Mechanical Engineering
School of Engineering & Applied Sciences

FutureME 2023 Conference

Washington State University Tri-Cities

2710 Crimson Way, Richland, WA 99354

Saturday April 29th, 2023

8:30 AM – 2:15 PM

East Auditorium

Conference Chair

Dr. Changki Mo

Conference Organizer

Dr. Messiha Saad

Conference Officers

Dr. Joseph Iannelli, Dr. Yuxin Zhang, Dr. Che-Hao Yang

Keynote Speaker

“How Engineers Can Help Prevent Climate Change”

Presented by

Steve Ghan

Global warming is being driven by emissions of several different greenhouse gases from a wide variety of human activities, so there is no single “silver bullet” solution to climate change. Many climate solutions that reduce emissions or remove carbon from the atmosphere have been identified. The challenge for engineers is to make them economically competitive and scalable to make a big impact on the global carbon cycle. This presentation will provide a context that will inspire engineers to provide the climate solutions that are needed now and through the rest of this century.

Guest Speakers

“ASME and Your Future”

Presented by

Kelly Mears
Chair, Columbia Basin Section, ASME

“ANS and Your Future”

Presented by

Consuelo Guzman-Leong
Chair, ANS-EWS

Sponsors: ASME Columbia Basin Section, ANS-EWS, and WSU Tri-Cities Student Section

FutureME 2023 Conference

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East Auditorium

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Time (PDT)	Topic
8:30 – 8:45 AM	**Coffee & Donuts** **Introduction & Welcome** Changki Mo, Conference Chair Messiha Saad, Conference Organizer
8:45 – 9:00 AM	**Forming Complex Nuclear Fuel Shapes in High-Loaded Silicide Surrogates** Dustin Clelland
9:00 – 9:15 AM	**Development of a Glass Fiber Reinforced Sandwich Composite Accumulator Container for a Formula Student Race Car** Jason Hayes
9:15 – 9:30 AM	**Saturated Filter Media Separation System** Jovanny Llepez, Mason Machart, Annalisa McKinney, Troy Pfaffle, Jake Saunders
9:30 – 9:45 AM	**Computational Fluid Dynamic Analysis of Organic Studies Laboratory Room to Optimize Thermal Comfort to Users** Kyra Taylor Kuhn
9:45 – 10:00 AM	**Research Summary of Digital Twin Application Towards Nuclear Reactors and Robotics** Eric Loeffler
10:00 – 10:15 AM	**Break**
10:15 – 10:30 AM	**Next Generation Tank Level Detector Design** Gabriel Antunez, Amani Christopher, Briseida Fajardo, Rachel Forsberg, Adrian Garza
10:30 – 10:45 AM	**A Finite Element Program for 3D Structural Analysis Using Python** James Fitzpatrick

10:45 – 11:00 AM	**Building Energy Use:** **Modeling and Analysis of Lighting & Mechanical Systems** **A Case Study** Aron Powers
11:00 – 11:15 AM	**Core Barrel Assembly Simulation** Nicholas Adams, Trevor Arm, Julia Cragin, Sayan Banks, Kameron Markham
11:15 – 11:30 AM	**Advances Toward Robotic Pollination** Ezekyel Ochoa
11:30 – 11:50 PM	**Keynote Speaker** **"How Engineers Can Help Prevent Climate Change"** Steve Ghan
11:50 – 12:00 PM	**Guest Speaker** **ASME and Your Future** Kelly Mears Chair, Columbia Basin Section, ASME
12:00 – 12:50 PM	**Lunch**
12:50- 1:00 PM	**Guest Speaker** **ANS and Your Future** Consuelo Guzman-Leong Chair, ANS-EWS
1:00 – 1:15 PM	**Integrated Computational Materials Science for Nuclear Engineering Applications** William E. Frazier, Lei Li, Yucheng Fu, Kyoo Sil Choi, Ram Devanathan, Vineet V. Joshi, Ayoub Soulami
1:15 – 1:30 PM	**Lid Detachment System** Samantha Grade, Ross Kieffer, John Lavender, Eli Mendoza
1:30 – 1:45 PM	**Design and Construction of a Subsonic Wind Tunnel** Kameron Markham
1:45 – 2:00 PM	**Flight Dynamics of a Spacecraft from Earth to Mars with an Artificial Gravity Environment.** Aaron Torres Mendoza
2:00 – 2:15 PM	**Closing Remarks** **International Program Opportunity** Dr. Joseph Iannelli

