DEPARTMENT OF ENERGY TECHNOLOGY

AALBORG UNIVERSITY

CONFERENCE FOR ENERGY STUDENTS

CES 2016

Conference Programme

20 December 2016

Pontoppidanstræde 111

Rooms 1.177 and 1.031

The Energy Sponsor Programme

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Co-Chairs: Lasse Rosendahl & Dezso Sera

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	Session a1: Wind Energy – Part 1 **Session Chair: Tamas Kerekes**
09:30 – 09:45	**Investigation of changes in aerodynamic performance for wind turbine blades with ice accretion in cold climate regions** *Kasper Petersen, Mathias Christensen, Niels Rasmussen, Stig Seiferheld*
09:50 – 10:05	**A thermal model for developing temperature controllers used in wind turbine cooling systems** *Thomas T. Jensen*
10:10 – 10:25	**Control of digital displacement wind turbine transmission** *Henrik Hauge, Nicolai Daugbjerg, Rasmus Kinch*
10:30 – 10:45	**Coffee in the hall outside rooms 1.177 & 1.031**

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11:05 – 11:20	**Modelling and verification of tower dynamics for a scaled floating offshore wind turbine** *Jesper K. Jensen, Kasper Jessen, Kasper Laugesen, Signe M. Mortensen*
11:25 – 11:40	**Design and optimization of a permanent magnet synchronous generator for a direct drive horizontal axis wind turbine** *Orlin B. Simeonov*

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	Session Chair: Dezso Sera
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13:20 – 13:35	**The evolving grid: Modeling and control of electrical and heating systems** *Konstantinos Katsavounis*
13:40 – 13:55	**Adaptation of substations into SCADA – North Cyprus** *Rifat Celiloglu*
14:00 – 14:15	**Study of a novel algorithm for tribodynamic measurements using ultrasound** *Nicolaj W. Johansen*
14:20 – 14:35	**Coordinated Control of Combined Solar PV and Energy Storage Systems** *Andreea C. Zaharof*
14:40 – 14:55	**“Gløgg” and Danish doughnuts in the hall outside rooms 1.177 & 1.031**

	Session a4: Hydraulics **Session Chair: Lasse Schmidt**
14:55 – 15:10	**Friction modelling of hydraulic cylinder** *Niels Pedersen, Stefan M. Jørgensen*
15:15 – 15:30	**Optimum design of a bi-stable moving magnet hydraulic valve actuator with parallel coil windings** *Esben L. Madsen, Janus M. T. Jørgensen*
15:35 – 15:50	**Trajectory control for hydraulic servo robot** *Christian Jørgensen, Daniel Brusen, Jacob Andersen, Lars Holm, Rasmus Lomholt, Thomas E. Pedersen*
15:55 – 16:10	**Monitoring a solenoid valve** *Magnus F. Asmussen, Nikolaj S. Høyer*
16:15 – 16:30	**Modelling and optimization of fast switching solenoid valve** *Torben Jørgensen*
16:45 – 17:00	**Award Ceremony**

17:00	**Conference Closure**

Oral Session

Pontoppidanstræde 111 room 1.031

Conference Chair: Dr. Ewen Ritchie
Co-Chairs: Lasse Rosendahl & Dezso Sera

08:30 – 09:00	**Coffee in the hall outside rooms 1.031 & 1.177**
09:00 – 09:30	**Conference Opening & Keynote Speech** - **Dean Mogens Rysholt Pedersen** - **Research Manager Per H. Lauritsen, Siemens Wind Power**

	Session b1: Power Electronics & Control – Part 1 **Session Chair: Erik Schaltz**
09:30 – 09:45	**Design and control of modular multilevel converters** *Anurag Bose*
09:50 – 10:05	**Oscillations of tractor with implement** *Morten L. Winther, Mathias Galberg, Nicklas K. Jensen*
10:10 – 10:25	**A contemporary guide to model and characterize a permanent magnet synchronous motor** *Charlie Sørensen, Martin L. Fogsgaard, Mads K. Graungaard, Jacob B. Nørgaard*
10:30 – 10:45	**Coffee in the hall outside rooms 1.031 & 1.177**

	Session b2: Power Electronics & Control – Part 2 **Session Chair: Erik Schaltz**
10:45 – 11:00	**Investigation on power MOSFET switching speed: reaching the physical limits of the device** *Davide Cittanti*
11:05 – 11:20	**Compensation of time delays caused by digital control of PWM inverter with predictive control techniques** *Dimitar N. Nikolov*
11:25 – 11:40	**Compensation of time delays caused by digital control of PWM inverter with predictive control techniques** *Alex B. Nielsen, Malte T. Thomé*

11:45 – 12:00	**Design and analysis of a double-stator permanent magnet machine for high power density applications** *Ying Meng*
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13:20 – 13:35	**Winglets reducing trailing vortices generated by airfoil** *Rasheed Fallah, Line J. Pløger, Morten Krantz, Nikolai H. Kirkedal, Troels B. Landbo*
13:40 – 13:55	**CFD study of the hot air chamber of a continuous flow grain dryer** *Mathias Poulsen, Lotte S. Kjær*
14:00 – 14:15	**Optimization of a high pressure EGR waste heat recovery boiler** *Kristian Kristensen, Søren S. Batz*
14:20 – 14:35	**Verification of basic turbulence models for flow-mixing** *Rune K. Jensen, Kasper L. Lassen, Christian Bach*
14:40 – 14:55	**"Gløgg" and Danish doughnuts in the hall outside rooms 1.177 & 1.031**

