Mechanical Engineering

Senior Design 2017 - 2018

UCONN
SCHOOL OF ENGINEERING
MECHANICAL ENGINEERING

Mechanical Engineering

Senior Design Demonstration Day

Friday, April 27, 2018
1:00 - 4:00 PM
Gampel Pavillion
University of Connecticut
Storrs, CT 06269

Guest Lecturers

Mr. Daniel Matyas, Pratt & Whitney
'Project Management'

Mr. Mark Austin, CT Society of Professional Engineers
'Professionalism and Licensing'

Dr. Mary Caravella, UCONN
'Product Marketing'

Mr. John Wilbur
'Blueprint Construction and reading'

Dr. Tom Barber, UCONN Retired
'Engineering Ethics'

Dr. Krishna Pattipati, UCONN
'Quality and Reliability'

Mr. Evan Twarog – Parker
'Hydraulics and Pumps'

Mr. Scott Ingalls -Zachry Corporation
'Impact of Energy Prices'

Mr. Alex Tsarouhas, Pratt & Whitney
'Patent Law and Intellectual Property'

Mr. Brian Montanari, Habco Inc.
'Lean Manufacturing'

A Note from Professor Vito Moreno
Director

The UCONN Senior Design Project program is a hallmark of success for the Department of Mechanical Engineering. In this two semester course, senior student teams work to solve real life engineering problems for industry sponsors. They learn and experience the importance of teamwork, communication, schedules and budgets, intellectual property and meeting customer expectations and deliverables. The projects provide the opportunity for the students to apply design know how, judgment, technical skills, analysis, creativity and innovation to design, optimize and manufacture prototype models and perform product simulations. Senior Design Demonstration Day on April 27 gives sponsors, faculty, family and friends the opportunity to see the results of these efforts and learn more about Mechanical Engineering at the University of Connecticut. Gampel Pavilion is filled with students explaining their projects to visitors and a team of industry judges who award first to third place cash prizes considering technical application, innovation and overall presentation.

Tom Mealy

As the Director of the Mechanical Engineering Senior Design program, I am truly impressed by the energy and dedication of the students and faculty advisors to ensure that each project provides a real benefit to the sponsor companies. The successful completion of this program each year requires the efforts of many people within the Mechanical Engineering Department. I specifically want to recognize the efforts of my co-director Professor Bryan Weber, Mr. Thomas Mealy, Senior Machine Shop Engineer and our Teaching Assistant Dr. Reza Amin. Bryan contributes to class room lectures and serves as a Faculty Advisor to many of the teams. Tom, who is a graduate of the program, works with all of the teams as they design, machine, fabricate and setup their experiments. Reza manages all class data and logistics. The knowledge, energy and dedication provided by Bryan, Tom and Reza are key elements of the success of this program.

Bryan Weber

Reza Amin

For additional information or future participation contact:

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A Message from the Department Head

When asked by prospective students, parents, alumni, and friends what makes our Mechanical Engineering department unique, one of the important items on my list is the senior design program. As we conclude the 19th year of our engagement with our industrial partners, we are grateful for the 35+ companies and funding agencies that have sponsored 60+ industry relevant senior design projects during the 2017 academic year. Our senior design projects have involved partner organizations — large and small — from across Connecticut as well as New England and beyond.

Our students, who worked very hard throughout the academic year solving industrially relevant engineering problems, experienced the fulfillment of solving real engineering design and manufacturing problems by synthesizing and applying classroom knowledge. They also had to convince their faculty and industrial mentors that their fresh ideas are worth considering, which helped them hone their soft professional skills. At the same time, some of our students integrate the senior design project into their Accelerated Master's degree program, an effort that is typically supported by federal funding agencies. During this time, these students conduct supervised research as their senior design project, which continues into their M.S study.

Seeing the results of this year's senior design projects reminds me of how proud I am to be part of such an exceptional group of faculty and staff who, in collaboration with the industrial mentors working with each project, masterfully navigated the meanders of the engineering product development to prepare our students for leadership in the conception, design, implementation and operation of technology-intensive products and processes. Please join me and the ME faculty and staff on April 27 @ the Gampel Pavilion on the UConn Storrs Campus where we will showcase this year's projects.

Our well-established two-semester senior design program is certainly not a zero-sum game. It is not only the culmination of the students' undergraduate education, but also an excellent mechanism for the participating companies to get access to outstanding potential new hires that they can observe over the extended project duration. Moreover, project sponsors can retain the intellectual property developed during the project and can assess fresh perspectives of specific engineering problems that they are interested in.

The UConn ME department is thriving, with faculty and students that are recognized with the highest honors for their contribution in actively shaping the future of mechanical engineering. We provide a world-class education to the future generation of mechanical engineering leaders at one of the best public universities in the United States and engage in visionary research to develop solutions to some of the world's greatest engineering challenges.

Horea Ilies

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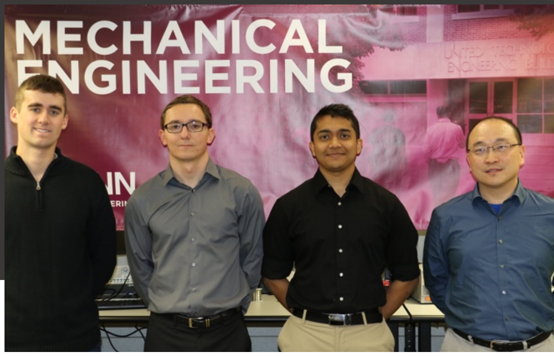
UCONN Combustion Diagnostics Lab

TEAM 01



Dylan Roach, Karol Kuczynski, Hrishikesh Bhange, Dr. Tianfeng Lu.

MECHANICAL ENGINEERING

TEAM: ME 01
SPONSOR: Carl Johnson
ADVISOR: Dr. Tianfeng Lu

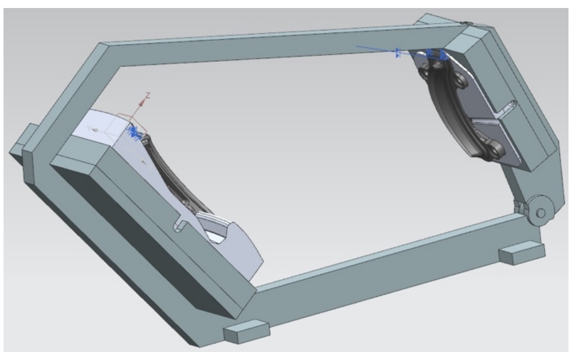
Adhesive Injection Into Aerospace Assembly

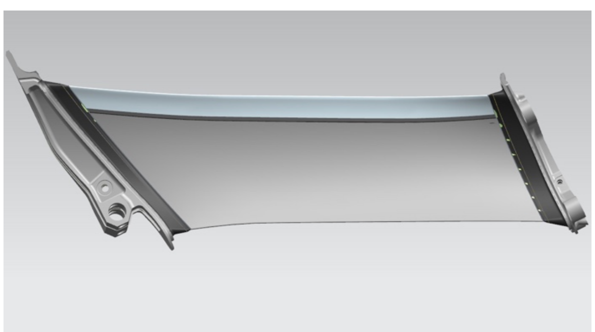
ACMT, Inc. is a manufacturer of components of various complexity for a number of domestic and international manufacturers. ACMT, Inc. also deals with overhaul and repair of gas turbine components for military and commercial aviation, as well as packaging adhesives and chemicals to commercial aviation related companies. The project in consideration is one that deals with flow analysis and tooling design to improve coverage and consistency in an injection process. The designed set-up for an adhesive injection process facilitates bonding of three components manufactured from titanium and carbon fiber required for structural components in a jet engine. The end result is to create a system capable of performing a repeatable injection process with 100% conformance to customer requirements. Desirable results include minimal components in the set-up, cost efficiency and the ability of the system to perform the injection with minimum number of workers.

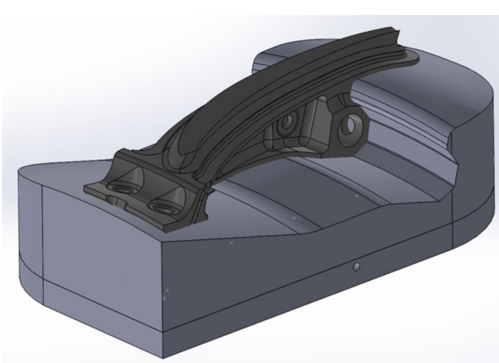
After studying the properties of the adhesive from 3M, ANSYS simulations and SolidWorks designs were made based on a previously existing design model for a less complicated component. These designs underwent rapid prototyping based on different dimensions of multiple components, with operation/ process integrations being a crucial aspect. These designed had to be tested non-destructively, and so CT scans had to be performed on the parts to check the consistency of the adhesive and hence, the capabilities of the design model. Based on the results of these scans, alterations were made on the designs to better comply with conformance and consistency issues. Clamps were also designed to aid in holding all components together and facilitate the initial steps of the process.

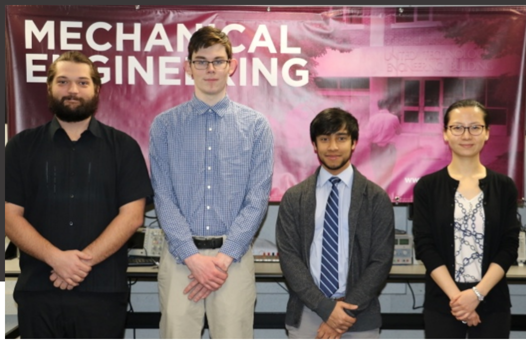
In the end, a set up was designed to hold all parts, complete the injection process and obtain the required final product. The set-up now used by ACMT, Inc. consists of the main structure, clamps and other miscellaneous components used based on the dimensions and shape of the airfoil that has to be attached to the carbon fiber. All these components have been designed by this team, which form the entire set-up and satisfy customer requirements.

ACMT, Inc.
Advanced Composites & Metalforming Technologies









Greg Smith, Nikita Noskov, Nafiz Mustaqim,
Dr. Zhanzhan Jia

MECHANICAL ENGINEERING

TEAM: ME 02
SPONSOR: David Shurtleff
ADVISOR: Dr. Zhanzhan Jia (ME),
Dr. Mousumi Roy (MEM)

TEAM 02

Clamp Fixture Improvement for 5-Axis Machining

AeroCision manufactures unique components used for jet turbine engines. The components are manufactured to precision and accuracy each time they are constructed. The result of a defective part leads to wasted resources and could potentially cause bigger problems if they are not caught in time. AeroCision uses automated manufacturing to improve their precision of each part. The parts are produced using G-Codes specifically designed for milling and cutting purposes. The current process uses a clamping fixture to hold the ring in place, which is then locked onto the machine arm to move systematically through the cutting and milling process of the part. The company has had axial torsional slipping problems between the ring and the fixture. This issue has caused AeroCision a number of flawed pieces that must be scrapped; costing them lots of money. AeroCision has added a safety pin to lock the ring in place and prevent it from slipping. However, incorporating the drive pin has caused other manufacturing problems and has triggered more defects. AeroCison's goal is to install a clamping fixture that does not cause the ring to slip while also removing the drive pin, ultimately removing an extra step in their process to save time.