Forming Complex Nuclear Fuel Shapes in High-Loaded Silicide Surrogates

Dustin Clelland
Faculty Advisor: Dr. Changki Mo

This work provides proof of the concept that high silicide loading nuclear fuel meat surrogates with complicated geometries can be produced with uniform density through an application of cold isostatic pressing (CIP). Dispersion fuels with high volumetric loading of U3Si2 have challenges in fabrication. Experimental work was undertaken using MoSi2 and WSi2 surrogates to explore the feasibility of reducing or eliminating the issues through the application of CIP in the powder compaction step. The composites were prepared at approximately 42 vol% silicide, which was representative of 4.8 grams of uranium per cubic centimeter of fuel plus matrix (gU/cc) and formed via CIP at 344.7 MPa (50 KSI). In order to provide the proof of concept, the density of a CIP surrogate fuel was examined for uniformity by cutting it into 9 approximately equal portions and measuring each portion's bulk density individually using ASTM Standard B963. The surrogate fuel was found to have a standard deviation in density of 0.01345 g/cc. The CIP mold design was iterated to reduce defects and increase precision. Then the precision achieved was examined by 3D surface imaging. The metal powders used were characterized in terms of particle size by ASTM Standard B214 and their morphology was examined by scanning election microscopy. The interaction of the metal powder particles after CIP were examined by optical microscopy. The information associated with this document is preliminary, for information only, and should not be used as design input or operating parameters without user qualification.

Development of a Glass Fiber Reinforced Sandwich Composite Accumulator Container for a Formula Student Race Car

Jason Hayes
Faculty Advisors: Dr. Iannelli, Dr. Hesselbarth

The aim of this thesis is to design and investigate the feasibility of a sandwich PVC foam and glass fiber reinforced composite accumulator container for the Zurich University of Applied Sciences 2023 race car. Considering that weight has a detrimental effect on the performance and efficiency of an electric race car, this thesis serves as a guide for the weight reduction objective set by the ZHAW race team. A newly designed accumulator container is modeled in SolidWorks and simulated in SolidWorks Simulation using finite element analysis. Several loading scenarios are simulated to achieve an optimal balance between weight and strength. A low-weight and high-strength container is a top priority during the testing and design phase. The phase following this includes work for the benefit of next year's team. The geometry of the container is described in detail, and the optimizations developed in the context of this thesis are explained.

Saturated Filter Media Separation System

Jovanny Llepez, Mason Machart, Annalisa McKinney, Troy Pfaffle, Jake Saunders
Faculty Advisor: Dr. Che-Hao Yang
Sponsor: Framatome

Problem Statement: help Framatome create an efficient way to dry saturated sand filter media in 55-gallon drums.

The project is a proof of concept for a device that will solve the issue of long periods of drying. The design is modeled to be a large-scale heated auger that will agitate the sand causing an efficient drying time. The device will also be attached to air ventilation that will reduce humidity and keep the surrounding workers safe. A small-scale prototype was created to acquire a baseline for design specifications that would be implemented in a full-size mockup. The focus of the prototype was to get information about the interactions between the auger bit and the sand. We know that the addition of heat and ventilation will create a faster drying time, but our main goal was to prove the agitation of sand causes even faster drying times. The information discovered from testing includes a torque value of roughly 250 ft-lbs of force to turn saturated media in the drum. An auger diameter of 18 inches to prevent buildup of media, and other appropriate design modifications to create a clean, and safe work environment. Framatomes current process takes 5 days, and our estimated dry time is 1 day or less.