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14:55 – 15:10	**Numerical investigation of a steady state flow with a backward facing step** *J.R.C. Leth, R.F. Hansen, A. Haji*
15:15 – 15:30	**Laser velocity validation of a turbulent fluid-mixing model** *K.H. Fornitz, J.K. Larsen, L.M. Lund*
15:35 – 15:50	**Monitoring of oil-in-water using JORIN VIPA** *Lærke S. Hansen, Sissel Hågensen*
15:55 – 16:10	**Investigation of thermodynamic conditions in a two phase pipe flow** *Camilla N. Gade*
16:15 – 16:30	**Generic modelling tool for techno-economic analyses of hydrothermal liquefaction process scenarios** *Oscar Miralles, Nick Høy, Daniel Villamar*

16:45 – 17:00	**Award Ceremony**
17:00	**Conference Closure**

INVESTIGATION OF THE UNSTEADY FLOW IN THE NEAR-TONGUE REGION OF A CENTRIFUGAL PUMP

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Abstract: The centrifugal pump is widely used throughout the world to handle waste water. Common problems in waste water handling are clogging and pressure pulsations within the pump. These phenomena mainly occur in the near-tongue region at heavy part load, thus designing the tongue is a critical part of the design process. Therefore, the correlation between the tongue geometry, the corresponding flow and the occurrence of pressure pulsations is investigated in this paper. The correlation is investigated using state-of-the-art Computational Fluid Dynamics (CFD) which is validated using Particle Image Velocimetry (PIV). The validation is made for one tongue geometry after which the CFD model is used to test various geometries of the tongue. The numerical results indicate that an asymmetric tongue geometry yields the greatest pressure difference between the high and low pressure sides of the tongue, which may reduce clogging near the tongue, but it also increases pressure pulsations. However, a symmetric tongue reduces pressure pulsations and yields the highest hydraulic efficiency. It is suggested that considerations are made regarding the purpose of the pump, since different tongue geometries yield different advantages.

Keywords: Centrifugal pump, S-tube impeller, Tongue, PIV, CFD

INVESTIGATION OF CHANGES IN AERODYNAMIC PERFORMANCE FOR WIND TURBINE BLADES WITH ICE ACCRETION IN COLD CLIMATE REGIONS

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Abstract: There is a great wind energy potential in the worlds northern regions, where low temperatures and high air densities provide more kinetic energy. The cold climate causes problems with ice accretion on wind turbine blades which degrades the aerodynamic performance up to 40% and causes wear and potential permanent damage to vital components. A common wind turbine blade profile – a NACA 63-415 airfoil – has been investigated with Computational Fluid Dynamics (CFD) in ANSYS Fluent to analyse the change in flow properties for the airfoil, with and without rime-ice accretion. The CFD simulations have been validated through experimental work with a strain gauge set-up with the aim to obtain the drag- and lift coefficients. The simulations and the experiments have been done for the same range of angle of attack. The results showed a degradation in the performance of the airfoil with added ice accretion and that flow separation occurs at lower angles of attack with ice accretion. As the wind energy industry seek to expand in the Nordic regions, tools for predicting the power yield for different airfoils are valuable. The utilised methodology can be applied to other airfoils.

KEYWORDS: CFD, turbulence modelling, airfoil, wind energy, aerodynamics

WINGLETS REDUCING TRAILING VORTICES GENERATED BY AIRFOIL

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Abstract: Vortices induce drag and reduce lift which leads to higher energy dissipation. The addition of winglets reduces vortices at the trailing edge of an airfoil. Studies have proved that winglets reduce the induced drag on airfoils by up to 20%. In this project three airfoils with NACA 2412 profile have been designed; a reference without winglet and two with winglets at respectively 45° and 90° normal to the trailing edge. The effects of the winglets have been analyzed using a CFD model. In order to validate the CFD model experiments have been conducted by subjecting the models to flow in a wind tunnel. The velocity profile over the airfoil was measured using Constant Temperature Anemometry (CTA). The analysis of the CFD model and the results from the experiments demonstrated that the winglets reduce vortices. The agreement between the CFD model and the experiments was within acceptable range. The CFD model verifies that reduction in vortices decreases induced drag. The 90° winglet reduces the induced drag more than the 45° winglet. The results are in accordance with previous studies.

Keywords: CFD; CTA; Wind tunnel; Induced drag; NACA 2412; CFD; CTA; Wind tunnel; Induced drag; NACA 2412;

OPTIMIZATION OF A HIGH-PRESSURE EGR WASTE HEAT RECOVERY BOILER

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Abstract: The reduction of emissions relating to maritime transportation has become an increasingly larger topic. The emission requirements of nitrogen oxides or NO_x in designated Emission Control Areas has been regulated. This means that new built ships are required to use NO_x reduction technologies when operating in these areas. One such technology is Exhaust Gas Recirculation or EGR which utilizes recirculation of exhaust gas from the main engine back into the combustion chamber. This lowers the formation of NO_x during combustion. Because exhaust gas from burning heavy fuel oil contains Sulphur oxides and particulate matters, scrubbing and cooling of the recirculated gas is required. For this purpose, a high pressure boiler is used to cool the recirculated exhaust gas while utilizing extracted heat for steam production. The purpose of this project is to model the exhaust gas flow distribution, transferred energy and pressure loss in the boiler using Computational Fluid Dynamics and analytic modelling. These parameters are optimized by modelling changes applied to the boiler geometry and insertion of guide vanes into the flow path. It is shown that CFD simulation can be used to optimize the boiler geometry to achieve enhanced heat transfer and a lower pressure loss.

