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MEGSC2

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Preface

Dear students, faculty members and guests - welcome to the second annual mechanical engineering graduate students conference (MEGSC2). The MEGS conference has now been established as an annual event in the Department of Mechanical Engineering, with the goal of providing an opportunity for graduate students to present their ongoing research activities or engineering interests to the UNB community. The conference is centered on presentations, with judges to provide valuable feedback to the students in developing their presentation skills. It also gives an opportunity for students within the Mechanical Engineering Department to share their ideas and broaden their perspectives. A conference brochure is provided with abstracts providing more details on the presentation content.

The conference is a joint effort between the Mechanical Engineering Graduate Student Society (MEGSS) and the Department of Mechanical Engineering. Both organizations have seen the benefit in providing a realistic conference setting for our students in preparation for their later professional responsibilities. With this in mind, many thanks go to the MEGSS officers and the secretarial staff in the Department of Mechanical Engineering for organizing the events. It is hoped that the provision of food and prizes, including a best presentation prize, will foster an environment for meeting one another and discussion of the research.

Lastly we want to thank all of the graduate students who have offered to present their research work to the UNB community. It is always a challenging step, but the willingness to make our work open and accountable also leads to opportunities. In this case, opportunities for new ideas as our own ideas are challenged, but also to receive validation that our efforts are valuable and a contribution to the engineering community and ultimately society.

Andrew Gerber, PhD, PEng
Associate Professor &
Director of Graduate Studies

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Finite Element Based Model Predictive Control of a Rotating Beam

Chunying Li, MSc Candidate

A new Model Predictive Control (MPC) method is developed and demonstrated on vibration suppression of a rotating beam. The physical system is modeled as an Euler-Bernoulli beam including the effect of a driving motor using Lagrange's equation associated with an assumed mode method. The experimental set-up consists of a DC motor to drive the beam to a desired angle; a strain gauge to sense the deformation of the flexible beam; four piezoceramic actuators for actively suppressing the undesired vibrations caused by the torque during the motion; and a signal conditioner to filtering the noise of the signals. A multivariable MPC controller is designed to control both the angular rotation and the beam oscillation. In the standard MPC algorithm, the process behavior is represented by an empirical model which is identified from open loop test data. It is well known that if the process runs beyond the operating range of the test data, the empirical model is not expected to accurately predict process behavior. This factor limits the application of MPC to a system that have a high level of nonlinearity. A finite element (FE) model of the system is proposed to be used in the MPC algorithm to predict the process dynamic behavior. The proposed methodology can accurately predict process behavior over a much wider range of operating conditions and therefore will have a better capability to deal with nonlinearity. Numerical simulations and experiments were conducted and improved results were obtained in terms of level of vibration reduction when compared to using the standard MPC.

Contact dynamics in the simulation of flexible slack tethers

André Roy

Tethered systems are used in many applications, most notably in underwater exploration. In the operation of such systems, especially for underwater Remotely Operated Vehicle (ROV) operations, it is critical that operators remain in the control loop. Currently, the only viable means of maintaining human control during underwater ROV operation is through the vehicle's tether, which also provides power to the system.Due to the high cost of ROV and their tethers, a realistic simulator is needed to train their pilots. To accurately simulate the tether, which has a large impact on the dynamics of the ROV, it is important to detect collisions of the tether with the environment or itself and calculate the forces involved.

The aim of this work is to present a computationally efficient and accurate contact dynamics model for flexible slender objects. To achieve this, collisions between the tether and itself or the environment first need to be detected. To this end, a combinatorial global optimization method is used to determine the exact separation distance and the location of the closest points. When a collision is detected, an accurate contact geometry is calculated. With this information, a method consistent with the Hertzian contact model will be used to obtain the forces involved. Such forces are to be included in an existing finite element lumped-mass model of the tether to determine the tether's state in the next time step.