Computational Fluid Dynamic Analysis of Organic Studies Laboratory Room to Optimize Thermal Comfort to Users

Kyra Taylor Kuhn
Faculty Advisor: Dr. Messiha Saad

An organic studies laboratory room houses over eight instrument systems which provide the critical analysis for sampling at the Hanford Nuclear Site in Washington State. The heat load from this room causes user discomfort and condensation from existing fan-coil units was the origin of an instrument fire. This project presentation provides the sample point trend-analysis measurements and computer-aided simulation using computational fluid dynamics (CFD) for optimization on room configuration for thermal considerations. The sample point experiment tracked temperature and air velocity outputs over the course of four months. The CFD simulation provided analysis on current room configuration and various adjustments to room including upgraded air-conditioning units, the removal of various analytical devices, and the additions of exhaust hoods. The results of measurement data and simulation provided a consensus that optimization of room configuration is to [conclusion results, WIP]. Going forward with the optimization recommendation should allow for better room air flow and temperature distribution to provide thermal comfort to both users and recommended ranges for analytical devices internal to the laboratory room.

Research Summary of Digital Twin Application Towards Nuclear Reactors and Robotics

Eric Loeffler
Faculty Advisor: Dr. Changki Mo

In beginning research on Digital Twin technology, the focus has primarily been on performing a literature review. The intention here is to set a baseline on the status of the Digital Twin technology to set a trajectory for focusing this researcher's efforts, as well as determining novelty. It was found that there are many definitions for Digital Twins but the overarching theme from these definitions is that a Digital Twin is an exact digital replica of a physical asset. This digital replica would receive measured signal input from the physical asset, assess the effect on the asset, alter the digital replica or digital model, determine the future outcome, and modify the control of the asset to align best with set goals and strategies. Many control systems attempt to achieve this with varying methods, however the benefit seen with Digital Twins is that the physical asset and the model maintain a link throughout the lifecycle which allows for a unique operational strategy. As the Digital Twin accumulates data of the physical asset, the opportunity to apply advanced technology such as Artificial Intelligence/Machine Learning (AI/ML) to the control methodology. This is where many avenues for research into the Digital Twin technologies diverge into specialized research topics. The next steps are to refine the research to align both with industry needs as well as Washington State University resources.

Next Generation Tank Level Detector Design

Gabriel Antunez, Amani Christopher, Briseida Fajardo,
Rachel Forsberg, Adrian Garza
Faculty Advisor: Dr. Messiha Saad
Sponsor: Washington River Protection Solutions (WRPS)

Washington State University Tri-Cities senior design group was appointed to work on the Next Generation Tank Level Detector capstone project. This project is sponsored by the Chief Technology Office (CTO) of Washington River Protection Solutions (WRPS). The CTO is chartered with advancing technologies within the Hanford Site tank farm. WRPS is the Hanford Tank Operations Contractor for the U.S Department of Energy (DOE) Office of River Protection. WRPS is responsible for retrieving and treating nuclear waste to reduce the risk of environmental exposure from radioactive material.

The purpose of The Next Generation Tank Level Detector is to collect accurate and reliable tank level measurements. The WSU senior design team is tasked with improving upon a previous tank level detector design presented by a previous WSU design team. As with the previous design the chosen technology for level detection is the radar technology. Radar is essential because it can detect the reflection of a pulsed signal that is being sent from the radar to the peaks and troughs of the radioactive material in the tank. The radar can convert the collected signals to calculate the distance.

A Finite Element Program for 3D Structural Analysis Using Python

James Fitzpatrick

Faculty Advisor: Dr. Joseph Iannelli

The finite element method is a well-developed numerical tool used for the approximation of the partial differential equations that describe the laws of many physical processes occurring in physics. The method is widely used for many disciplines of physics including structural mechanics, fluid dynamics, and heat and mass transfer. This project aims to develop a finite element program for the solution of problems arising in structural mechanics. The program was written in the well-known object-oriented language, Python, and utilizes selected Python libraries such as Numpy, SciPy, PyVista and Matplotlib. The open-source software, Gmsh, a 3-dimensional mesh generator with Python application programming interface (API) is used for mesh generation. This presentation will address the motivation for the project and proceed to introduce the program in its current state. The currently available features and limitations, including model visualization, loads, boundary conditions, material models, and others will be discussed, and selected example problems will be presented. The presentation will conclude with intended future work activities.