Keywords: CFD simulation, Exhaust Gas Recirculation, Flow distribution optimization, Guide vanes, NO_x reduction technologies

CFD STUDY OF THE HOT AIR CHAMBER OF A CONTINUOUS FLOW GRAIN DRYER

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Abstract: A three-dimensional model of the hot air chamber of a newly designed industrial continuous flow dryer was developed by applying the Computational Fluid Dynamics (CFD) technique. In previous flow dryer designs the intake air is heated by a gas burner in the hot air chamber before being led into the drying column. Due to the large cross sectional area of the hot air chamber of the dryer, the airflow velocity is relatively low and combined with the placement of the burner, improper mixing occurs. This results in a varied temperature distribution of the air going into the drying column, which is undesirable. It is studied whether the new dryer design improves mixing, and thereby secures a uniform temperature distribution of the air. Numerical calculations were performed using the commercial CFD code ANSYS Fluent 17.2, which provided the velocity, temperature and pressure distributions of the fluid flow. The results indicated that the new design improves the mixing of the air, and by that leads to a more uniform temperature distribution of the air. This causes the grain to be dried more evenly and reduces the drying time.

Keywords: flow dryer, CFD, flow distribution, temperature distribution, airflow

INVESTIGATION OF THERMODYNAMIC CONDITIONS IN A TWO-PHASE PIPE FLOW

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Abstract: This paper investigates how the thermodynamic conditions inside a closed superheated pipe change, when a saturated liquid natural gas is added by a pump. The pressure and phase change inside the pipe until it is completely filled with liquid natural gas, which causes thermal strains in the walls of the pipe as well as significant dynamics in the pump performance profile. In order to address this from a reliability perspective, this paper models and analyses this two-phase process in two models. Initially, the pipe is filled with a warm natural gas and gradually filled with colder liquid natural gas. The start-up process of the two-phase flow is modelled in the programme Engineering Equation Solver and the results are used as an input to a dynamic CFD-model, modelled in ANSYS Fluent. The CFD-model includes the effects of the two-phase process in the pipe and temperature gradients in the pipe walls in order to predict thermal strain and expansion/contraction of the pipe material.

Keywords: Two-phase, Pipe Flow, Gas-liquid Flow, EES, CFD

GENERIC MODELLING TOOL FOR TECHNOECONOMIC ANALYSES OF HYDROTHERMAL LIQUEFACTION PROCESS SCENARIOS

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Abstract: Drop-in fuels from biomass represent a suitable alternative to replace fossil fuels due to their comparable thermo-physical characteristics and lower CO2 associated emissions. Hydrothermal liquefaction (HTL) is a prospective technology that converts biomass into biocrude, an upgradeable precursor for drop-in fuels production. This study demonstrates the bio-oil production viability of a conceptual industrial scale plant, based on the development of a generic model by means of Aspen Plus® simulations. State-of-the-art experimental data of the biocrude composition are adopted for the modelling. A techno-economic analysis is developed in order to analyze the feasibility of a continuous biofuel production, with the objective to estimate the production cost per gallon of biofuel. Complementary an energy study is carried out in order to optimize the energy consumption of the process. As well as a sensibility analysis, with the purpose to identify the key parameters and to what extent they affect the production cost. Additionally, different configuration strategies are analyzed with the objective to find the cost optimal design.

Keywords: hydrothermal liquefaction, biomass, hydrotreating, drop-in fuels, techno-economic analysis

A THERMAL MODEL FOR DEVELOPING TEMPERATURE CONTROLLERS USED IN WIND TURBINE COOLING SYSTEMS

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Abstract: Modern wind turbines require robust cooling designs to maximize turbine availability and component lifetime. Considering offshore turbines, the importance of these solutions is further increased. Naturally, the turbine subsystems causing downtime are given special attention. This study presents a dynamic, lumped parameter thermal model of the liquid cooling system conveying the heat losses from the power converters and the transformer to the ambient air. The model constitutes a software tool aiding the development of new, robust temperature controllers. A Siemens Wind Power direct drive prototype turbine serves as the model design case, and the model validation uses field measurements from the turbine. The modelling approach and limitations are discussed. An example, in which an alternative temperature controller performance is benchmarked, is given.

TRAJECTORY CONTROL FOR HYDRAULIC SERVO ROBOT

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Abstract: This paper investigates several linear and non-linear control strategies for a hydraulic servo robot using advanced trajectory planning. The study is undertaken in order to improve response of industrial robots as these often use a simpler and slower form of trajectory control, which in turn yields lower computational demands [Kim & Croft, 2014]. The goal of improving the response is achieved by implementing advanced trajectory control that reduce the RMS tracking error of the tool point (TP) while maintaining high TP velocity, effectively optimizing the movement of the robot. The robot is modelled using MATLAB-Simulink and validated using experimental data from the actual robot setup. Subsequently the trajectory planning and control strategies are developed. A comparison is made between classical linear control and non-linear control strategies to support the use of these. The significant control strategies tested are a classical PI controller with velocity feedforward and a non-linear gain scheduling controller. Among these the non-linear gain scheduling controller proved to have the smallest RMS tracking error while maintaining acceptable velocity. Lastly the advanced trajectory control scheme is compared with an ordinary LSPB (Linear Segment with Parabolic Blends) trajectory control, which showed results that supported the use of advanced trajectory control.