Pore Level Simulation of Fluid Flow in Porous Media using Lattice Boltzmann Method

Aydin Nabovati, PhD Candidate

Calculating the permeability of the porous media has been a challenge for engineers and scientists and a huge number of the experimental, analytical and numerical works have been done in this field. To do numerical analysis, two different approaches have been developed. In the first approach, volume averaged velocity through the porous medium is modeled. In this approach, a correlation for the permeability of the medium as a function of the geometrical parameters of the problem is needed (Hooman and Merrikh 2006). The second approach is the fluid flow simulation at pore level (Nakayama et al. 2002). Mesoscopic methods like Lattice Gas Automata (Frisch et al. 1986) and Lattice Boltzmann Method (McNamara and Zanetti 1989) are alternatives for the Navier Stokes equations for the fluid flow simulations at pore level. These methods are suitable for dealing with the complex geometry of the porous media at pore level and flows which may experience either continuum or slip flow regime. Porous medium flow analysis was one of the first applications to which LBM was applied (Succi et al. 1989).

In the present study, fluid flow in two dimensional random porous media is simulated at pore level using the lattice Boltzmann method. Random media have been constructed by placing the identical rectangles randomly with free overlapping. Different domain resolutions have been examined and it has been shown that the effect of the domain resolution is negligible in the range examined. Simulations show that the permeability of the random porous media is an exponential function of the porosity and is higher than the permeability of the regularly ordered medium with the same porosity. The simulated tortuosity and permeability are in very good agreement with the available correlations. Effect of the aspect ratio of the randomly placed obstacle has been studied on the tortuosity and permeability. It is shown that the higher is the aspect ratio (height to width ratio), the lower is the permeability. Tortuosity is increased by increasing the obstacle aspect ratio.

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Numerical analysis of the effect of stress triaxiality on void coalescence

Yang Zhang, PhD Candidate

The fracture of ductile materials has frequently been observed to result from the coalescence of microscopic voids. The stress triaxiality is one of the primary factors that influence void coalescence. In this work 3D unit cell model is employed to investigate the effect of stress triaxiality on void coalescence. The cell model contains two linearly aligned primary ellipsoidal voids. Finite element simulations based on Mises matrix unit cell models, Zhang's new failure criterion Gurson model, and new failure criterion for the Sun's model were performed to predict the onset of void coalescence at different stress triaxiality levels.

Damage-based finite element simulation of void nucleation in Al-Mg alloy sheet

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With ever-increasing fuel prices and emission regulations, the automotive industry has turned to using advanced high strength steels (AHSS) and aluminum alloys to reduce weight and improve fuel economy. Aluminum is particularly attractive due to its combination of strength, weight, crash-energy absorption, corrosion resistance and thermal and electrical properties. Despite these desirable properties, aluminum alloys generally exhibit inferior formability compared to steel. Aluminum alloys experience poor formability due to the presence of second-phase particles which crack or decohere to form voids (damage) during forming which grow and coalesce to form micro-cracks leading to ductile fracture.

The objective of the present work is to determine the void nucleation rule and its parameters for Al-Mg alloy AA5182 sheet using notched tensile tests. Upper and lower bound damage-based constitutive models are used as the actual material behavior and nucleation parameter lies within these limits. Simple and complex nucleation models are compared to the experimental results and an appropriate model suggested. The lower-bound yield criterion of Sun and Wang (1989) with a modified stress-controlled nucleation rule was found to give strong agreement with the experimental observations.

Crossflow Hydrodynamics of the DRDC Bare Hull Submarine at Incidence

Tiger L Jeans, PhD Candidate

An important contribution to the hydrodynamic forces on undersea vehicles is the normal force and pitching moment on the streamlined hull. This is especially true when the hull is at moderate to large angles of incidence where the need for control of the vehicle's dynamic motion is the greatest. The primary goal of this paper is to expose the hydrodynamics of the flow around the Defence Research and Development Canada (DRDC) standard bare submarine hull at moderate to high incidence angles. In particular, to study the relationship between the crossflow and the normal force and pitching moment on the hull by evaluating the flow in planes normal to the body axis. This approach is meant to emphasize the locally two dimensional character of the flow over the hull to provide a basis of evaluation for an analogy between flow over slender bodies at incidence and the transient flow problem of an expanding and contracting two-dimensional cylinder in a uniform flow.