Building Energy Use: Modeling and Analysis of Lighting & Mechanical Systems A Case Study

Aron Powers

Faculty Advisor: Dr. Messiha Saad

Sponsor: Washington State University Tri-Cities Campus Facilities Office

Understanding how energy is used and where it can be saved in an existing building is critical not only from a cost and environmental standpoint, but for legal compliance as well, as the United States and the rest of the world increasingly have set tighter restrictions on energy usage and carbon emissions. Energy savings can be achieved from installing LED lights and occupancy sensors; however, the exact savings and impact of each method can vary depending on the building in question. The objective of this case study is to perform analysis of the lighting and mechanical systems in Washington State University Tri-Cities' Floyd & East buildings to determine energy savings potential. Lighting systems in each building were broken into several groups based on their operational patterns and then numerically modeled with the aid of Python. The results of this case study show that 60% energy savings, totaling 350 MWh in a year, can be achieved by retrofitting fluorescent lights with LEDs and occupancy sensors. This energy savings translates to a reduction of 62.4 tonnes of CO_2 emissions per year. The results of our cost-analysis in this model shows that the LED light retrofit has a break-even point at 15 months of operation. For the existing mechanical systems, three recommendations were proposed to improve its performance, including: the addition of water treatment for the HVAC process water, replacing pneumatic controls with digital ones, and the installation of variable speed drives.

Core Barrel Assembly Simulation

Nicholas Adams, Trevor Arm, Julia Cragin, Sayan Banks, Kameron Markham
Faculty Advisors: Dr. Messiha Saad, Dr. Yuxin Zhang, Dr. Che-Hao Yang
Sponsor: Framatome

Within nuclear reactors sits the core barrel assembly, containing the nuclear fuel rods. The fission reaction occurring within the reactor produces heat, which causes pressure to develop within the system and against the baffle plates and bolts. The baffle plates and bolts perform two functions: (1) to maintain a rectilinear shape within the cylindrical core barrel for fitment and (2) to direct coolant through the fuel assemblies. This project overview outlines progress made in modeling a quarter section of the core barrel assembly in SolidWorks, porting it to ANSYS and meshing the model, and running thermal and pressure studies on our system. Given a full core barrel assembly model, we were able to split the assembly into quarter sections to allow for simpler simulation. From here, meshing is being created to properly represent the assembly and most accurately predict behavior under various stresses. In ANSYS, we are applying heat conditions and pressure conditions to both individual meshed parts as well as the fully meshed model. Studies to be run in ANSYS will be used to determine (1) the deflections on the baffle plates from pressure through the system, and (2) the forces acting upon the baffle bolts. Results will be validated through convergence with previous models and hand calculations. Computation will encompass heat transfer which includes convection and conduction through the system. Through both simulation and hand calculations, we can produce effective results which will include: forces acting within the system, 3D models depicting the system as it undergoes forces, and life of each bolt as well as how individual bolt failures affect the system.

Advances Toward Robotic Pollination

Ezekyel Ochoa
Faculty Advisor: Dr. Changki Mo

Motivated to incorporate WSU's electro-static sprayer design onto robotic systems already established within the apple harvesting field, a collaboration with FF Robotics allows for efficient progress to be made towards more automated procedures. Provided with a robust, cartesian-style robotic shelf, a modular-type gantry frame was constructed for the development of a fourth (vertical) axis for the robot, with initial static simulations provided and a single drive system established. The utilized control system will further be proposed along with its benefits to this project, as it has become a standard within the automation industry. Being adaptable in its nature, various network topologies are to be explored for the system in search of optimal communication between nodes. Part of a multi-year project that anticipates potential for a universal robot within the agricultural industry, the cartesian system will be fitted with pruning and pollinating devices to complement the established apple picking.