AEROCISION

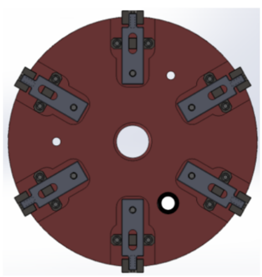


Figure 13 (original Clamp assembly)

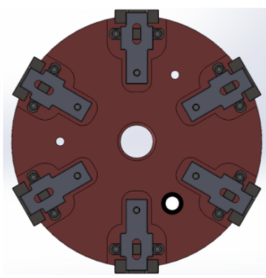
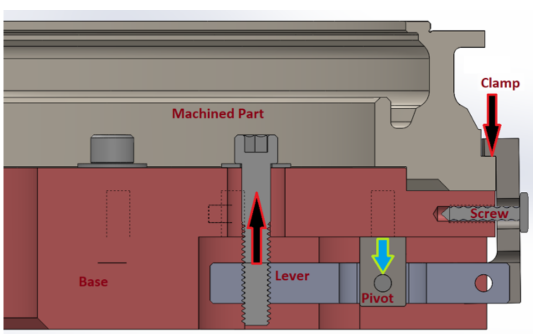
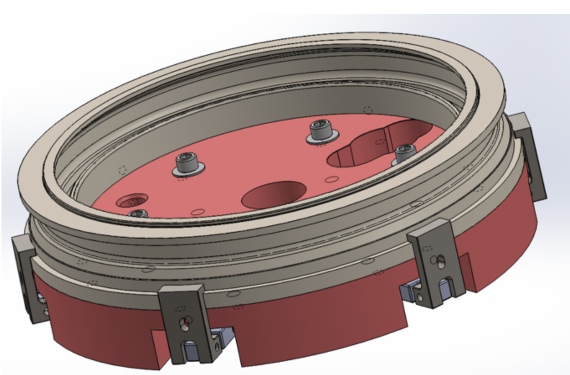


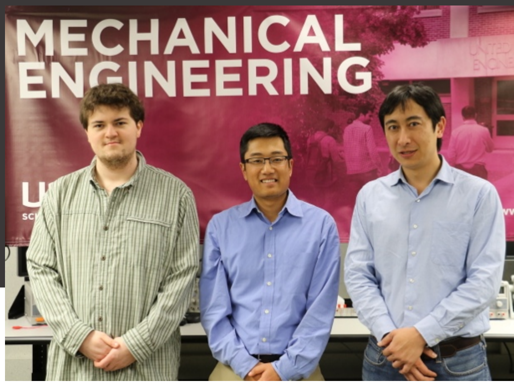
Figure 14 (Modified Clamp Assembly)





Our Senior Design team has found a new design that would fulfill Aerocision's objectives without changing the current clamping fixture's dimensions that is set to fit the ring. The team looked at the different components of the clamping fixture and realized that the lever arms of the clamps could be redesigned to produce a larger normal force pressing down on the ring. With more force being exerted by the clamp, it will provide a stronger hold between the clamp and the ring, thus reducing ring slippage. Testing procedures included finding the normal force produced by the original clamps as well as finding the coefficient of friction between the ring and the clamping fixtures base. The Unit Load Tests were run to find the clamps force, while the angle testing method was used to find the coefficient of friction. Ultimately, after looking at the geometry of the clamping fixture, our team recommended widening of the lever arms as well as moving the pivot point closer to the clamp to deliver the best results. This will be reducing the load on the threads of the bolt while also improving the friction force being applied from the clamps to the ring. The ability to apply more frictional force on the ring will eliminate the likeliness of ring slippage and the need for the drive pin.

TEAM 03



Jonathan Englaert, Patrick Lyon, Dr. Jason Lee

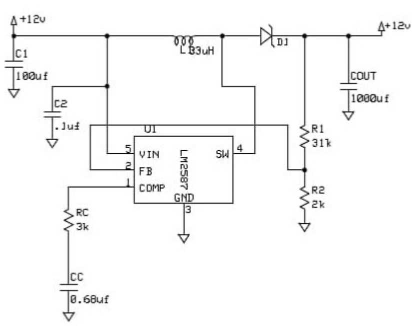
MECHANICAL ENGINEERING

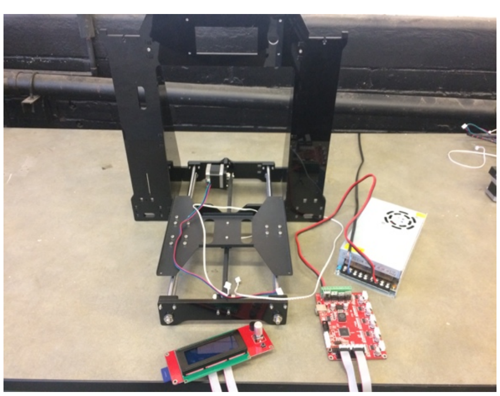
TEAM: ME 03

SPONSOR: Thomas Weinlandt

ADVISOR: Dr. Jason Lee

EIP Redesign-High Acceleration





As technology advances the need for computers with higher processing power is increasing. In order to meet the demand for these chips lithography has become extremely precise, down to the nanometer scale. ASML is at the forefront of producing very precise lithography equipment and has become a world leading supplier for many companies.

To be able to get down to the precision that many companies desire, particle contamination on the surface of the template, known as a reticle, is unacceptable. The reticle is protected by something known as an EIP, or Extreme-ultraviolet Inner Pod during transportation. ASML wishes to increase the throughput of their machines in order to greater meet the demands of the market. In order to do so, the speed of the manufacturing process must be increased and ASML needs a stronger clamping device to prevent reticle motion. The goal of this project is to provide ASML with a stronger clamping device that will protect it from movement and particle contamination while it is transported inside the EIP.

There were several ideas to create a clamping device, however the one the group settled on was an electrostatic clamp. Using the principles of electro-adhesion the electrostatic clamp will be able to both protect the reticle from movement and be integrated into the current iteration of the EIP.

A scaled down 4x4 prototype electrostatic clamp was produced at UConn using the electrode fabrication lab. Using a modified 3D printer as a test rig the clamping device was tested for accelerations of up to 1g using a sample reticle. Based on initial observations, the clamp held the reticle in place with enough clamping force motion. This was later confirmed by testing for particle contamination on the surface of the reticle; it was found that the electrostatic clamp did a good job securing the reticle. This final prototype device was presented to ASML as a proof of concept that the electrostatic clamp idea would work to prevent reticle motion.

MECHANICAL ENGINEERING

TEAM: ME 04

SPONSOR: John Walsh

ADVISOR: Dr. Horea Ilies

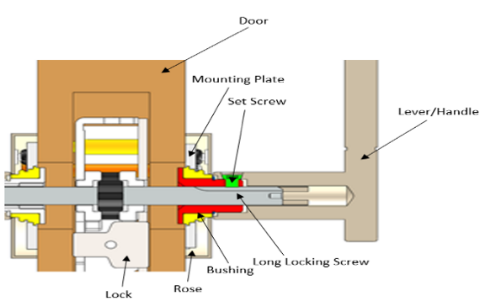
TEAM 04

Jason Yanaros, David Lagace, Fahim Ibrahim, Prof. Horea Ilies

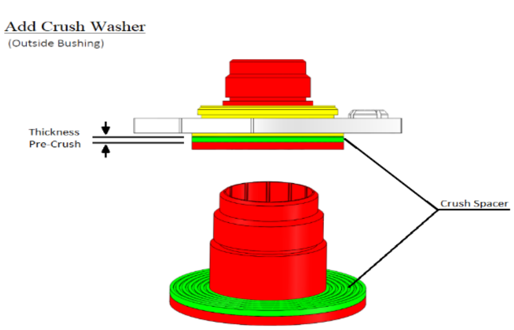
Designer Lever Lock Wobble Reduction and Part Consolidation

ASSA ABLOY

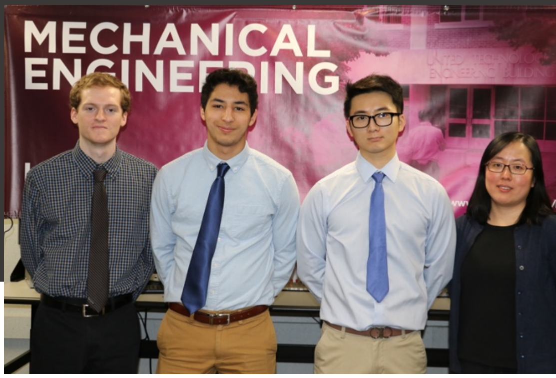
Assa Abloy is a lock manufacturing company which produces three brands, Sargent, Corbin-Russwin and Yale, each in a variety of trim styles. Across all brands there exists noticeable free movement of the handle in the outward direction from the door. This free handle movement, also known as wobble, is most prevalent in decorative door handles and has a significant negative impact on the perception of quality. This project has the goal of improving wobble by 50% with a focus on the Sargent and Corbin-Russwin decorative attachment styles. In addition, this project includes an effort to consolidate the parts between brands. Part cost, implementation cost, and ease of manufacturability are all important considerations for this project. Assa Abloy currently has a large inventory of premade parts and so maximizing the use of existing parts is critical to keeping implementation costs low.



For the purpose of this project, starting with the Sargent brand, then later applying the method of improvement was helpful. In the Sargent mounting system, the handle is attached to a bushing which protrudes through and spins against a mounting plate. The mounting plate is screwed into bolts that pass through and secure it to the door. With the mounting plate being securely fastened to the door, there are then two major interactions that cause handle wobble, the bushing/mounting plate interaction and the bushing/handle interaction. Through tolerance stack analysis, it was determined that the axial distance between the bushing and mounting plate surfaces was the largest contributor to bushing/mounting plate wobble followed secondly by the bushing surface diameters. Increasing the bushing surface diameters would require altering multiple part designs and making a large inventory of parts obsolete so the final design change proposed focused on improving the bushing surface to mounting plate axial gap. This was accomplished by inserting a washer between the bushing and mounting plate with ribs that could be crushed during assembly to fill the wide range of possible gaps found during production. This proposal not only decreases the average handle wobble but also makes handle wobble much more consistent which also improves perception of quality.



TEAM 05



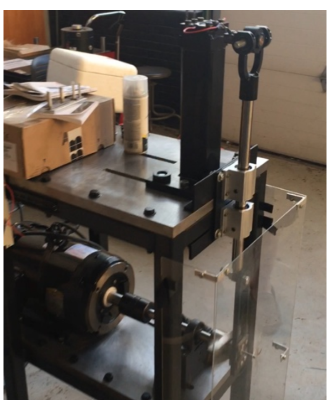
Nicolas Coombs, Marwane Taroua, Hyunseok Ryu, Dr. Dianyun Zhang

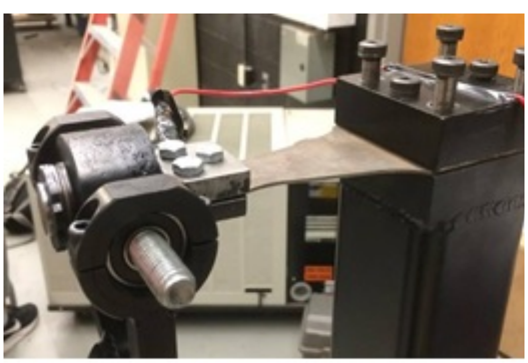
MECHANICAL ENGINEERING

TEAM: ME 05
SPONSOR: Jason Sicotte
ADVISOR: Dr. Dianyun Zhang

Associated Spring Fatigue Tester

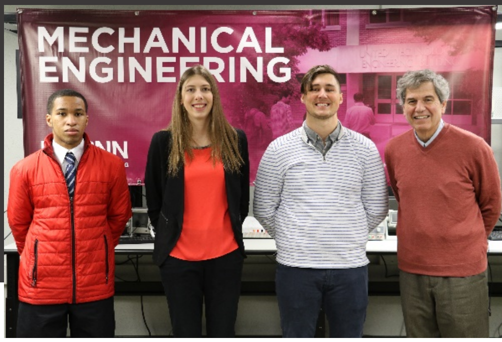
Associated Spring
A business of BARNES GROUP INC





Associated Spring focuses on advanced engineered springs and precision metals. The main component that this company manufactures are high precision spring stampings for automotive industry use. This is used from various products ranging from custom valve springs for top fuel dragster engines, to internal springs used in multi speed transmissions. The goal of our project is to improve upon the current fatigue tester design. The test is required to operate in a safe manner. Guards must be set in place in order to prevent injury to operators of the machine. Another requirement is to stay within certain range of uncertainty. In Ideal case study the test coupons should crack in the middle showing uniform fatigue. The current test coupons required minor changes in the boundary conditions in order to fall with in this range. This machine must also be capable of High Cycle Fatigue test which these materials will undergo in their lifetime. Standard procedures will be used to create accurate repeatable results that will provide data to understand how different materials, and surface conditions will affect fatigue life.

Before running multiple test, the main way of the system will be verified is with strain gauges. The gauge reading will take place in the area were the test coupon will crack on the trapezoidal surface. Based on the frequency and deflection height selected, certain strain values are expected. A strain gauge is attached to the test coupon and the fatigue tester would be run to see if to will produce similar values obtained from the ANSYS model simulations. If these results match up with in a certain degree of accuracy, then the machine will be proven to produce repeatable results, and we will use it produce multiple S-N data based on different materials, and additional shot peening treatment.