The basis of this study is a comprehensive Computational Fluid Dynamics (CFD) study that was performed at the University of New Brunswick on the DRDC standard submarine hull [1] for a Reynolds number of 23×10^6 and incidence angles up to 30^o. This work was meant to complement an earlier experimental wind tunnel study of the hull shape [2, 3] in which three components of force and moments were measured.

From the study it was concluded that two key features of this flow are the sink/source effect that occur over the nose and tail regions, and separation that forms on the leeside of the tail at low incidence and migrates noseward as incidence is increased. When the separation is strong, a separation sheet rolls up into a vortex, which is continually feed by a shear layer along the body causing it to grow in both size and strength.

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Control of Cavity Pressure during Injection in an Injection Molding Machine

Jose Mauricio Hernandez, PhD Candidate

The cavity pressure inside the mold in an injection molding machine has been recognized as an important parameter affecting final product quality. Maintaining a given cavity pressure profile in light of disturbances such as changes in melt temperature, coolant temperature, and melt composition ensures the production of a good quality part. The focus of this investigation is to provide a mechanism to control the cavity pressure during the injection cycle in an injection molding machine.

Controlling the cavity pressure required the development of a control mechanism. Pressure sensors inside the mold cavity were used to measure the pressure of the melt as it is injected. The cavity pressure is affected by the movement of the screw as it injects the melt is injected into the mold. The screw movement during injection is affected mainly by the manipulation of the variable size hydraulic valve Y3.

Open loop tests were performed to obtain the relationship between the Y3 hydraulic valve and the cavity pressure. Using the test results a controller was developed. The control used in this investigation is a form of model predictive control known as Dynamic Matrix Control (DMC). Simulation and implementation tests were performed on an industrial scale injection molding machine with good control performance.

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Prediction of Fluid Force Coefficients for Tube Arrays Using Computational Fluid Dynamics Simulation

M.A. Gerber, M. Hassan, H. Omar, PhD Candidate

Fluid elastic instability is the most damaging flow excitation mechanism in heat exchanger tube arrays. The most comprehensive unsteady flow theory presented to date has been by Chen and Tanaka and Takahara. However the unsteady flow model is valid for any tube array geometry and for any number of tubes. The force coefficients required for this model are only available for two tube array geometries. The first objective of this work is to calculate the unavailable tube array geometries fluid force coefficients required to solve the unsteady flow theory model for fluid elastic instability. The second objective is to verify that the use of computational fluid dynamics **(CFD)** model is a powerful method for extracting fluid force coefficients. In this work **CFD** had been used to model the fluid forces generated by forced oscillation of a single tube within an otherwise rigid array. The Navier-Stokes equations are solved for the Reynolds-averaged fluid flow and turbulence conditions, and are cast in Arbitrary Lagrangian-Eulerian **(ALE)** form to account for the effects of grid motion in a moving boundary problem. CFX-TASC flow, a commercially available structured **CFD** solver which uses **ALE** mesh remapping to solve moving grid problems was utilized. The software will be used to model a single degree of freedom (x or y displacement) moving tube in a static array on a range of reduced velocities comparable with the experiments of Tanaka and Takahara. The unsteady flow model has been generally accepted as the most complete model for fluid-elastic instability and yet the coefficients required to utilize the model have not been evaluated for the wide variety of tube arrays in common use due to the prohibitive amount of experimental work required. This research is a worthwhile endeavor in that it would permit the calculation of the unsteady flow coefficients relatively quickly and accurately when compared to experimental methods. This paper presented fluid force coefficients for square array tube layout which produced by **CFD** simulation. Validation of the model includes comparison with unsteady flow coefficients obtained by experiments. **CFD** results have very good agreement with experimental results for inline square tube array. The **CFD** fluid force coefficients were used to simulate fluid elastic instability over arrange of mass damping parameter. The results were located in the stability map to validate the results with different investigators. Also the **CFD** results have very good agreement with published results. It can be concluded from this work that a **CFD** model is a powerful method for extracting fluid force coefficients for different tube array geometries instead of using experimental approach which is very expensive and time consumer.