Keywords: Hydraulic Servo System, Trajectory Planning, Non-linear Control, Gain Scheduling, Hydraulic Robot

CONTROL OF DIGITAL DISPLACEMENT WIND TURBINE TRANSMISSION

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Abstract: The availability of offshore wind turbines is considered one of the main problems with the known wind turbine topologies where the transmission system contributes with 45% of the total downtime. To improve the availability of the wind turbines Digital Fluid Power (DFP) transmission has been proposed as an alternative to the conventional transmission. Utilizing DFP based transmission does however complicate the control design as the control design are not straightforward the since pressure pulsations and discrete effects are added to the system. In this paper, different control strategies for a DFP based transmission system, consisting of two digital displacement® (DD) machines, are investigated. A dynamic model of the DFP transmission system is presented. The DFP model is combined with the NREL 5 MW reference wind turbine model to analyze the performance of the DFP transmission system. The control of the digital displacement machines is based on a full stroke strategy where a Delta Sigma pulse density modulator is used to determine the chamber activation sequence. To design the controller a discrete linear time invariant model is presented. The results from the performance analysis will be basis of a comparison in the end of the paper.

Keywords: Digital Fluid Power, Digital Displacement® machines, Offshore wind turbine, Digital Linear Invariant model, Delta Sigma modulator

MONITORING OF A SOLENOID VALVE

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Abstract: For applications used in the industry, reliability is of great importance. This paper deals with monitoring of hydraulic solenoid valves used in hydraulic High Torque Low Speed(HTLS) motor applications, with the purpose of increasing the reliability of the system. Knowing the state of the solenoid valves is of much importance, and enables automation and flexibility in maintenance and control of the solenoid valves. At best incipient failures in the system can be predicted and avoided. Methods for estimating the position of the valve plunger, based on current and voltage measurements are presented and evaluated. Furthermore, a method to measure fault indicators for the solenoid valves is presented and tested. This is done with the purpose of providing early information regarding incipient failures, such that maintenance may be scheduled and downtime of the system is minimized.

Keywords: Sensorless Position Estimation, Fault Diagnostic, Solenoid Valve, Electromagnetic Actuator, Monitoring.

OSCILLATIONS OF TRACTOR WITH IMPLEMENT

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Abstract: This paper reviews off-road vehicles with an implement mounted at the rear of the vehicle and how external disturbances exerted during transport on roads at speeds of 30 – 50 [km/h] can be damped since the disturbances affect the dynamic behavior of the tractor with regard to mechanical stress, and safety - and comfort for the driver. A typical problem during transport is mechanical stress on the links connecting the implement and the off-road vehicle together with reduced traction of the front tires with the road as the vehicle oscillates. A model and analysis of the mechanical structure is made based on a chosen tractor and implement representing a general case structure. Additionally, models of external disturbances are made to represent the possible disturbances which could occur. The mechanical model is validated through experiments conducted with the given tractor-plough configuration.

Keywords: Off-road vehicles, Oscillations, Mathematical model, Road disturbances

MODELLING AND OPTIMIZATION OF FAST SWITCHING SOLENOID VALVE

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Abstract: This paper seeks to optimize a solenoid actuator design to improve performance and robustness of Digital Displacement (DD) machines which offers a lighter and more versatile alternative to the mechanical transmission used in modern wind turbines. Due to the solenoids simple structure and lack of moving magnets or coil it is a very reliable alternative to its more advanced counterparts in the moving magnet and moving coil topologies. The solenoid has been optimized to have minimum flow losses and electrical power consumption. The actuator force and inductance has been modelled using a static finite element analysis, and the flow losses have been approximated by a dynamic model of a single chamber.

Keywords: Solenoid, Digital Displacement, Optimization, Finite Element Analysis, Wind Turbine

OPTIMUM DESIGN OF A BI-STABLE MOVING MAGNET HYDRAULIC VALVE ACTUATOR WITH PARALLEL COIL WINDINGS

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Abstract: High efficiency hydraulic machines using digital valves is presently a topic of great focus. Digital valve performance, with respect to valve opening/closing time as well as power consumption, is key to obtaining high efficiency performance. A recent digital valve design developed at Aalborg University utilizing moving coil actuation, achieves admirable performance. This paper builds upon this design by proposing a retrofit which preserves the seat valve design, but uses moving magnet actuation. The moving magnet actuation has the advantage of stationary coils (which can improve reliability), as well as the possibility of obtaining magnetic latching in both open and closed valve position (bi-stability).

4 topologies using moving magnets are considered where magnet and coil positioning is varied as well as designs with 2 and 4 coils, and 1 and 2 layers of magnets, are considered. Electrical power consumption and valve opening/closing time is achieved through a dynamic lumped parameter model. The flux linking the individual coils and the actuator force is found using finite element analysis. Finally, through Generalized Differential Evolution optimization, the 4 topologies are optimized with respect to electrical power consumption and opening/closing time. An outstanding design with respect to performance and degree of practical realization is highlighted.

Keywords: Digital Hydraulic Valve, Moving Magnet Actuator, Generalized Differential Evolution Multi-Objective Optimization, Parallel Coil Excitation, Digital Displacement Machines.