Russel Tomlinson, Danielle LaButis, Connor McAdams, Prof. Vito Moreno

MECHANICAL ENGINEERING

TEAM: ME 06
SPONSOR: Stephen Wilder
ADVISOR: Professor Vito Moreno

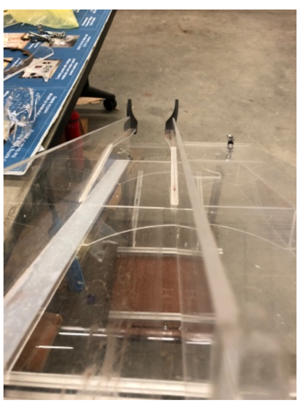
TEAM 06

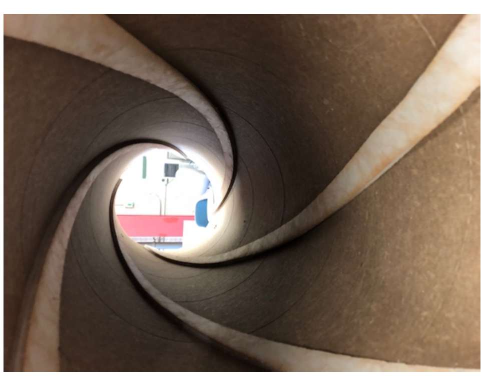
Associated Spring
A business of BARNES GROUP INC

Transmission Spring Sorting and Stacking Device

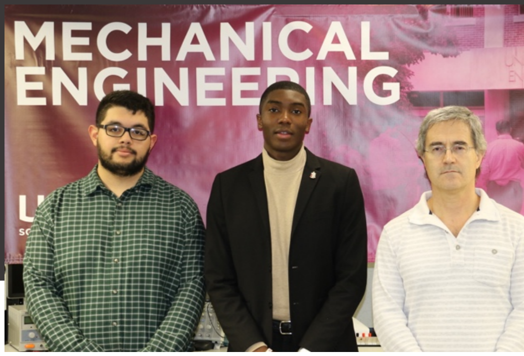
Associated Spring is well known for making many different types of springs. What started as clock springs has now blossomed into many different types of springs with various applications. This project focuses on the Bellville springs. These springs are used in automobile transmissions. In the manufacturing operations, the springs travel from one operation to another in a large bin. Bellville springs are particularly interesting since they have angled tabs which can get tangled in the bins. As the springs leave the final deburring operation they then head to a fatigue testing stage to make sure the springs are made to the correct specifications. Currently, an operator is responsible for separating and stacking the springs before they put the springs through fatigue testing. This project aims to create a device that can automate this sorting and stacking process, so that the operator can complete other tasks and doesn't have to spend time stacking springs.

The rig the team has worked on and designed is a continuation of a previous year's project, and is broken up into 3 major components. The tumbler, the conveyor, and the catching mechanism. The tumbler is the first aspect of the rig and is used to separate the springs as they are introduced to the rig. The tumbler consists of angled splines to help separate the springs which may be tangled due to the angled tabs. After the tumbler, the conveyor transitions the springs to the separation ramp. After the springs are untangled, they move to a ramp which separates the springs based on the orientation of the tabs. From the separation ramp, the springs are then caught by the catching mechanism in two neat stacks either with the tabs facing up or the tabs facing down. These neat stacks can be easily moved by the workers can then be easily presented to the fatigue testing process. The goal of this device is to achieve a high efficiency in the catching of the springs on the catching mechanism. These springs are produced in batches of thousands at a time, so a high efficiency means more springs stacked neatly and less time operators have to spend untangling and stacking.





TEAM 07



Jordan Rivera, Julian Nugent,
Dr. George Lykotrafitis

MECHANICAL ENGINEERING

TEAM: ME 07
SPONSOR: Paul Omichinski
ADVISOR: Dr. George Lykotrafitis

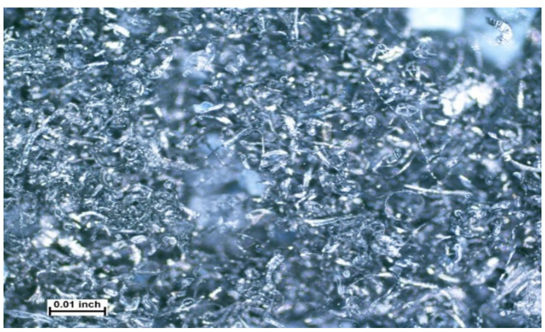
Grinding Process Evaluation

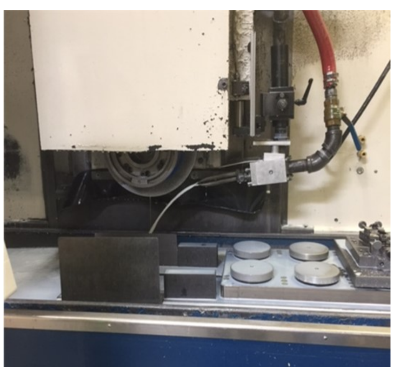
A machining process used extensively at Barnes Aerospace: Windsor Division for manufacturing parts from high temperature Nickel alloys is grinding. During the grinding process, a grinding wheel of either a plated or vitrified construction, and a working fluid acting as a lubricant and coolant, are used to remove material from work pieces. The chips of removed metal and the abrasive particles from the grinding wheel are debris known as “swarf” from the grinding process. The swarf is carried from the cutting point by the fluid. The fluid must then be filtered to separate and remove the swarf before the fluid can be returned to the cutting process. The filtering process at Barnes Aerospace currently uses a thin filter paper which, once used is removed, carrying with it the filtered particles. The filtering of the lubricant and disposal of the paper filters and swarf collectively is a costly process.

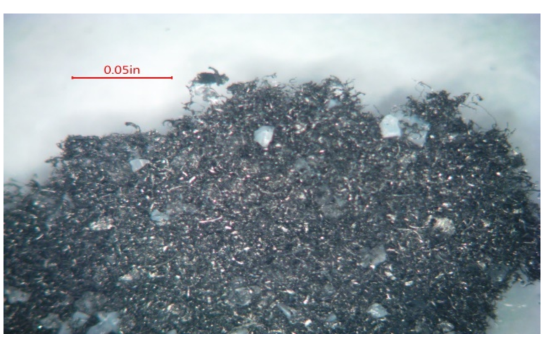
The purpose of this project is to gain an understanding through research and experimentation of the degree of cleanliness (DOC) of the lubricant necessary to produce parts which meet the design requirements and particularly, to achieve a surface finish ranging from 32 to 63 RA. Additionally, it is hoped this will lead to determining the appropriate DOC and filtering process for optimum processing efficiency. This research and experimentation, in collaboration with Barnes Aerospace and Norton Saint-Gobain Research & Development Grinding Center will then assist in optimizing the overall grinding process.

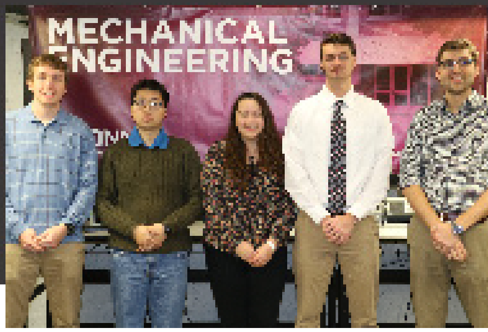
An experiment was conducted on site at Barnes Aerospace in which chip length was determined using microscopy. As seen in the pictures to the left in this brochure, chip swarf was first heated and then separated between wheel abrasive and metal aggregates so that only the chip sizes could be analyzed. These sizes, then contributed into analyzing the test samples of filtration paper with the tested production parts being ground.

Barnes
GROUP INC









Andrew Shepherd, Mingji Chen, Lily Dennison, Christopher Connor, Prof. Bryan Weber

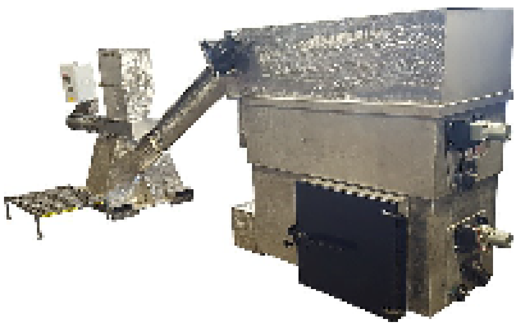
MECHANICAL ENGINEERING

TEAM: ME 08
SPONSOR: Jeff Hallowell
ADVISOR: Prof. Bryan Weber

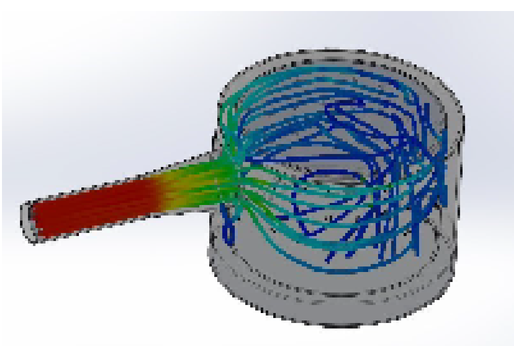
TEAM 08

Pyrolysis Design for Resource Recovery of High Moisture Feedstocks

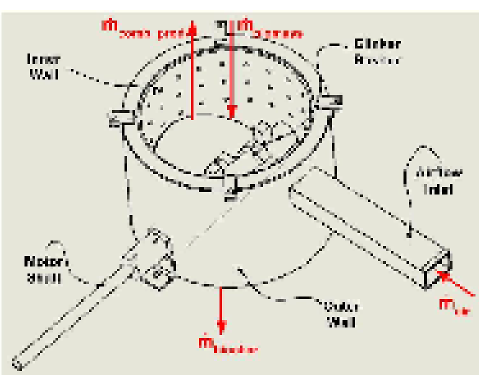
Biomass Controls is a company based out of Putnam, Connecticut that specializes in biogenic control technology for thermal and power applications. With over 100 years of combined experience in the control technology and data analysis industry, Biomass Controls has successfully designed a biogenic refinery that uses a form of high temperature decomposition known as pyrolysis, to convert waste to biochar and combustible gases for energy. Since biochar can be used as a soil amendment, it is utilized in agriculture to keep the soil rich with nutrients. Through the use of their mobile and web application, Kelvin, they can monitor the refineries to ensure the system is performing in the manner it is expected to.

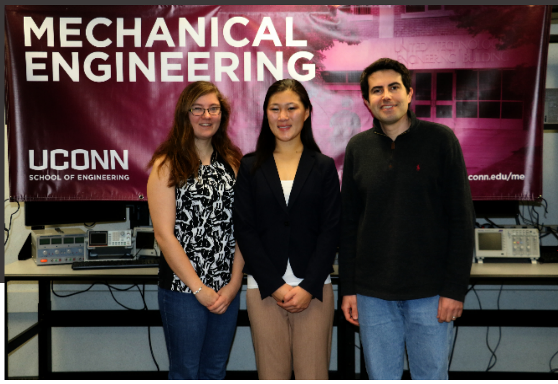


Given the high demand for resource recovery in some low-income areas throughout the world, our team was given the task of designing a pyrolysis pot with the capability of pyrolyzing 60-120 pounds of biomass per hour. Additional requirements that had to be met included compliance with emissions standards, durability, biochar output, a temperature threshold, and integration with the current system.



Due to the complexity of the biomass' composition, there is very little known about its combustive properties. Thus our solution was heavily based on our experimental results, as well as our results from detailed simulations. In order to reach our goal, our team designed a testing-pot with various airflow patterns that was used to discover the optimal airflow for the burn rate needed to sustain the volume of biomass fed into the pot. In addition to the changes to the airflow pattern, our design included slight modifications to the fuel agitation technique. Multiple experiments were conducted to fully measure the performance of each airflow configuration. Simultaneously, thermal and flow simulations were conducted using both Solidworks and ANSYS. These simulations allowed our team to study physical phenomena that would otherwise be impossible to predict. Using the qualitative data from our results, we were able to make key alterations to our design to control the variables that were most influential in the system. After our experimental testing and simulations, our team was able gather the necessary information to create a design that allowed our goals to be attained.





Danielle Browning, Chloe Vollaro,
Dr. Savas Tasaglu

MECHANICAL ENGINEERING

TEAM: ME 09
SPONSOR: Prof. Faqir Jain
ADVISOR: Dr. Savas Tasoglu

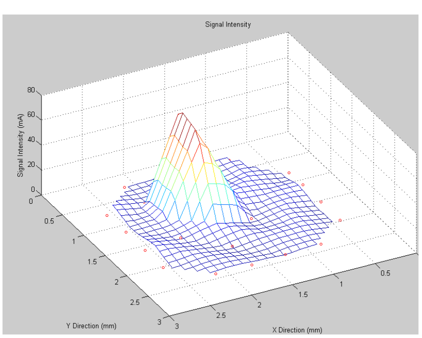
Subcutaneous Glucose Sensor Location System

Biorasis
Needle-Implantable, Wireless-Enabled Biosensors

Biorasis is a start-up company founded by UConn professors Dr. Faqir Jain and Dr. Fotios Papadimitrakopoulos. Their main product is the needle implantable Glucowizzard blood glucose sensor. The Glucowizzard is inserted in the subcutaneous tissue on the top of the wrist and continuously monitors the patient's glucose levels without the need to prick the patient's fingers. The user wears a smart watch directly over the Glucowizzard that powers and communicates with the glucose sensor via LED lights. The Glucowizzard is a 0.5 x 0.5 x 5 mm rectangular prism that needs to be replaced every 3 to 6 months before it gets enveloped by the surrounding tissue. Due to the small size, it is not possible to manually locate the Glucowizzard several months after insertion. To extract the sensor, Biorasis first needs a noninvasive location method.

Our team's goal was to provide a location method using an array of location sensors. Biorasis provided an array of 32 location sensors laid out in a grid. These sensors receive a signal from the Glucowizzard and output the intensity of that signal. Our team used the signal intensity data at known locations to determine trends and create a model that determines the position of the Glucowizzard in rectangular coordinates where the x-y plane is the surface of the wrist and the positive z axis points down into the skin.

