conceptual framework, data mining