STUDY OF A NOVEL ALGORITHM FOR TRIBODYNAMIC MEASUREMENTS USING ULTRASOUND

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Abstract: A new direct approach for calculating film thickness in tribodynamic applications, using ultrasonic measurements, is presented. Analytical deviation of the new approach is performed, using quasi-static wave equations. The usability of new approach is quantified through a statistical error analysis, including the calculation bias and standard deviation when measurements are subjected to random noise. The statistical findings show significant improvements in terms of noise rejection when compared to the existing spring model approach, commonly used in literature. The larger noise rejection found in the new approach may not only increase the accuracy of the calculated film thickness but also extend the measurable film thickness range, making the approach even more advantageous.

Simulations of ultrasonic wave reflections, in a steel-oil-steel set-up, are conducted in COMSOL. The wave reflection data from the COMSOL simulations are used to calculated the film thicknesses using the new approach and the spring model. The findings in the statistical error analysis are clearly illustrated in the simulation results, where the direct approach has a larger measurable range compared to the spring model approach.
Experimental verification of the COMSOL simulations are conducted using a test set-up especially made for ultrasonic film thickness measurements in the micron range. The experimental validation shows good compliance with the COMSOL simulations, thus evident that the COMSOL simulations may be used to verify the results of the statistical analysis.

Keywords: tribodynamic, ultrasonic, COMSOL, fluid thickness, direct approach,

MODEL-BASED CONTROL OF A DIGITAL FLUID POWER TRANSMISSION DRIVETRAIN IN A WIND TURBINE

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Abstract: In recent years there has been increased attention on the reliability of drivetrains utilised in modern wind turbines, especially multi-megawatt machines. An increased proportion of the operating wind turbines today are reaching an age, where failures caused by wear out in the mechanical and electrical parts of the drivetrain occur. One alternative to conventional drivetrains is a digital fluid power transmission (DFPT) based drivetrain, wherein the traditional gearbox and power converter may be omitted. The DFPT based drivetrain offers high power to weight ratio and a rugged mechanically decoupled gear. In the past conventional FPT have shown poor partial load efficiency, however, due to recent advances within DFP partial load efficiencies may be improved. The utilisation of digital machines comes with the cost of non-smooth torque and pressure characteristics, which necessitates the design of suitable control algorithms. This non-smooth behaviour extends to the control system, which is discrete. This paper investigates how model based control strategies suitable for DFPT based drivetrains can be developed for modern utility-scale wind turbines. For this, a dynamic model of a DFP transmission for a NREL 5 MW wind turbine has been developed upon which different control strategies are evaluated.

Keywords: digital fluid power, DFP, wind turbine, digital machines, digital hydraulics

FRICTION MODELLING OF HYDRAULIC CYLINDER

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Abstract: This paper investigates the usability of the New Modified LuGre model to describe the friction behaviour in a hydraulic cylinder. If the New Modified LuGre model cannot describe the friction behaviour accurately in the entire range of work areas, modifications will be made. To estimate the friction model parameters, the least-squares method will be used to obtain an accurate fit between the model and measurements. The proposed friction model and parameter estimation algorithm will be included in a fully automatic test sequence which can estimate friction model parameters. This parameter estimation sequence can be utilized to easily estimate friction parameters in a wide range of cylinders. To validate the friction model and parameter estimation method, the sequence is tested on another test-bench of the same type. The parameter estimation sequence should be able to easily determine accurate friction parameters for the friction model.

Keywords: Friction, Friction models, Parameter estimation, Hydraulic cylinder friction, LuGre model

LOSS-ESTIMATION AND MEASUREMENTS IN SUBMARINE CABLES

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Abstract: Due to the environmental concerns today, an increase in offshore windfarms are seen. This results in an increased demand for submarine cables, however these are over dimensioned which leads to higher material costs. The overestimation is due to the IEC60287 standard for calculation of ampacity. To help finding an optimized method, to be used by manufactures, this paper conducts measurements on a submarine cable to clarify the loss phenomenon. Recent studies have different explanations as to why the IEC standard overestimates the losses and how to model them, though the studies agree that presence of wire armour is the cause. Therefore, more fieldwork is needed in order to acquire more knowledge about this topic. Several measurements are conducted; the results comply with the derived physics-theory for submarine cables. A main finding is that the mag-netic field outside the cable with armour is much lower than without. In this case the sheath current is bigger, this indicates that induced current in the armour effects the magnetic field produced by the conductor current. It is concluded that more research is needed to explain the wire armours effect on the magnetic field, however the information provided can lead to more precise model simulations.

Keywords: COMSOL, Submarine Cables, Armour losses, Cable Measurements, IEC60287

THE EVOLVING GRID: MODELING AND CONTROL OF ELECTRICAL AND HEATING SYSTEMS

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Abstract: Developments in heating and power sector facilitate the transition from a traditional system, where each sub-system is analyzed individually, to the creation of an integrated power and heat system, which will play a vital role in providing clean, non-polluting energy in a reliable way. Although this integrated system offers a lot of benefits, such as carbon emission reduction, increase integration and utilization of RES and increased reliability and flexibility, analyzing such a network is a complex task. The scope of this project is, initially, to identify and analyze the linking components between the heating and electricity networks, giving more emphasis to the most popular of the aforementioned components. Subsequently, the dominant parameters from electrical systems are paired to their equivalent in heating systems and then the procedures to model and control the integrated system are presented and explained. Finally, the optimization of the modeled integrated system is performed. Specifically, the amount of energy interaction between the electrical system and the heating system, under fluctuating wind power production, that will lead to the minimal cost is investigated. Software Matlab is used to model and operate the system and DIgSILENT Power Factory and PSS SINCAL are used to validate the results.