We gathered data by placing the Glucowizzard on a three axis stage which allowed us to fix the position of the Glucowizzard with respect to the location array. We then moved the Glucowizzard in one direction at a time, for example, we moved the sensor in increments of 0.2 mm in the z direction while keeping the x and y coordinates the same. To map signal intensity to position of the Glucowizzard we used curve fitting in Matlab and existing models for the material properties of the Glucowizzard. We also explored the maximum value of the intensity and the full width of the intensity curve at half max and how they related to Glucowizzard depth and orientation. We produced a Matlab script based on our empirical data that takes the input from the location array and gives the user the x, y, and z components on the Glucowizzard for extraction.



MECHANICAL ENGINEERING

TEAM: ME 10
SPONSOR: Dr. Syam Nukavarapu
ADVISOR: Dr. David Pierce

TEAM 10

Kasey Butts, Anna Clesinski, Josh Scovill, Dr. David Pierce

UCONN HEALTH

Bioreactor for Articular Cartilage Regeneration

The purpose for this project is to design a device that will test the differentiation of chondrocytes in environments that mimic natural growth conditions of an in-vivo articulating cartilage. The device must be maintained sterile and autoclave throughout the process of chondrocyte insertion, application of pressure, and chondrocyte removal.

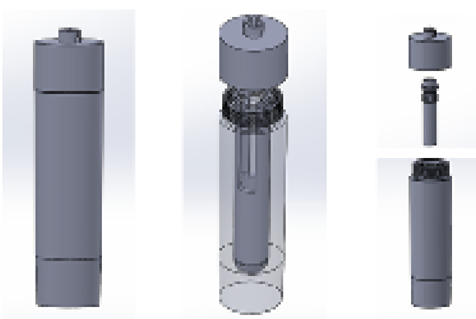
Essentially, the device will be composed of pressurized tubes containing the cells and the centrifuge in which the tubes will be located and spun. The goal of both methods of pressure is to strengthen and grow chondrocytes into strong articular cartilage, simulating a similar environment to the knee where cartilage of this composition is found.

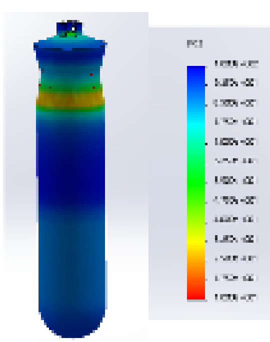
The first method of pressure application is the pressurized tubes. The tubes are designed to be light weight and at a size that the group can test with as well as can be used in an already created lab setting. They must be strong to withstand high pressure and have the ability to be sealed with an O-ring so that no air leakage may occur. An insert is also being created in order to supply easy input and output of the small test tubes.

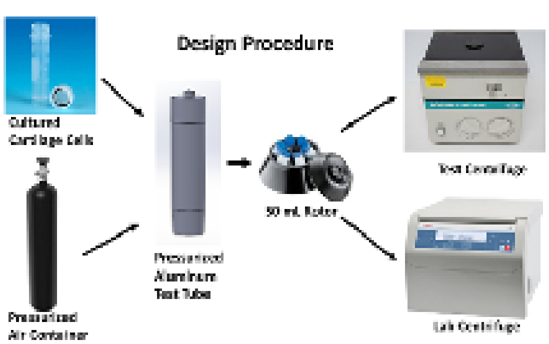
The second method of applying pressure will be with a centrifuge. The rapid rotations of the centrifuge lead to an inertial centrifugal force that opposes the centripetal force caused by the angular acceleration. The inertial force presses on the medium at the end of the test tubes creating a hydrostatic pressure felt throughout the medium, and therefore, by the chondrocytes themselves.

Since the centrifuge is already purchased, the main focus is now on the designed tubes. The current decisions being made are the material of the tubes, the type of valve used, the securing of the small plastic test tubes, and the best rotor for the pressurized tubes to be spun in.

As far as the goal of the project and the deliverables, the main idea is to test the theory of Dr. Nukavarapu. He believes applying pressure to the cells as they grow will allow the development of a strong cartilage instead of the soft cartilage that can be grown easily at this point in time. The group needs to supply a method of applying a total pressure of about 300psi to the cells in a safe and controlled environment. Eventually, the goal is to create a device that can be used in the future in Dr. Nukavarapu's lab.







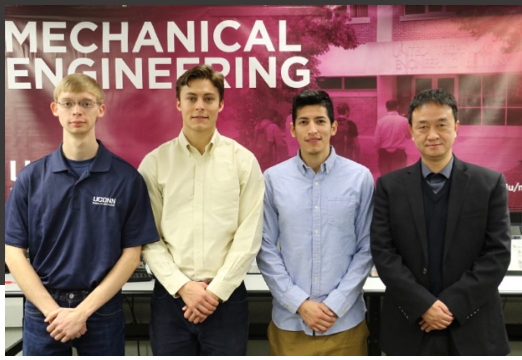
TEAM 11

MECHANICAL ENGINEERING

TEAM: ME 11

SPONSOR: Josh Liposky

ADVISOR: Dr. Chengyu Cao

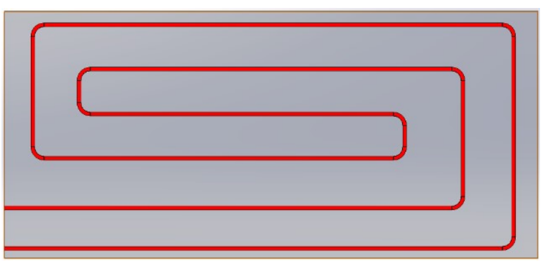


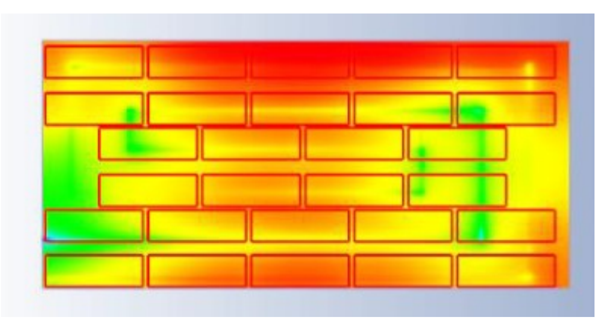
Gregory Wooding, Alexander Keane, Carlos Lobato-Ceran, Dr. Chengyu Cao

Design of a Lithium–Ion Battery Module

The Design of a Lithium–Ion Battery Module project is an effort initiated by sponsor company Cadenza Innovation. As an energy storage company, Cadenza Innovation aims to challenge the high cost of peak power plant power production though the introduction of grid storage assemblies. Peak power plants are much more costly to run due to the short period of time they are in use for power production on a daily basis. Using many of Cadenza's lithium-ion supercells, this project aimed to create a fully functional battery rack for grid storage. High energy-density battery elements generate a significant amount of heat which must be addressed to reduce possible safety hazards or malfunctions, as well as maintain battery life. Some of these malfunctions include, but are not limited to, thermal runaway, loss in battery efficiency, and potential damage to housing structures. Extensive thermal analysis is required to obtain sufficient experimental and numerical data to ensure proper battery storage functionality and verification that the designed coolant system meets required parameters. High heat profiles experienced during charge and discharge events can lead to irreversible battery failure.

A study was conducted to understand the heat transfer phenomena occurring between the elements in the battery assembly. This research and analysis involved both academic and theoretical investigation as well as 3D modeling and simulation using software. We built several CAD models to investigate the assorted heat transfer concepts and ran through numerous ANSYS Fluent simulations to determine if each design would meet thermal transfer requirements. After multiple design iterations, this research yielded a better understanding of the heat transfer methods and multiple cooling designs in which thermal requirements were full met. This project provided Cadenza Innovation with a feasible and reliable cooling system design to aid in the production of high energy density grid storage assemblies.





Irad Nazmi, Marc Himmel, Orlando Romero,
Dr. Chengyu Cao

MECHANICAL ENGINEERING

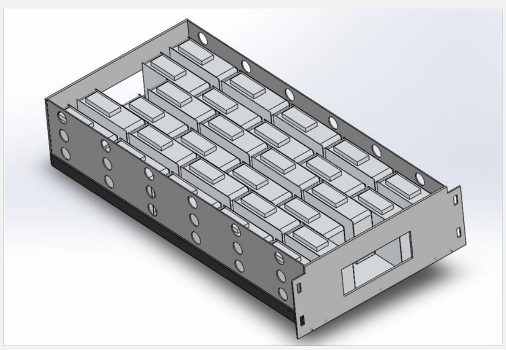
TEAM: ME 12
SPONSOR: Josh Liposky
ADVISOR: Dr. Chengyu Cao

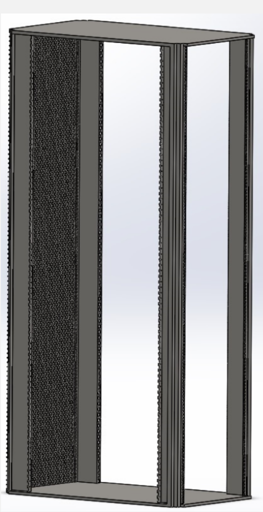
Design of a Rack-Based Lithium-Ion Battery Module for Grid Storage Application

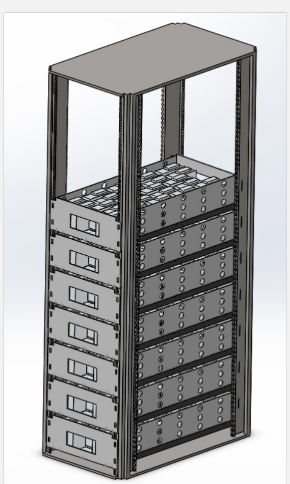
Cadenza Innovation Inc., located in Bethel CT, is a global technology leader in large lithium-ion energy storage systems. The objective of this project was to design and build a prototype housing unit, referred to as a “module”. The module holds numerous supercells, which are Cadenza Innovation’s patented lithium-ion battery packs. Modules would also need to be compatible with one another so that they could be connected, and then stored within a cabinet-style rack.

This project was interdisciplinary, requiring cooperation between students from the Mechanical Engineering, Electrical and Computer Engineering, and the Management and Engineering for Manufacturing departments. Our team’s main responsibility was to incorporate the components designed by the other ME group members and the ECE group members into the final prototype. These components included a cold plate (which acted as the module’s cooling system), a battery management system (BMS), interconnects and thermal insulating pads between the supercells, and wiring harnesses.

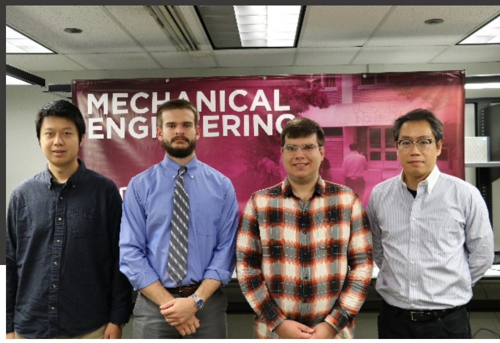
Optimizing energy density was integral in our design. It was important to design the module to be able to hold as many supercells as possible. Doing so maximized the cost effectiveness of the materials as well as the space being used. The next important consideration was safety. Our team focused on the structural integrity of the module and the entire rack as a whole, while the other ME group members dealt with the thermal safety concerns. The final major design parameter that we needed to consider was the geometry of the rack. The module had to be designed to fit into a large rack which was provided to us by Cadenza Innovations. Additionally, modules in the rack needed to be designed in such a way that they would be easily accessible for installation and maintenance purposes.







TEAM 13



Kai Ye, Daniel Chapman, Lars Gorczyca, Dr. Tai-Hsi Fan

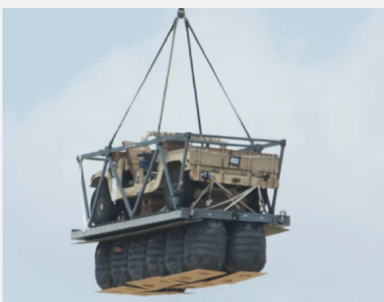
MECHANICAL ENGINEERING

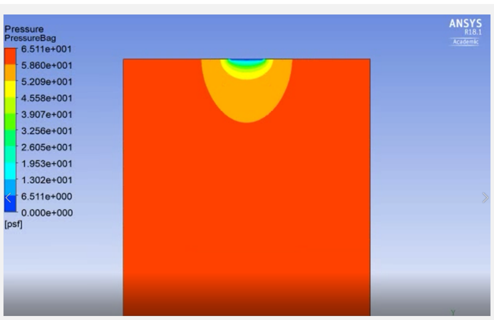
TEAM: ME 13
SPONSOR: Steve Parkinson
ADVISOR: Dr. Tai-Hsi Fan

Cushioned Platform Airbag Analysis

Capewell Aerial Systems is an innovative designer and manufacturer of aerial delivery systems, specializing in military applications. In order to properly protect a payload when ejected from a C-130 aircraft, a combination of a parachute and airbag platform are used to cushion the impact. Optimizing the airbag platform is necessary in order to provide optimal protection of the payload. One major flaw that is clear through experimental trials is the detrimental effect of having the airbags on the platform being in the shape of cylinders. The current cylindrical design requires the bags to be relatively tall compared to the whole platform. This current condition creates issues of a payload tipping upon impact with the ground due to instability from the airbag being too tall, as well as the payload being carried off the drop target by strong winds due to a large cross sectional area. These issues lead to inconsistency in payload drops as payloads often are blown off target and fall on their sides upon impact increasing the time required to remove the payload from the cushioned platform.