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Reliability of Lower-Extremity Isokinetic Dynamometry Testing of the Ankle, Knee and Hip

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Catherine M. MacPhail, and Chris A. McGibbon

Isokinetic dynamometry systems are commonly used to acquire clinical measures of peak muscle torque in healthy and physically impaired individuals; however, there are limited data available regarding the test-retest reliability of ID for isometric and isokinetic measures for the ankle, knee and hip.

PURPOSE: To measure test-retest reliability for peak isometric torque and peak isokinetic torque, for ankle plantar/ dorsi flexors, knee flexors/ extensors, and hip flexors/ extensors and adductors/ abductors, in health young adults.

METHODS: Six healthy adults (mean age: 23 ± 6 yrs, 4 female) were recruited for the study. Isokinetic testing was performed at 60°/s and consisted of 5 repetitions. Each repetition consisted of a flexion (abduction) trial followed by a 15 second rest and then an extension (adduction) trial followed by another 15 seconds rest. Isometric tests were measured at joint angles functionally relevant to gait and everyday activities, and followed the isokinetic tests after a 30 sec rest period. Hip flexion and extension strength was measured at 15° and 30°, hip abductor and adductor strength at neutral position, knee flexion and extension strength at 15° and 60°, and ankle dorsi/plantar flexion at ± 15° from neutral. The isometric trials were held for 5 seconds. Each subject repeated the measurement session after 1 week. Test re-test reliability was assessed using the Interclass Correlation Coefficient (ICC).

RESULTS: ICC values for peak isokinetic torque ranged between 0.726 for the hip joint and 0.926 for the knee joint, while ICC values for peak isometric torque ranged between 0.883 for the knee joint and 0.733 for the ankle joint. For the knee, testing in flexion was more reliable (ICC = 0.844) than in extension (ICC=0.781), while for the hip, testing in flexion was less reliable (ICC=0.682) and than in extension (ICC = 0.738). For the ankle, testing in dorsi-flexion was more reliable (ICC = 0.809) than in plantar flexion (ICC = 0.622).

CONCLUSION: Isokinetic dynamometry is, for the most part, a reliable method for acquiring isokinetic and isometric measures of muscle strength in young healthy adults. The lower reliability of peak torque measurement for hip flexors & knee extensors, as well as ankle plantar flexors, warrants further investigation.

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Measuring Upper Limb Loads During Activities of Daily Living

Colleen Dewis, MSc Candidate, Benjamin MacPhee, Dr. Edmund Biden, Bertin Mallet, Michael Lamb, John Landry, Greg Bush, Krista Fraser, Wendy Hill, John Hayden

There is currently no quantitative method for analyzing the forces and moments that can lead to serious skin issues within the socket of a prosthetic arm. Over the past few years we have been piloting several potential methods to implant sensors into a prosthetic socket to get a map of the pressures occurring, however to date these efforts have not seen a great deal of success as a result of humidity issues within the socket. We are currently attacking the issue from the other end of the arm, and starting our analysis at the hands.

Work done at the University of New Brunswick has been using motion analysis to build a database of kinematic data for both upper limb prosthetic users and normally limbed children during play activities including swinging on a playground swing and riding a bicycle. This work has been focused on comparing the postures of normally limbed children to those of prosthetic users with omni-wrist and uni-axial friction wrists.

The current study adds transducers that fit onto the chains which support the swing. The transducers have been custom designed and fabricated and are able to collect the grip and shear forces during the swinging phase of the testing. Similar transducers to measure forces during bicycling are in development.

The basic design of the transducers is relatively simple, while being highly effective. A semi-circular collar was manufactured out of aluminum. There is a gap down one side, which closes as the collar is gripped, which allows the semi-circle to bend as a curved beam, with this deflection recorded using strain gauges on the inner wall. The core of the device is comprised of a rectangular section of solid aluminum, which is then attached to the rear wall of the collar using pins. The pins are both outfitted with four strain gauges, two on top and two on the bottom, to measure the strain on the pins as the collar is loaded relative to the core. Shackles allow the transducer to replace a section of the chain at the point where the child swinging would hold on.