Keywords: Integrated energy systems, District heating, Heat pump, Co-generation, Optimization

ADAPTATION OF SUBSTATIONS INTO SCADA – NORTH CYPRUS

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Abstract: This project is aimed for preparation of a guideline to apply on adaptation process of substations into SCADA in North Cyprus. Electricity Authority of North Cyprus (KIB-TEK) was started adaptation process in 2007 and only a certain number of substations were adapted within first stage. In second stage, completion of SCADA system has been planned to adapt all substations for controling them over a computer-based control center. Within scope, major problem has been seen as existing communication system (RF communication). It needs to be replaced by a new communication system to provide reliable data transfer between substations and control center. To progress smoothly, project has been divided into 3 sections as communication system, substations and control center. A general analysis of system has been shared with readers in each section to present existing system. Necessary changes and improvements have been discussed by considering requests of KIB-TEK. Best practices have been examined by technical analysis done to select best fits (equipments and systems) for preparing utilizable guideline for KIB-TEK. As a result, overall discussion has been reflected for guideline to have applicable plan for implementation. Fiber Optic communication system (OPGW) has been offered for resolving problems on existing system and RF communication system remained its place as a back-up communication system.

Keywords: SCADA, RF communication, OPGW, İmprovements, Substation, Control center

DESIGN AND CONTROL OF MODULAR MULTILEVEL CONVERTERS

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Abstract: AC has been preferred as the global platform for electrical transmission throughout the world. However, with the passage of time a number of demerits of AC transmission system have been encountered like power losses and difficulty in interconnection of two asynchronous grids etc. This led to the growth of HVDC. Use of HVDC reduces the losses in the transmission line and provides higher reliability to interconnect the asynchronous AC grids. It also enhances the opportunities of using underground and subsea cables. Modular Multilevel Converters are an emerging technology and is widely used in HVDC applications. However, the size of the sub module capacitors used in MMC is still large and the energy balancing under unbalanced circumstances is still impending. In this project an analytical model focusing on energy stored in capacitor and voltage variations in order to achieve higher performance of MMC is discussed. A harmonic component is injected into the system, thereby reducing the energy variations and voltage ripples in the capacitor, which will further lead to reduction in the size of the sub module capacitors. This will reduce the size and cost of MMCs. The proposed method will be tested though simulations.

Keywords: HVDC, MMC, Voltage variations, Energy balance, Capacitor sizing

DESIGN AND OPTIMIZATION OF A PERMANENT-MAGNET SYNCHRONOUS GENERATOR FOR A DIRECT-DRIVE HORIZONTAL-AXIS WIND TURBINE

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Abstract: A permanent-magnet fractional-slot concentrated-winding direct-drive synchronous generator design aspects and optimization was studied in this project. Dynamic modelling was introduced with modelling the wind turbine generator. Finite element based Electromagnetic and Transient analysis was performed to the generator for the purpose of diagnose and optimize the wind turbine system in terms of electrical conditions. Harmonic content optimization, cogging torque reduction, winding type and specifications, number of stator slots and number of poles were designed and decided with interpreting of electromagnetic (EM) simulation. Electrical parameters were predicted with the support of transient and finite element analysis (FEA). Permanent-magnet material & shape, sheet steel type & stator slot shape were defined and revised up on cost / efficiency ratio of generator for mass production purposes. A scaled generator was built and tested with a test bench. Torque, speed, phase current and voltage, power factor and thermal parameters were tested and recorded for validation. Finite element model (FEM) revised up on mass production changes. Validation of optimized wind turbine generator with comparison of laboratory tests and simulation results were evaluated. Future works were presented.

Keywords: Fractional-Slot, Concentrated-Winding, Permanent-Magnet, FEA, EM-simulation

COORDINATED CONTROL OF COMBINED SOLAR PV AND ENERGY STORAGE SYSTEMS

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Abstract: Nowadays, a new challenge is growing in the energy power systems field, which is the increase of distributed generation from renewable sources. The main drawback is the intermittency in power generation from these sources, thus new systems are needed to satisfy the continuously growth of energy demand. The storage systems associated with photovoltaic energy is a promising solution for future residential homes, being more viable in areas with high solar penetration level and high retail electricity prices. The main objective of this project is to develop a control scheme between solar PV and storage systems for residential users in the LV network. To fulfil this, services such as frequency control, active and reactive power control must be considered, thereby ensuring a better overall stability. Furthermore, operational strategies for increasing energy capture and household autonomy (smoothening effect, peak-shaving) will be considered.