This project goal was to create an accurate computational fluid dynamics model (CFD) based on the current cylindrical airbag design that would allow for an easier and more accurate redesign of the airbag design into a rectangular bag that would decrease the height of the airbags while maintaining sufficient damping effects upon impact. By reshaping the airbags into a rectangular design, the area of airbag impacting the ground would increase, thus allowing for a shorter airbag design and a solution to the main issue with the current system. In addition to the main issues presented by Capewell, creating an accurate CFD model allows for further optimization of the current design as a short term fix to improve airbag function. Analysis through CFD enables a better understanding of the stresses and pressures on the airbag during impact. Between CFD analysis and experimental trials, overall understanding of the airbag characteristics during impact have been improved and allowed for better designing of future airbags deployed by Capewell.





Erik Eaton, Elaine Carrier, Dr. Vito Moreno

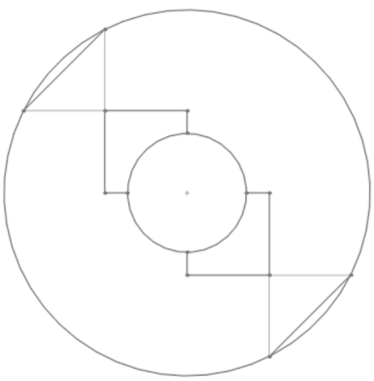
MECHANICAL ENGINEERING

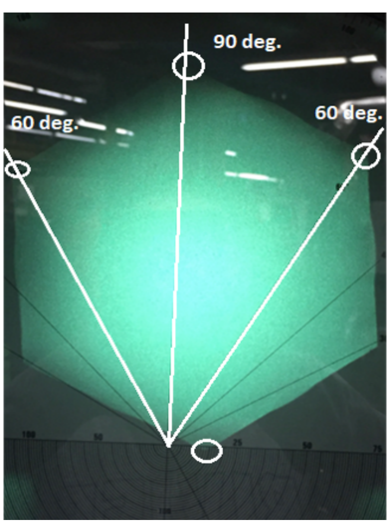
TEAM: ME 15
SPONSOR: Tracy Camassar
ADVISOR: Dr. Vito Moreno

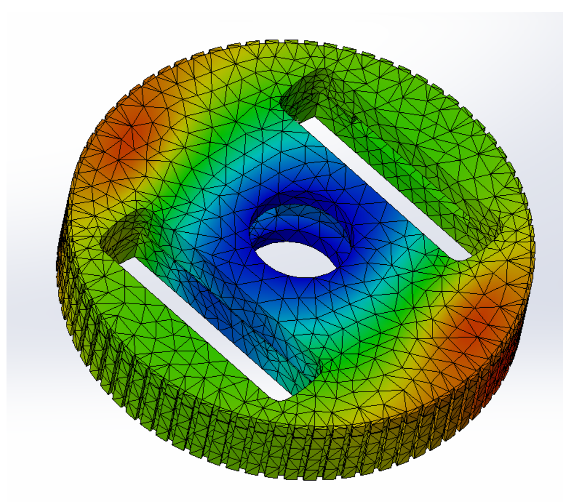
Palm Ratchet

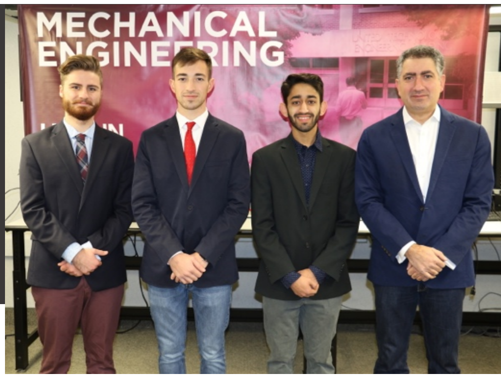
Chapman Manufacturing wanted to create a new ratchet that would allow customers to ratchet parts down in tighter spaces with just a simple wrist movement. The inner mechanism includes a spring, pawl, and gear that are cross compatible with their popular Midget Ratchets; these parts must stay the same. The pocket holding the inner mechanism underwent different design changes to reach the necessary torque requirements. Material selection was also an important part of the process; the team tried different materials ranging from various plastics, such as reinforced nylon, to metals, such as aluminum 1060. The manufacturing methods explored were machining and 3D printed ratchets.

There are two types of gears that Chapman is using. Chapman experimented with a different gear broaching method that resulted in functional gears with a slight twist. The twist in the gear was approximately 12° along its length. Twist gears are being used in the palm ratchet because a person's maximum input torque will not approach the breaking point of the gears for a tool the size of the Chapman Palm Ratchet. In order to minimize material waste, Chapman will exhaust the stock of twisted gears before installing their original non-twisted gears. The team re-designed and tested the pocket to ensure that the gear would be able to withstand the advertised torque.







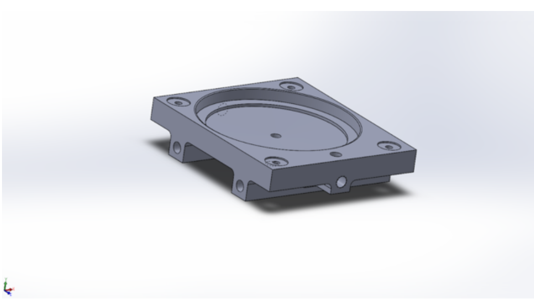


Ray Rega, Tom Boswell, Rishul Marwah
Dr. George Matheou

MECHANICAL ENGINEERING

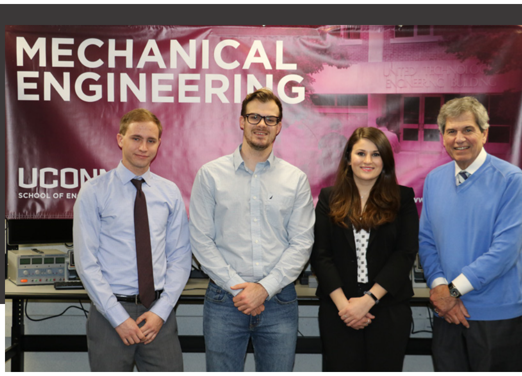
TEAM: ME 16
SPONSOR: Parker
ADVISOR: Dr. George Matheou

Filtration Medium Performance Prediction Model



The Parker Hannifin Corp. Filtration Group, formerly Clarcor, located in East Hartford, CT, specializes in the design and manufacturing of fuel filtration devices for a client product base stretching from off road construction and agricultural equipment to road going transit vehicles. The importance of fuel filtration cannot be stressed enough in providing the cleanest running and most efficient engine power. This project focused specifically on the filtration medium within a fuel filter, that being a cellulose fiber material that does the actual filtration of the fuel, and its development. The heavily iterative testing method used currently, flat sheet media testing, is the only way for engineers to obtain data on the pressure drop, degree of blockage, and key flow characteristics across a specific piece of a given filtration medium, and it often takes several hours to obtain data for just one type of medium. The goal of this project was to craft a performance prediction model that can provide consistent and accurate results, while significantly reducing the time it takes to obtain the aforementioned data.

The first step in achieving the goal was to obtain flat sheet testing data from which to base the model. The first round of tests dealt with running clean Viscor calibration fluid through the testing unit, both with and without a piece of flat sheet medium. The second round of tests dealt with running Viscor with particulate added through the testing unit. With the results from these tests, an accurate model of the relationship between the degree of blockage in the filtration medium and the pressure drop across the medium was deduced. Using this relationship, a drafted CAD model of the flat sheet testing unit, and specific material data for the cellulose filtration medium, an editable ANSYS simulation along with an accompanying work instruction file were created, allowing a user to input various material properties pertaining to both the fuel being used and the filtration medium inside the testing unit, and obtain the flow characteristics, pressure drop, and degree of blockage with respect to time until the medium was choked, all in a matter of minutes. The results obtained from this simulation were then verified using the initial flat sheet testing data before implementing the prediction model at the Parker facility.



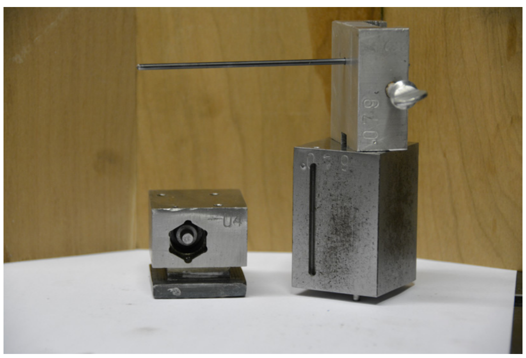
Tyler Olsen, Travis Braisted, Michelle Debs, Professor Vito Moreno

MECHANICAL ENGINEERING

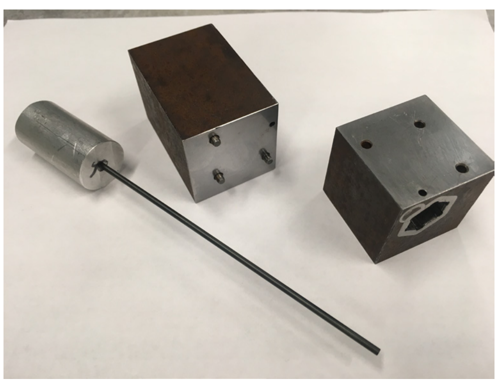
TEAM: ME 17
SPONSOR: E.A. Patten – Ken Kleitz
ADVISOR: Professor Vito Moreno

Thrust Wire Insertion Tool

In the aerospace industry, E.A. Patten is a leader in the production of precision tubing in jet engines, whether it is for newly manufactured engines or repairing existing engines. The method used by E.A. Patten to fasten the tubes together is a common fastening method for older style tubes. With a ferrule and nut arrangement, the ferrule is secured to a nut by a thrust wire as a locking mechanism. The thrust wire is inserted through a hole in the nut tangential to the inner circumference of the nut. The thrust wire is then pressed into the nut until the wire is flush with the surface of the nut. The wire must be completely flush to ensure that the wire completely encircles the inner circumference of the nut, thus ensuring the nut will be locked to the tube. The current process of inserting the thrust wire is via a manual strike, which can be time-consuming and inaccurate, thus damaging material and increasing costs. The goal of this project is to design, build, and develop a device that can more quickly and accurately insert thrust wires as a part of the E.A. Patten assembly process.



One design concept for an insertion device is a stationary structure that mounted the tube-nut assembly and drives the wire using an oscillating eccentric cam. The v-shaped mount and outer-boundary will ensure the accuracy of the insertion. However, since the cam drive may be difficult to equally drive a force in one position, other existing devices, such as an arbor press, are being considered.



Another design uses sockets as inspiration for the holding the nuts. To create a quick and accurate method for holding the nuts, a fitted hexagonal hole is cut in the block, thus providing a stop and a guide hole for the wire. The design then uses drivers and guides, specific to the various wire diameters, to connect the individual blocks.

A third design is inspired by a lathe. Two thrust nuts are secured in a v-shaped mount which is adjustable for the various nut sizes. A long arm slides vertically along the rods to drive the wire. The arm contains a pin with a concave end to hold the wire and push it below the nut surface.