Integrated Computational Materials Science for Nuclear Engineering Applications

William E. Frazier, Lei Li, Yucheng Fu, Kyoo Sil Choi, Ram Devanathan, Vineet V. Joshi, Ayoub Soulami
Pacific Northwest National Laboratory

The implications of advancements in computational materials science on the development of nuclear fuel materials and reactor component materials are profound. This work aims to discuss several areas in which we have used mesoscale simulation techniques working in coordination with each other in order to promote the efficient prediction of material microstructure and performance. Discussed topics include: 1.) microstructure-based finite element method – kinetic Monte Carlo (FEM-KMC) simulations of the rolling and annealing process for the fabrication of monolithic U-10Mo fuel foils, and 2.) simulations of the aging behavior and property degradation of 316L stainless steel nuclear reactor components. More broadly, the role integrated computational materials engineering (ICME) can play in career development will be discussed.

Lid Detachment System

Samantha Grade, Ross Kieffer, John Lavender, Eli Mendoza
Faculty Advisor: Dr. Yuxin Zhang
Sponsor: Atkins

The objective of our project is to safely remove the lid from a 55-gallon drum to ensure the lid is not dropped in the event of power failure. A dropped lid will result in human intervention for lid retrieval and cause an immediate risk of radiation exposure. Atkins current design uses electromagnets to lift the lid. The electromagnets require power to actuate a lifting force and in the event of a power failure, the lid would be dropped. Through design consideration, we have determined that magnetism is the optimal method of lid removal; our proposed solutions will continue to use magnetism as the lid-lifting force. In our new design, electropermanent magnets replace electromagnets. The key innovation is that electropermanent magnets lift the lid in an unpowered state, without requiring electricity. Electricity cancels the magnetic field of an electropermanent magnet. The change from electromagnet to electropermanent magnet meets engineering requirements: the force required to lift the lid, the amount of power needed to operate the system, and the allowable magnet weight for the current system structure. This design incurs the smallest change to the current design. Given the desired budget, the cost of materials is well within Atkins’ preferred range. We have determined that the finished solution remains economical, reliable, available, safe, and maintainable.

Design and Construction of a Subsonic Wind Tunnel

Kameron Markham
Faculty Advisor: Dr. Yuxin Zhang
Sponsor: School of Engineering & Applied Sciences

In this report, we present the design and construction of a low-cost wind tunnel for aerodynamic studies. Our objective was to create a design that was informed by prior research in wind tunnel science and that would be a repeatable construction process. We used a CNC mill and flat panels of commercial cabinetry plywood to construct the wind tunnel, and we tested the design using Autodesk CFD simulation software to ensure it would perform as expected. We also used a CNC laser to create the acrylic test section and an Arduino microcontroller and sensors to create a fully interactive user menu. In our experiments, we tested airfoils to gather data on their aerodynamic performance. Our results indicate that the wind tunnel is an effective tool for aerodynamic studies, and our design offers a low-cost alternative to commercial wind tunnels. This wind tunnel will be used in the thermofluids lab at Washington State University Tri-Cities. Our report concludes with suggestions for future improvements and uses for the wind tunnel.

Flight Dynamics of a Spacecraft from Earth to Mars with an Artificial Gravity Environment.

Aaron Torres Mendoza
Faculty Advisor: Dr. Joseph Iannelli

This project has investigated the rotational dynamics and the motion of the center of mass of a spacecraft on a journey from Earth to Mars. One of the unique elements of this project is the rotational dynamics of the torus about the center module. The spacecraft consists of a central module and a spinning Torus inspired by the Stanford Torus. The Torus rotates to provide artificial gravity and directional stability. Lagrange equations were used to derive the equations of motion for the spacecraft. An artificial gravity environment was introduced to the Torus through centripetal acceleration. The incorporation of artificial gravity was essential since long-term exposure of zero gravity has a negative impact on human health. The results of the project successfully modeled the effects of the Torus to provide artificial gravity and directional stability from Earth's orbit to Mar's orbit.