Keywords: control, storage systems, photovoltaic, PV

MODELLING AND VERIFICATION OF TOWER DYNAMICS FOR A SCALED FLOATING OFFSHORE WIND TURBINE

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Abstract: Prediction of early stages of structural damage on a floating offshore wind turbine (FOWT) tower leads to decrease in cost of repair and maintenance. To provide predictions which are sufficiently accurate and trustworthy, mathematical models of the structure and external forces must be developed and verified experimentally. This paper presents structural modeling of the tower of a FOWT dynamics influenced simultaneously by hydrodynamic and aerodynamic external forces. This model will be used for designing the wind turbine control to avoid structural damages. Especially the natural frequencies of the tower are important to avoid, and are shown in a Campbell diagram. The mathematical model is simulated in MATLAB, ANSYS and FAST, all based on finite element analysis. To verify the mathematical models experimentally, a scaled physical model of a 1:35 NREL 5 MW wind turbine is designed and constructed. The physical tower model is a flexible cylinder, monitored by strain-gauges, accelerometers and cameras. The experiments consist of static load, free decay and harmonic excitation tests on the tower separately and mounted on a floating tension leg platform. The results are expected to verify the developed models of the tower dynamics which can predict structural damages, when exposed to environmental forces.

Keywords: Floating offshore wind turbine, Scaled model, Hydrodynamics, Offshore wind turbine tower, Finite Element Analysis

MONITORING OF OIL-IN-WATER USING JORIN VIPA

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Abstract: In the past decades oil production has been an important energy source for the industrial and private sector. When the crude oil is being extracted from the subsurface a separation process is essential. The crude oil consists of formation water, oil, gas and dirt. After the separation the formation water is being discharged into the sea. The discharge is limited by the oil-in-water (OiW) ratio being maximum 30 PPM (part pr. million) due to environmental concerns. A way to control and observe the OiW-ratio is by using Jorin ViPA. A Jorin ViPA has different features including measurements of particle size and shape and hereby the concentration of OiW. Since the Jorin ViPA is a relatively new machine this project concerns validation and calibration by experimental data. The experiments will concern three particle samples with already known particle size. After this validation an experiment including a high shear pump and two Jorin ViPAs is performed in order to see, which extent the pump is able to tear and mix the oil and water.

Keywords: OiW (oil in water), separation, Jorin ViPA, particle size, experiments.

A CONTEMPORARY GUIDE TO MODEL AND CHARACTERISE A PERMANENT MAGNET SYNCHRONOUS MOTOR

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Abstract: This paper provides a basic guide for characterising and modelling a permanent magnet synchronous motor (PMSM). This is done to ease the transition into motor analysis and modelling for electrical engineers with limited experience and knowledge in electrical machines. There exists a lot of literature describing motor analysis and modelling, but not many papers providing a thorough, structured and complete guide. To characterise the motor the direct and quadrature inductances of the PMSM, the flux linkage of the rotor permanent magnets and the torque in the air gap are found. To account for non-linearity of the motor, the current dependent direct and quadrature inductances are modelled together with the cross coupling between them. In addition, a guide to experimentally determine these parameters is given. A blocked rotor test is conducted to find the direct and quadrature inductances. An open-circuit test is carried out in order to find the flux linkage of the rotor permanent magnets by measuring the open circuit induced voltages (EMF). These parameters are combined to establish a dynamic model, which is implemented in Simulink. The dynamic results are compared with a motor-generator test in the laboratory. With this simple guide, inexperienced engineers can find essential motor parameters and develop a dynamic model both numerically and experimentally.

Keywords: Permanent magnet synchronous motor (PMSM), Direct- and quadrature inductances, Flux linkage, Cross coupling, Dynamic modelling

DESIGN AND ANALYSIS OF A DOUBLE-STATOR PERMANENT MAGNET MACHINE FOR HIGH POWER DENSITY APPLICATIONS

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Abstract: Compared with conventional machines, permanent magnet machines are much more efficient because of no requirement of electrical excitation. However, high energy product permanent magnet is very expensive and is one of main cost of the machine. Hence, it is very important to effectively utilise permanent magnet material, i.e. high power to magnet material ratio. On the other hand, it is always a key target to improve the power density and efficiency of the machine. Therefore, it is necessary to investigate a new type of permanent magnet machines, double stator permanent magnet machines. This paper proposes a permanent magnet machine having two air gaps on both inner and outer sides of magnets. Both stators can act on the rotor to produce torque. The double stator topology can greatly boost the power rating of wind power generators. Therefore, achieving higher rating on each tower can significantly reduce the cost per kw electricity. It requires higher power rating of wind power generator. In the paper, the airgap field distribution and the back-emf and cogging torque waveforms of double stator permanent magnet machine are calculated by the finite element (FE) analysis. The detailed analysis will be given in the full paper.

Keywords: permanent magnet synchronous machines (PMSMs) dual-stator, finite element method

INVESTIGATION ON POWER MOSFET SWITCHING SPEED: REACHING THE PHYSICAL LIMITS OF THE DEVICE

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Abstract: Hard switching represents the cheapest and easiest way of designing and controlling a power electronics converter, as it doesn't need special control strategies or additional passive components to achieve its operation. Increasing switching speed (i.e. reducing switching time) enables lower switching losses and higher operating frequencies, leading to converters with higher efficiency and higher power density. But greater di/dt and dv/dt coming with higher switching speed also lead to EMI worsening and increased device stress. With the advent of wide band gap devices, which enable a higher theoretical switching speed, a more detailed comprehension of switching operation and loss mechanisms is required: parasitic components and semiconductor physical constraints can no longer be neglected. This project focuses on MOSFET hard switching operation: a detailed analysis of the theoretical switching loss mechanism is provided, followed by a description of major packaging-derived parasitic effects. An equivalent circuit model will be built for switching waveform simulation and a double-pulse test will be carried out in the lab for validation purposes. The aim of the project is to find out the theoretical limits and constraints in lowering MOSFET turn-on and turn-off times.