TEAM 18A

Matthew Balnis, Alexander Kerendian, Dr. Bryan Weber

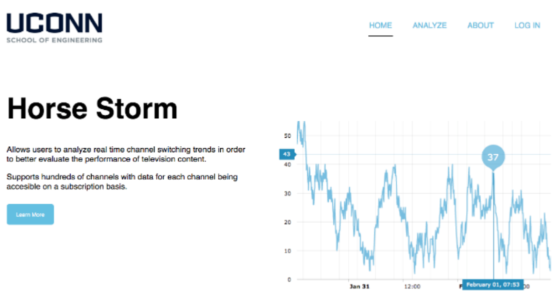
MECHANICAL ENGINEERING

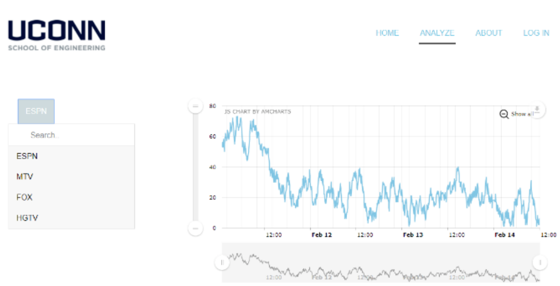
TEAM: 18A
SPONSOR: Reverge Anselmo
ADVISOR: Dr. Bryan Weber

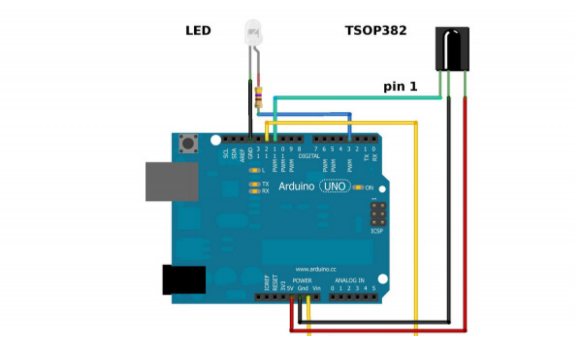
Horse Storm Monitoring System

Thousands of hours of content are broadcasted to household televisions every day, and billions of dollars are spent refining this content for target markets. Content producers, advertisers, and broadcasters are constantly looking for ways to evaluate how their content is performing with the desired demographics. Currently, this is done by tracking the number of viewers of a given television show at the beginning and end of the episode. The Nielsen ratings box acquires this data from the homes of consenting participants, transmitting all of the data at the end of the day. There are several problems with this system, though. Content producers can't view the data until the end of the day, and they don't have access to viewing data between the beginning and end of each episode.

The "Horse Storm" Monitoring System is meant to solve the issues associated with the Nielsen ratings box. The system is named after the rocking sensation created by horses shifting back and forth at the same time while being transported via boat. 'Shifts' in channel viewership can be compared to the shifting weight of the horses in the boat, and are captured using the Horse Storm Monitoring System. Horse Storm is a combination of hardware and software that tracks television remote inputs and streams them to a central storage/processing location. This system functions as a subscription-based service that allows viewing data to be streamed to content producers, broadcasters, advertisers, and other subscribers in real time. Viewing data is transmitted near-continuously, allowing users to pinpoint specific content within episodes that resulted in a shift. The data is presented in an intuitive web-based interface, which makes it easy for users to identify meaningful trends. The main objective of the Horse Storm Monitoring System is to allow its users to quickly and accurately identify viewing trends, empowering them to improve their content.







MECHANICAL ENGINEERING

TEAM: ME 18B
SPONSOR: Ray Parker
ADVISOR: Professor David Giblin

TEAM 18B

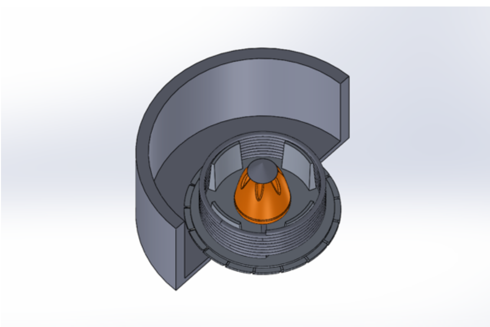
Spencer Cohen, Michael Ferrara, Marc Cacioppo, Professor David Giblin

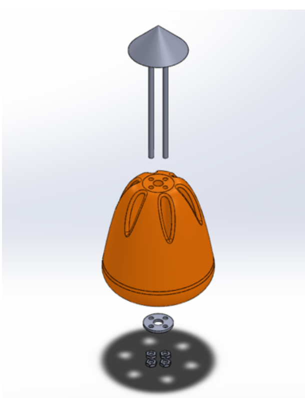
GENERAL DYNAMICS
Electric Boat

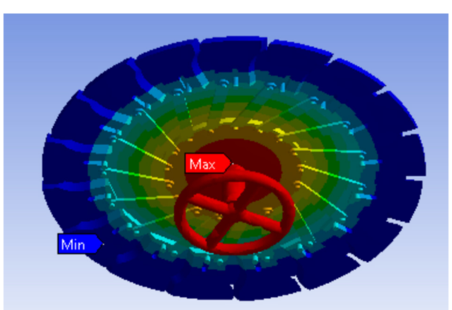
Disabled Submarine Compartment Decompression

In 1988, a Peruvian submarine called the Pacocha was rammed by a commercial fishing vessel, causing it to sink to the ocean floor. It was resting at 140 feet below sea level as the crew waited for a rescue vehicle to arrive. Due to a lack of communication between the crew and the rescuers, the crew were in the submarine for almost 24 hours after the accident. The air pressure in the submarine rose due to a leak in a vent valve allowing seawater into the ship, which compressed the air inside to an above-atmospheric pressure. Issues arose when the submariners tried to surface without letting their bodies decompress slowly prior to ascension. When the body decompresses at a fast rate, dissolved gasses come out of solution in the form of bubbles and can negatively affect many different aspects of the body. The goal is to provide a way to successfully decompress an interior volume of the failed submarine in order to prevent decompression sickness on the ascent to the surface. This can be provided if there was a solid connection to the surface.

To connect the submarine to the surface, a hose strong enough to withstand pressures in the ocean must be used. An experiment using a sealed pipe and compressor was performed to simulate an ocean depth of 600 feet. A hose was sealed inside of the pipe before the pipe itself was bolted shut with gaskets and flanges to prevent leaks. The inside pressure of the pipe was increased to 270 psi, a similar pressure that would be experienced at 600 feet below sea level. This experiment confirmed the analytical results calculated prior to testing. A buoyant device must also be attached to the end of the hose in order to allow safe ascension to the surface. An experiment using a buoyant material and weights was performed. This experiment has shown that the volume of the buoyant material chosen is sufficient in providing the hose with safe ascension to the surface. The last component is the attachment of the hose to the submarine itself. A designed latching mechanism provides a strong attachment to the escape hatch in the submarine. It latches into the hatch and when the hose and buoy need to ascend, water is allowed into the escape hatch, allowing the buoyant device to pull the hose towards the surface. A valve is included to allow the crew members to decompress at a safe manual rate. Once the crew desires to escape, the hose will be released and the escape plan can proceed as planned.





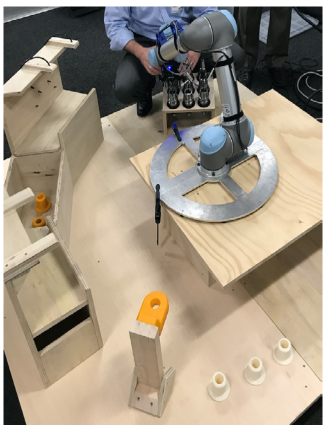


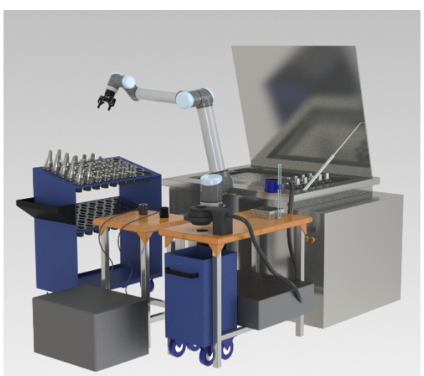
MECHANICAL ENGINEERING

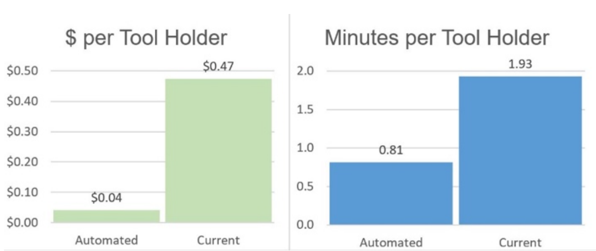
TEAM: ME19
SPONSOR: Dan Cleary
ADVISOR: Dr. Vito Moreno

Kyle Cabral, Jonathan Smith, Jeffrey Garnelis, Dr. Vito Moreno

EDAC TECHNOLOGIES







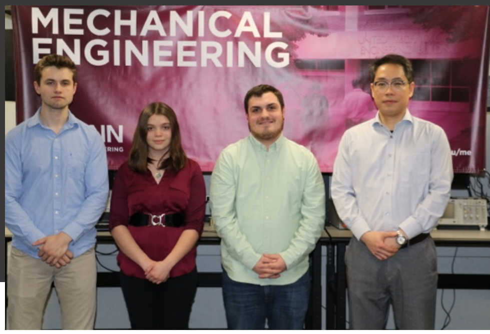
Automated Tool Holder Cleaning Process

EDAC Technologies, Rotating Components Division aims to double Integrally Bladed Rotor (IBR) production by the end of 2018. The IBR milling process requires several dozen reusable Haimer tool holders, however the current manual cleaning and tool removal process only has a capacity of 150 tools per day, creating a bottleneck. Without process improvement, the desired production rate cannot be met.

In order to prepare enough tooling and increase worker safety, EDAC has requested that the ME19 team develop an automated process that prepares at minimum 650 Haimer tool holders per day for tool setting. In order to determine the most effective solution, ME19 researched and created initial designs for three different cell configurations. Using data collected from the current process, economic factors, and size constraints, ME19 down selected and concluded that a process based around a general purpose robot would be the most effective method.

After the design selection, a proof of concept experiment was constructed to test the capabilities of the UR10 robot. Upon successful testing, ME19 developed the necessary subsystems of the process, i.e. washing, drying, tool removal, and cooling. The process flow was designed, programed, and optimized. The UR10 robot, Haimer shrink fitter and washing station were outsourced. The drying station, physical cell structures and system network were prototyped and tested by ME19.

The development and construction of the cell is an ongoing process, however, initial calculations show the design to be cost effective, safer, and more reliable than a human.



Christopher Ersevim, Sharon Ruggiero,
Connor Smith, Dr. Tai-Hsi Fan

MECHANICAL ENGINEERING

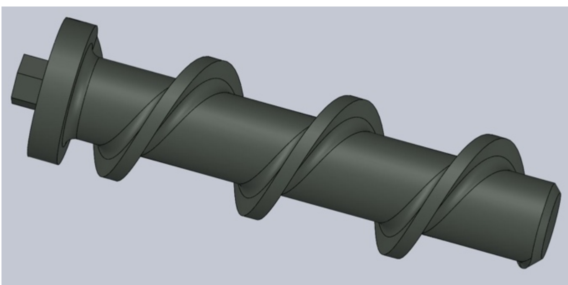
TEAM: ME 20
SPONSOR: Steve Haldezos
ADVISOR: Dr. Tai-Hsi Fan

TEAM 20

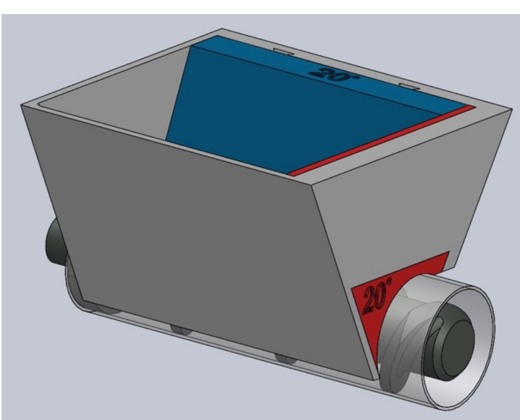
Study of Variables Affecting the Intake of Materials into a Polymer Extruder

FARREL POMINI
continuous compounding systems

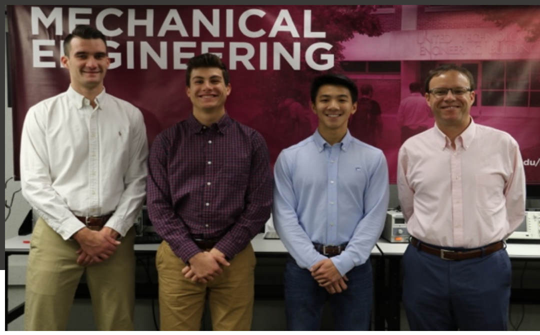
Farrel Pomini is a global leader in the research, design, and manufacturing of continuous mixing systems for the polymer processing industry. One of their innovative products is the Farrel Continuous Mixer which allows for the continuous mixing of polymers, previously only performed in quantized batches. Once processed, the polymers flow into a hopper and are subsequently pelletized by passing through a single screw hot feed extruder. Every polymer mixture tested at Farrel Pomini passes through the same hopper design, and because each polymer substance has a unique set of properties, some extrude quicker and more efficiently than others. Thinner compounds flow continuously and have no trouble being directed into the hopper; however, the rubber compounds with the highest viscosities have a tendency to accumulate in the hopper before being grabbed by the feed screw for extrusion. The main objective is to improve the design of Farrel Pomini's hopper and feedscrew system to cut down on the buildup of the thicker materials within the hopper, while maintaining a system design that is functional for thinner and less viscous polymers.