Strain gauges are used to measure how hard the child is gripping the transducer and how much they are tending to pull up or down on the chain. A small electronics package provides power to the strain gauges and basic signal conditioning. There are a total of 4 output channels, one shear and one grip for each hand. The data from the transducers is collected simultaneously with electromyography data and motion data using the Vicon MCam system's A-D boards external output channels.

Testing of the transducers has been promising, with outputs clearly illustrating when a user was squeezing, pushing or pulling on them. The transducers are able to measure a wide range of loadings.

The data collected from these transducers can then be used in a manner similar to the way force plate data are used in gait analysis. These forces, when combined with kinematic data from the VICON tracking system allow estimation of the forces and moments in the prosthesis and arm. Comparison with results from normally limbed children suggests that prosthesis users are significantly less symmetrical.

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Examining the Prosthetic Function and Body Behavior of Prosthetic Users Performing Activities of Daily Living

B. MacPhee, MSc Candidate, E. Biden, G. Bush, V. Chester,
C. Dewis, K. Fraser, W. Hill, and M. Ross

A prosthetic limb cannot exactly mimic the physical properties and capabilities of a natural limb. For unilateral below-elbow amputees, this introduces unique challenges for the body to overcome. An imbalance in the weight distribution alone will cause an increase in core muscle activity on one side of the body to compensate and/or poor body posture will result. Heavy batteries and motors required in the prosthesis are typically positioned closer to the hand in order to be concealed within the prosthetic forearm; this causes large moment forces for the biceps and triceps to overcome. For these prosthesis wearers there may be specific muscles or muscle groups that are being frequently overused and/or being used to perform abnormal tasks. This leads to a compounding problem where muscles fatigue and other muscles or muscle groups work to compensate for the loss.

This paper compares children using two different types of prosthetic wrist to an age matched group of normally limbed children. Prosthesis users enrolled in this study are between the ages of 4 and 13 years and use either a uni-axial friction wrist or an Omni-wrist on their below-elbow myoelectric prostheses.

To date, 13 prosthesis users have been recruited from among our clinical population. A group of 44, age matched, normally limbed controls have been recruited as a convenience sample from sports teams, schools etc. Testing is based on a set of three, large muscle, two handed tasks. These are: zipping up a vest; riding a semi-stationary bike; and swinging on a playground type swing. These tasks have been chosen because they benefit from coordination of the actions of the sound hand and the prosthesis. The zipper task is one where the child can control the pace of the task. For the swing the timing is determined almost entirely by the physics of the system and the child must respond accordingly. The bike task falls somewhere between the other two in that the child rides a bicycle which has been mounted in a support which allows the child to pedal against resistance. The bike is supported so that as the child leans the bike will respond. The child has various commands projected on a screen in front of them and responds by pretending to turn, standing up to pedal up a hill, etc. These activities have a sufficient "fun factor" that children returning to the clinic are asking to take part again.

Data collection is done using a VICON Mcam motion capture system and a Noraxon electromyography system. These two systems provide a means to examine the postures and movements of the children as well as their muscle activity during the activities. Preliminary analysis of the data shows interesting results. During the zipper task, prosthesis users have more difficulty when the zipper is on the same side of the vest as the prosthesis. The majority of prosthesis users use their sound hand to control the zipper while they use their myoelectric hand to grasp and hold down the bottom of the vest regardless of which side the zipper is on. For the swing task, correlations between the angles of the dominant shoulder, elbow, and wrist show a trend for the normally limbed children which the Omni-wrist users fall directly into. The uni-axial friction wrist users fall away from the trend. The bike riding task has shown that prosthesis users appear quite similar to normally limbed children; their muscle activity however is very different. Prosthesis users depend on the sound arm for the majority of the stabilization while riding which not only affects the muscles in their dominant arm but in their body core as well.

Inadequacy of Using Single DOF Models for Multiple DOF Systems

Phil Garland, PhD Candidate

Often engineers are interested in determining structural response of a system in order to determine safe operating loads. To obtain the response to different load conditions, it is desirable to simulate the response using a mathematical model of the system. For continuous systems, derivation of this model can be difficult. A common approach is to develop a lumped parameter model which closely approximates the response of the actual system. Appropriate mass, spring and damping parameter values can be found from modal parameters extracted from vibration testing on the system.