Keywords: power MOSFET, hard switching, switching losses, high-speed switching, packaging parasitics

COMPENSATION OF TIME DELAYS CAUSED BY DIGITAL CONTROL OF PWM INVERTER WITH PREDICTIVE CONTROL TECHNIQUES

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Abstract: Digital control is widely used in today's control system, because of its extensive array of possible control schemes. However, it does come with some disadvantages, like the delay caused by the sampling of continuous variables. This drawback affects the stability of the system. Its effect can be quite noticeable, when a high speed motors are involved or a low switching frequency has to be used for conventional motors. In this paper predictive techniques will be used, like the smith predictor, to eliminate the delay in a control system for a permanent magnet synchronous motor (PMSM). The stability of the system with predictive control, will be compared with the classic field oriented control (FOC) approach. The model and parameter accuracy of the implemented control schemes will be investigated. Conclusions about the presented predictive control methods will be made, and future suggestions, leading to their refinement, will be presented.

Keywords: permanent magnet synchronous motor, predictive control, time delay, smith predictor, field oriented control

COMPENSATION OF TIME DELAYS CAUSED BY DIGITAL CONTROL OF PWM INVERTER WITH PREDICTIVE CONTROL TECHNIQUES

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Abstract: Today power electronics have a main role in the conversion of renewable energy into useable energy. The control of the power electronics has moved towards using digital control instead of analog control due to e.g. higher flexibility, and endless control possibilities. One of the disadvantages of the digital control however, is the inevitable time delays introduced. The delays tend to destabilize the control system and complicate the control design and analysis. Therefore, the aim of this project is to implement a delay compensation within the existing field oriented machine control, as a case study. This involves analysis and comparison of different predictive control strategies, to predict the time delay influence on the system. The project will be based on theoretical investigation of time delay effects and compensation techniques, furthermore a practical implementation to support the theoretical analysis.

Keywords: Digital Time Delays, Predictive Control, PMSM, Field Oriented Control, Delay Compensation

NUMERICAL INVESTIGATION OF A STEADY STATE FLOW WITH A BACKWARD FACING STEP

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Abstract: This paper describes the procedure of programming a CFD code in MATLAB for solving a two dimensional flow, through a sudden expansion, where a backward facing step is accounted for. The motivation for carrying out this study was to get a thorough understanding of how pressure-velocity coupled problems are solved numerically. The assumptions are the following: the flow is steady state and laminar, the fluid is incompressible and its properties are assumed to be constant. The application of any turbulence models has been neglected. Based on the SIMPLE algorithm the Navier-Stokes equations are derived through the finite volume method such that they satisfy continuity. The boundary conditions are given as an inlet velocity and an outlet pressure. The no-slip condition applies to the walls such that the flow accounts for the boundary layer. The geometry in which the domain is based upon corresponds to an experiment found at ERCOFTAC. A comparison between the program and the experiment serves as a source of validation.

Keywords: CFD, FVM, Backward facing step, Navier-Stokes

LASER VELOCITY VALIDATION OF A TURBULENT FLUID-MIXING MODEL

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Abstract: Turbulent flows are an important topic in fluid dynamics, where the principles of fluid mixing are of interest in industrial applications. This paper presents the use of Laser Doppler Anemometry (LDA) for measurement of the velocity distribution in a turbulent mixing chamber, for comparison with a CFD model. The velocity distribution is measured non-intrusively using a high-powered laser and polyamide tracer particles, with scattering light being sampled with a photo sensor in backscatter-mode. The CFD model was developed in ANSYS Fluent incorporating several turbulence models for comparison, including k-ε, k-ω and LES models. A mesh quality and independency analysis was performed to find an optimum between accuracy and calculation time. The verification of CFD results is done, using multiple points of velocity measurement in the mixing chamber, and it is expected that the k-ε, will underestimate the mixing of the fluids. The LES model is thought to give a more accurate representation of the mixing behaviour inside the chamber.

Keywords: LDA, CFD, Fluid-mixing, Turbulence, Tracer particles.

VERIFICATION OF BASIC TURBULENCE MODELS FOR FLOW-MIXING

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Abstract: Turbulent flow-mixing is one of the physical phenomena most difficult to model. Therefore, it is common to use turbulence models to simplify the Navier-Stokes equations. In chemical processes, where mixing occurs, turbulence can be used to speed up the rate of reaction. Hence, the importance of being able to achieve precise results from predictive models. An existing experimental setup, designed for flow-mixing studies, is used to validate the results from the CFD model. This setup is constructed of acrylic glass making it possible to use Multi-Frame/Single Exposure Particle Image Velocimetry (PIV). The results from the non-intrusive PIV measurements are the instantaneous velocity field in the image-/object-plane. These results are processed using snapshot Proper Orthogonal Decomposition (POD) to obtain the average of the most energetic turbulent structures in the flow. The two-equation k-ε turbulence model is used as basis for the CFD model due to its simplicity and its extensive use in industrial CFD. The flow-mixing is modelled as steady state due to nature of the turbulence models. Thereby making the results from the snapshot POD comparable to the CFD results. Based on the comparability between the experimental data and the k-ε model's results more advanced turbulence models might be incorporated.

Keywords: Flow-mixing, PIV, CFD, POD, turbulence models