Through analytical and qualitative testing, three room-temperature materials with a range of viscosities and elasticities were identified to simulate the flows of molten polymers. It was determined that a mixture of glue and starch would serve as the thinnest of the tested fluids, honey combined with a food thickener called Xanthan Gum would act as the middle range viscosity fluid, and a dough formed from flour, water, salt and oil would be the most viscous material for testing. All three were fed directly into a hopper fabricated from metal sheets joined with corner brackets. The geometry of this configuration was easily altered by slotting modular 3D printed pieces into place so that both the front wall angle and downstream wall angle of the hopper could be changed between trials. A feedscrew was machined from a solid metal rod and housed in a clear polycarbonate tube so that the flow of the material would be visible as it was extruded. Utilizing quantitative testing of the test rig, the angles which facilitated the quickest and most efficient fluid flow for all three room-temperature materials was discovered.



TEAM 21



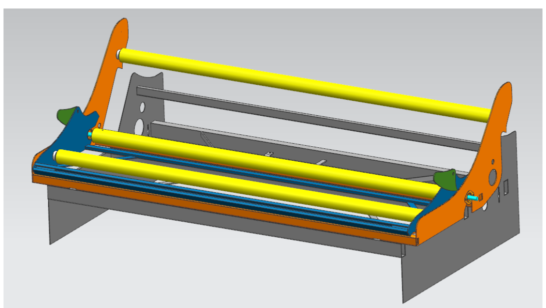
MECHANICAL ENGINEERING

TEAM: ME 21
SPONSOR: Kenneth Szarek
ADVISOR: Dr. Julian Norato

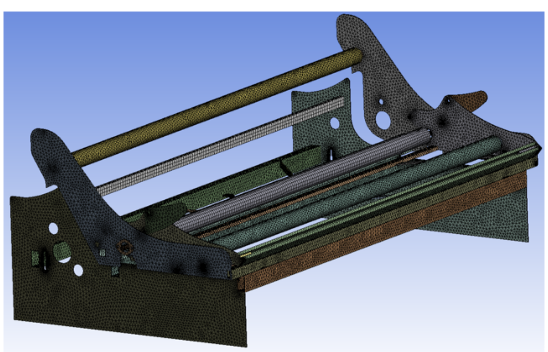
Bryan White, Matthew Maliniak, Jonathan Wong, Dr. Julian Norato

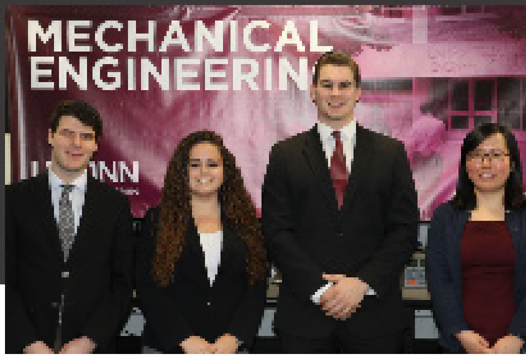
XLs 125 Spreader Capacity Analysis

Gerber Technology manufactures material spreading and cutting systems to help companies take their products to market smarter, faster and more efficiently. Gerber's line of spreaders (rated by weight capacity in kilograms at intervals of 50, 125, and 250) precisely and automatically spread sheets of material across a spreading table. Gerber has noticed a growing portion of their customers desire textile spreaders that can handle 200-kilogram rolls but are unwilling to purchase the 250-kilogram textile spreader due to high costs. As a result, Gerber wishes to improve upon the 125 kg design by adding structural reinforcements in order to target this market demand. The goal of this study is to analyze the XLs 125's structural integrity and propose necessary improvements to safely handle 200 kg textile rolls. Additionally, the power integrity and budget of this new spreader needs to be analyze after improvements are made as well.



The XLs 125 is made up of two main components, the cart weldment and the cradle; the cradle holds the fabric roll and the cart weldment attaches to the table which it rolls on. Gerber Technology provided the team with complete sets of CAD models for the entire assembly. To perform finite element analysis (FEA), the spreader assembly required structural and geometrical simplification. After a mesh was created, analyses for material weights of 125 kg, 150 kg and 200 kg were calculated. Based on these results, areas of concern were identified and provided a guide for strain gage placement. Multiple strain gage trials allowed both the ANSYS calculations and physical testing to align. To create a power budget for the XLs 125, information for both power and current for loaded and unloaded cases were gathered. Using the test results, the team determined whether or not the motors are capable of operating the spreader assembly when carrying a larger load. Using the discovered results, design upgrades and further testing recommendations for the XLs 125 spreader were proposed.





Giuliano Stabile, Alyssa Mae Cetone, Matthew Moll, Dr. Dianyun Zhang

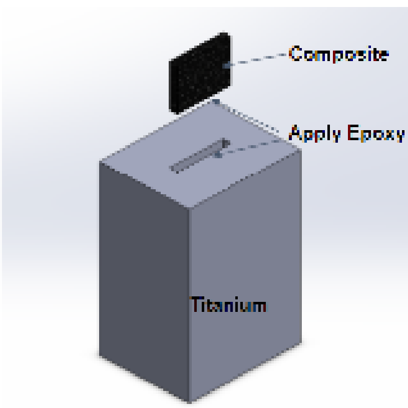
MECHANICAL ENGINEERING

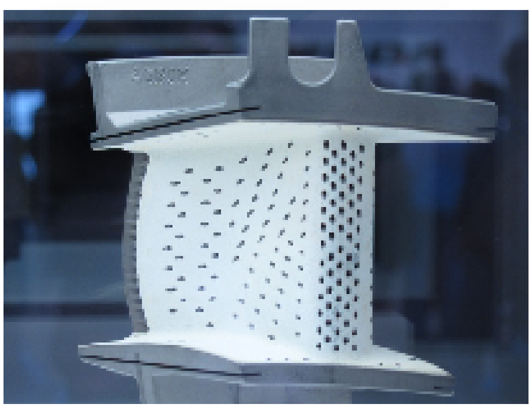
TEAM: ME 22
SPONSOR: Steven Hayse
ADVISOR: Dr. Dianyun Zhang

TEAM 22

Evaluation of Induction Heated Bonding of Titanium and Carbon Fiber Composite

GKN AEROSPACE



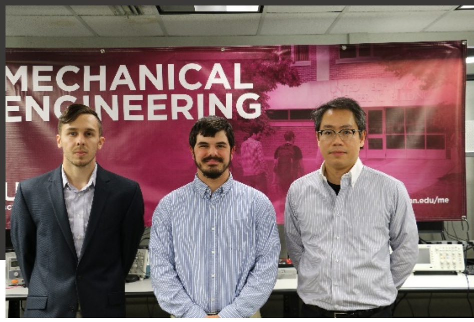


GKN Aerospace Services Structures, located in Wallingford, CT, is a large manufacturer of composite aerospace components. Its parent company, GKN PLC, is a global engineering business that designs, manufactures, and services components for transportation vehicles, from aircraft to automotive applications. GKN and many of today's aerospace industries require mass production of various components in a time efficient manner. A large number of these products are made from composite materials which are used for their light weight, flexibility, and strength. Most companies rely on heat curing in large ovens to manufacture composite parts. These ovens are time and energy inefficient, take up large amounts of space, and generate waste.

This composite manufacturing process may be able to be improved with induction heating methods. New inductive heating techniques can allow more localized, constant, and precise bonding of composite parts. Induction heating has the potential to improve the curing process efficiency by reducing cycle time and saving energy. This objective of this project was to determine if induction heat bonding would be a more efficient method for manufacturing GKN Aerospace's parts.

The team evaluated induction heat bonding of a simplified rectangular specimen made of titanium, carbon fiber, and resin. The simplified specimens were used to simulate a structural guide vane manufactured by GKN Aerospace that is used inside jet engines. The team fabricated several specimens of comparable thicknesses of titanium, carbon fiber, and resin layers as the actual part. In manufacture of the actual guide vane, there are specified heating rates and temperatures that must be complied with to meet customer standards. The team then developed a set process for curing using induction heating using an induction cooktop. The aim of this process was to bond the specimens while staying within the designated heating rates to produce the same quality final product and yield performance of bonding. The bond temperature and heating rates were continuously assessed using infrared laser measurement. Simulations were used for heat transfer analysis. The team performed a cost analysis and an assessment of the cycle time and efficiency of induction heating in comparison to oven curing to ultimately determine if induction heating would a viable process to be implemented by GKN Aerospace.

TEAM 23



Jonathan Pyshna, Ernie Bouthiette, Dr. Tai-Hsi Fan

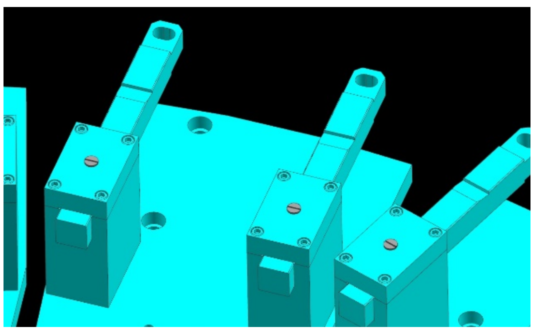
MECHANICAL ENGINEERING

TEAM: ME 23
SPONSOR: Andreas Andersson
ADVISOR: Dr. Tai-Hsi Fan

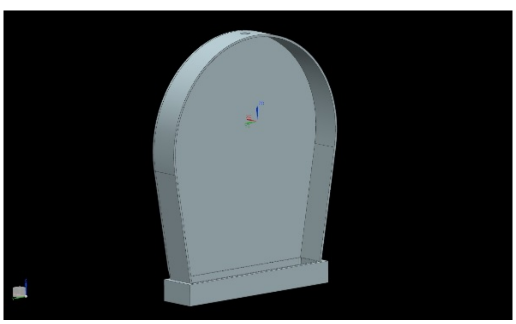
GKN AEROSPACE

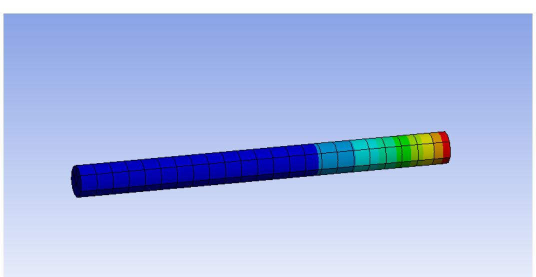
Improved Resource Utilization and Cost Reduction for Additive Manufacturing

The project seeks to find a way to minimize argon consumption in an additive manufacturing process. When reactive metals are additive manufactured they need to be made in a build chamber filled with an inert gas to prevent the part from oxidizing. Argon is typically used as the shielding gas in processes that involve reactive metals. The current process does not capture the argon that is flowing through the chamber. This results in a high cost and a large waste of resources. Our solution aims to reduce the argon consumed in two ways. The first way is by redesigning the build chamber. The geometry will be optimized to reduce the chamber volume. The fixture that the part sits on and that is inside the chamber will be redesigned to help with the geometry optimization of the chamber. A system to capture, filter, and recirculate the argon will be researched to reduce the amount of argon used.



A recirculation system was found that is produced by Inert Technologies. This system monitors oxygen content, recirculates, filters, and controls the inert gas atmosphere. When manufacturing this part the part will shrink due to thermal expansion. To account for this a new fixture was developed. The fixture itself is based off of a current fixture used for milling that has segments to hold the part in place. The new concept uses brake pads where segments connect to the rigid part of the fixture. They will control the movement of the segments by allowing the segments to slide when the force caused by part shrinkage over comes the friction force caused by the brake pads. Heat transfer simulation was performed to predict the temperature of the segments during the process. A welding experiment was also done to simulate how the additive manufacturing process will deform the part. Lastly, a chamber design was developed. The chamber design uses the density of argon and laminar flow to reduce the amount of purging needed before the process starts.