If the operating range is focused at or around one particular mode, analysis of the vibration test may be limited to the response in this range. This is understandable, given the complexity of calculation of the modal parameters of a multiple degree of freedom (DOF) system in comparison to that of a single DOF system. While this approach may be valid for systems whose response around a particular mode is dominated by that mode, interference of the other modes can sometimes lead to large differences between the actual and simulated response.

The effect of omitting the effect of the higher and lower frequency modes will be presented in terms of the frequency response function (FRF) of a simple beam with free-free end conditions. Comparison of the theoretically regenerated FRF's is made to the FRF of the actual impact test results. From the results, the single DOF assumption is seen to be inadequate for accurate approximation of the system.

Energy analysis of Combined Cycle Cogeneration Plant Using Air Blown Gasification of Coal and Solid Oxide Fuel Cell Technology

Adedoyin Odukoya, MSc Candidate

The growing energy demand and depleting natural resources have lead researches to look into more efficient ways of using coal as the source of fuel for power plants as coal is the most abundant of all fossil fuels.

Combined cycle power generation is till date the most efficient way to generate power with minimal fuel consumption. Gasification of coal remains the best way coal can be used as a fuel for power generation plants. However, the additional cost of the gasification process makes this technology only suitable for large power plants when compared with Natural Gas combined cycles. In most of the recent work in combining fuel cell technology and coal gasification for power production Oxygen Blown Gasifiers have been proposed [1]. This paper looks at using Air Blown Gasifiers [3] in place of the Oxygen Blown Gasifiers in order to reduce the cost of the plant while maintaining a high efficiency.

Tubular Solid Oxide Fuel cells will be used for the proposed cycle operating at a set temperature which will be varied between 1123 K and 1323 K [1]. The percentage utilization of the carbon monoxide and methane will be optimized using (Gauss-Newton's local optimization algorithm) and Differential Evolution (Global Optimization algorithm) [2].

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Non-Eutectic Equiaxed Dendritic Growth Model of a Nucleated Grain

Anna Healey, PhD Candidate

Solidification of a metal alloy begins with the dendritic growth between nucleated grains. Dendrite formation during solidification is influenced by the alloy phases and solute diffusion driven by temperature and concentration gradients in the liquid region ahead of the growing crystal. Microsegregation is the redistribution of solutal components on the interdendritic scale. Modeling microsegregation behavior of nucleated dendritic grains can further predict composition profiles, phase fraction profiles and cooling curves to demonstrate the solidification path of an alloy. Accurate microstructure simulation is essential for the evaluation and prediction of mechanical properties and has the potential to determine end-state defects such as macro-segregation patterns, void formation and residual stresses.

A microsegregation model is developed to describe the growth behavior of a nucleated grain for equiaxed dendritic growth. The evolution of one dendrite grain with initial composition of Al-Si of 5% wt. is modeled assuming no back- diffusion in the solid, complete solute diffusion in the interdendritic liquid, and a uniform temperature profile across the grain. It was found that a larger grain size (lower nuclei density) increases the duration and amplitude of recalesence during cooling. An increase in initial thermal undercooling accelerated recalesence. Increasing the cooling rate of course increased the solidification time forcing recalesence to occur at a lower grain temperature.

Yield Criteria for Porous Ductile Sheet Metals with Anisotropic Property

Weijie Xia, PhD Candidate

Anisotropic porous ductile sheet metals are investigated and corresponding yield criteria are developed in the current work. The sheet metals are assumed plastically normal anisotropy and planar isotropy, and obey the Hill-48 quadratic anisotropy yield criterion. A Gurson-type unit cell containing a void is simplified and employed to model porous materials. The Hill-48 quadratic yield function is used to describe the anisotropy properties by involving R, the normal anisotropic parameter. Under axisymmetric loading condition, a quasi-exact closed-form yield function is analytically obtained. Comparison of the analytical yield function is made with Sun and Wang's lower-bound yield criterion as well as Qiu and Weng's yield criterion, which is based on an energy approach instead of unit cell model. Comparison shows that the exact solution provides an accurate prediction of the yield behavior of porous sheet metals at high stress triaxiality, but slightly overestimates the yield stress at pure shear stress state. The overestimate may result form the assumption of fully plastic state in the unit cell. Furthermore, investigation of the yield limits of the sheet metals is extended to general loading conditions. A stress superposition method is adopted for solving the microscopic stress field in the unit cell. For each given ratio of biaxial loads, a corresponding lower-bound yield limit is numerically obtained. Lower-bound yield loci are consequently obtained for a group of desired load ratios in sheet forming operations and specified values of anisotropic parameter. Compared with Gurson's upper-bound and Sun-Wang's lower-bound yield loci, the current lower-bound locus mainly lies between their yield loci, except for high stress triaxiality, where a slight overestimate of yield limit occurs with the current result. Numerical calculations with both the exact solution and the lower-bound solution demonstrate that metals with higher R values are more damage sensitive.

Ranses Simulation of the Flow Past a Marine Propeller Under Design and Off-Design Conditions

Lucia Sileo, Visiting PhD Student

Abstract

In the present research activity a computational fluid dynamics (CFD) simulation of the flow past a marine propeller is carried out. The principal aim of the study is to verify the ability of a CFD method, solving the Reynolds-Averaged Navier-Stokes Equations (RANSEs), to predict the performances of a non-conventional marine propeller mounted on Romeo, an underwater vehicle designed by the RobotLab of Genoa, especially at off-design conditions.

The complexity in the mesh generation is one of the main obstacles for CFD. The propeller geometry has been imported directly from the CAD mapping of the propeller, than corrected and simplified. Following a hybrid mesh generation approach, prismatic cells have been generated in the boundary layer, where viscous phenomena are dominant, and tetrahedral cells in the remaining regions. A parallel RANS solver has been used, employing a cell-centered, finite-volume method that allows the use of computational cells of arbitrary polyhedral shape. Boundary conditions were given to simulate the flow past a rotating propeller in open water. The equations have been written in a moving reference frame fixed on the propeller blades. The steady-rotating reference frame source terms, i.e., the centrifugal and Coriolis force terms, therefore, are added to the RANS equations derived in the inertial frame. The k-ω model has been employed for turbulence closure.

Different values of advance ratio are considered, at design and off-design conditions. Computational results have been obtained for all the four-quadrant operational conditions: forward, backing, crashback and crashahead, considering also non-positive values for the advance ratio J. The thrust and torque coefficients, k_T and k_Q, have been selected as global quantities and compared with available experimental data. Pressure and velocity distributions and turbulent quantities were also used to analyze the computed flow field. The results show a good quantitative agreement with the experimental data. Important

issues need to be addressed like an extensively improvement in the mesh generation techniques and in turbulence modeling.

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Actuation scheme for a 6-DOF Kinematically Redundant Planar Parallel Manipulator

Iman Ibrahimi, Phd Candidate

Abstract

Path planning in parallel manipulators is an important issue for controlling the manipulator. A proper actuation scheme may avoid singularities and keep the stiffness and accuracy of the manipulator at an acceptable level. Approaching a singularity quickly deteriorates stiffness and accuracy of the manipulator, joints may lock up, or the actuators may become overloaded.

Parallel manipulators have several kinematic chains (limbs) that start from the base and reach the end-effector. Actuators should be actuated simultaneously to have the end-effector of the manipulators follow a specified path. For any point inside the workspace of a non-redundant parallel manipulator, there is a limited number of solutions for each limb. While for the redundant manipulators, depends on number of kinematic redundancy,there are one or more loci of solutions for the limb(s) with kinematic redundancy.

This paper presents a model of an actuation scheme and its effects on the singularities of a parallel manipulator. Two methods for determining the actuation scheme of the 3-_PR_RR, a kinematically redundant planar parallel manipulator, based on local optimisation routines are proposed. For a given path in the workspace, actuation schemes are obtained for the 3-_R_RR manipulator and for the 3-_PR_RR redundant manipulator. Two methods are proposed, one using the condition number, while the other has a geometrical interpretation. Results for both manipulators are illustrated.