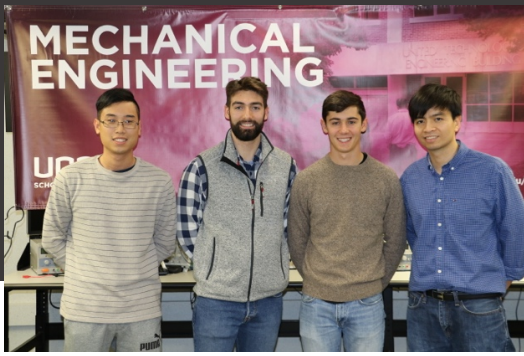
MECHANICAL ENGINEERING

TEAM: ME 24

SPONSOR: Michael Roy

ADVISOR: Dr. Thanh Nguyen

TEAM 24



Thinh Nguyen, Anthony D'Ercole, Scott Jones, Dr. Thanh Nguyen

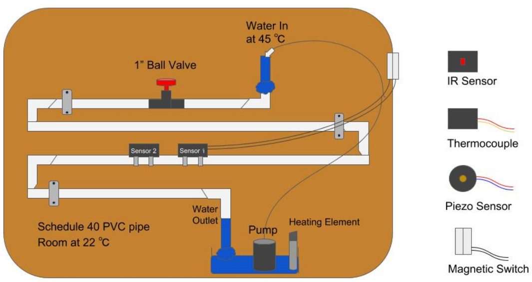
Internet of Things: Wireless Safety Sensor Suite

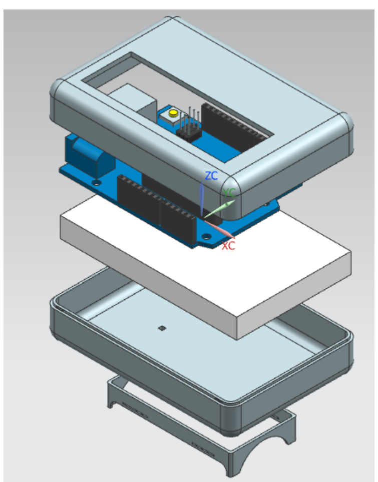
Hartford Steam Boiler has been considered an industry leader in equipment breakdown insurance over the past 150 years. With one of the largest teams of engineers and inspectors across the globe, the company continuously innovates standards of coverage and forwards advancements in preventative maintenance protocols. As part of the Internet of Things movement, HSB has partnered with the University of Connecticut's Mechanical Engineering School in hopes of solving the existing issues with proper maintenance operations. According to various accredited studies, boiler operation during low water conditions, improper or lack of regular blowdowns and faulty safety valves account for not only the majority but the most costly and catastrophic of failures. The American Society of Mechanical Engineers recommends for a typical maintenance routine to consist of a daily performance the blowdown valve, the testing of a low water cutoff valve bi-weekly in addition to a monthly safety valve release to test the functionality of the devices and to ensure an efficient and more durable boiler. The purpose of each device is as follows; The low water cutoff is a safety feature that will shut down the burner to prevent excessive buildups in heat and pressure which can cause boiler explosion, the blowdown valve releases the sediment that builds up along the bottom of the tank to prevent calcium buildup which would create inefficiencies, and finally the safety valve is set to open and release steam when the allowable pressure is exceeded to prevent eruption. Many of these failures can be attributed to improper or complete disregard for routine maintenance.

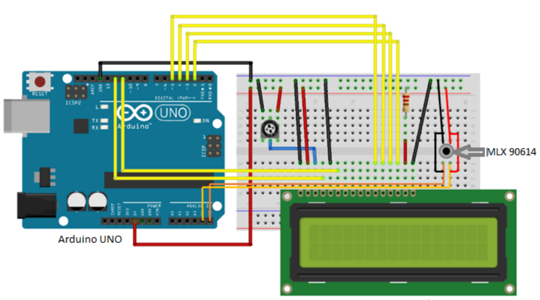
Aside from providing educational information on these topics, Hartford Steam Boiler is taking a more proactive stance in developing a wireless sensor network capable of collecting data associated with maintenance operations of each device. The data is processed by a designed device reading an engineering parameter to communicate the results over a wireless network providing the necessary Engineers with real time data. This data will be utilized for multiple purposes: ensuring the safety of clients, providing a method of rating customer compliance, and cutting the overall costs associated with equipment failure.

Munich RE

1866
Hartford Steam Boiler







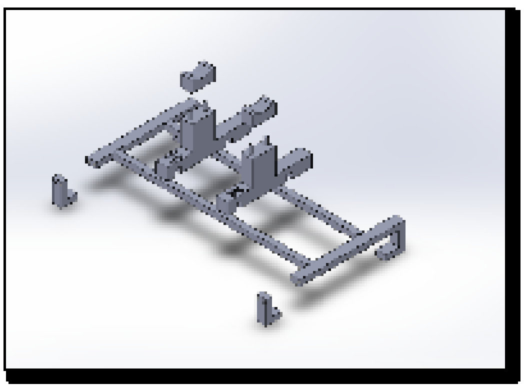
Patrick Purdy, Yani Lagoudis,
Professor Zhanzhan Jia

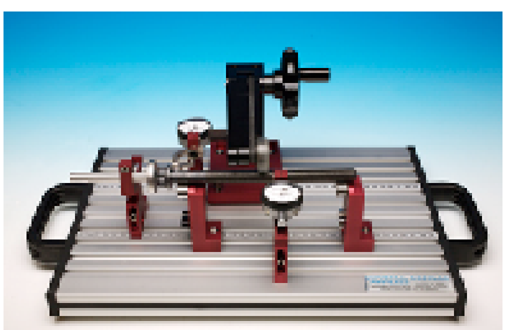
MECHANICAL ENGINEERING

TEAM: ME 25
SPONSOR: Roger Okenquist
ADVISOR: Professor Zhanzhan Jia

High Strength Fasteners – Automated Straightening Operation

HOLO-KROME®

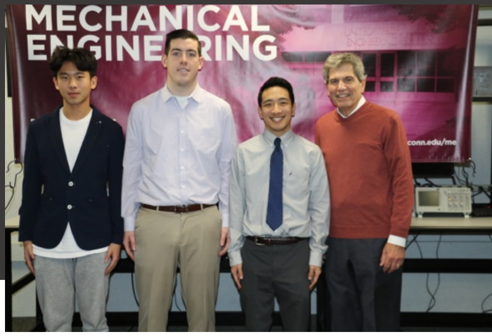




Holo-Krome developed the high strength socket head cap screw and manufacturing process in the 1950s. Their products are used in a wide variety of applications such as mining, wind turbines, and oil & gas production. Producing large length to diameter ratio screws requires straightening after heat treat.

The current process requires manual part inspection and straightening by a well-trained operator. The operator straightens the bolts on an Eitel straightening press using only judgement and intuition, as there are currently no standards for how to correct the unwanted bending in bolts. The bolts are held in the press on a bracket which is free to move on the press table and has parts that wear out easily. The bracket components' indefinite position and short life cycle is a source of variation in the straightening process while also requiring time to rework or remake the bracket frequently. The scope of the project focuses on the creation of a standardized algorithm for how to correct the bending in a bolt as well as the construction of an improved bracket to hold the bolts being straightened in the hydraulic press.

A Matlab script has been written which, when given bolt dimensions and parameters defining three point bending similar to the setup seen in an Eitel straightening press, will display an elementized cross section of a bolt in bending and return an array of residual strains for elements along the surface of the bolt. To reduce the time required to inspect bolts, measurement gauges have been researched and select companies which may provide proper measurement instruments have been contacted. New Eitel press brackets have been conceptualized with solidworks models made for visualization of the concept bracket, and to be used as a base for 3D printing. The Matlab script, inspection gauges, and new Eitel press bracket are not yet integrated with one another but each piece is designed and considered with the prospect of integration to further automate the straightening and inspection process. The use of each piece in the final solution will include documentation for the proper use of the equipment and may include step by step procedures to standardize the bolt straightening process.



MECHANICAL ENGINEERING

TEAM: ME 26

SPONSOR: Thomas Scanzillo

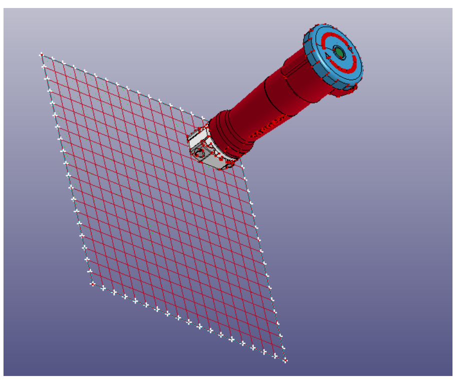
ADVISOR: Dr. Vito Moreno

TEAM 26

Chengzhang Li, Ronan Curry, Colin Murphy, Dr. Vito Moreno

Connector Impact Finite Element Analysis Model

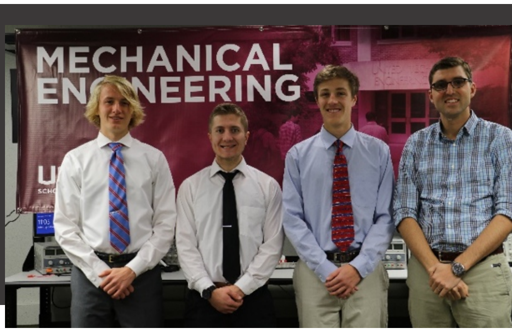
Hubbell Incorporated proposed the problem to create a finite element analysis model, that has the capability to predict the outcome of the Underwriters Laboratories (UL) standard 1682 test. This requires Hubbell's connectors to be cooled in a freezer at -25℃ for six hours. The connector is then removed from the freezer and attached to a cable (90 inches long), lifted 30 inches above a slab of concrete. The connector is then released, causing it to impact the floor. The test requires each of Hubbell's connectors to withstand that exact fall, a total of eight times, without showing any signs of deformation, cracking, or ultimate failure. Prior to each proceeding fall, when the connector is lifted to the set height it must be rotated 45° (encompassing the full 360° by the end of the eight drops). The company determines the survivability of their products through visual inspection. Empirically testing each design is an expensive process with a need for constant retooling.



The main deliverable is to provide Hubbell with the methodology behind finite element code that has the capability to accurately predict the outcome of this dynamic impact. The senior design team has successfully accomplished the task of providing the required steps that go into the creation of an impact model of this scale. This includes providing the necessary inputs, initial conditions, boundary conditions, and material requirements. The team performed the impact analysis for one of Hubbell's pin and sleeve connectors in a simulation program called LS DYNA. The output of the analysis consists of the stresses, strains, and energy values over the course of a fall.

Several experiments were run for the two thermoplastics that make up the outer shell, Valox 357U, and the cap, Valox 430. The goal of the experiments was to discover material data at the cooled temperature, there was no literature containing the material properties at the cooled temperature. The team ran a tensile test at Hubbell's facility for three control specimens and six at the cooled temperature. The results produced consisted of the respective stress strain curves (material input for LS DYNA), and were able to confirm the value for Young's Modulus of Elasticity. The team also performed a Charpy impact test ran with the same number of control and cooled specimen. The value obtained was used to discover how much energy the materials could absorb prior to fracture. This energy can be compared to the output of the simulation, to determine if there are any areas along the connector where it exceeds the fracture energy. If this occurs, then the redesign of the connector should be considered.

TEAM 27



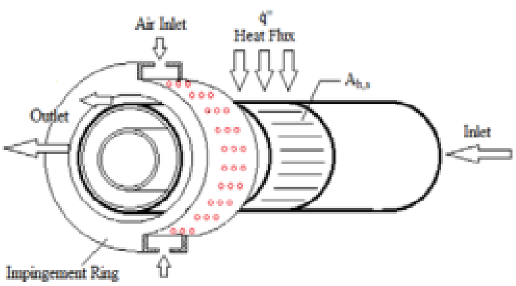
MECHANICAL ENGINEERING

TEAM: ME 27
SPONSOR: Roger Paolillo
ADVISOR: Dr. Bryan Weber

Patrick Begley, Benjamin Poettgen, Connor Leahy, Dr. Bryan Weber

Use of Impingement Cooling to Control Gas Turbine Clearances

Infotech Aerospace Services (IAS) is a joint venture of Pratt and Whitney located in Isabela, Puerto Rico. IAS designs, supports, and evaluates the creation of gas turbine engines, airframe systems, and various other aerospace products, including but not limited to software, tool design, structural analysis, and modeling. This is the third year that a UConn senior design team was tasked with working on this project. The first two teams had the responsibility of developing a test rig and analyses to study the thermal response of a heat pipe, while the goal of this year's team was to design and fabricate a test rig to determine the heat transfer coefficients of various impingement cooling ring geometries.



The main focus of this year's team was to implement the impingement cooling system and create a Computational Fluid Dynamics (CFD) model that would help the team understand the relationship between the heat transfer coefficient and the major parameters that must be considered in the impingement ring design process. These variables include the cooling jet velocity, cooling jet temperature, striking distance, impingement hole size, impingement hole spacing and number of impingement holes. By studying the effects of these geometric and flow conditions, the team was able to determine correlations between these parameters and the impingement heat transfer coefficient
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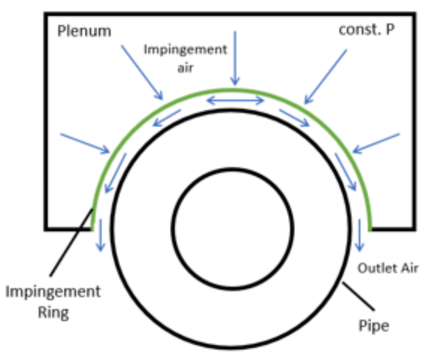
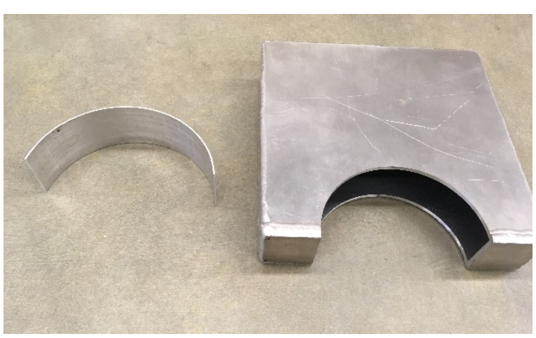
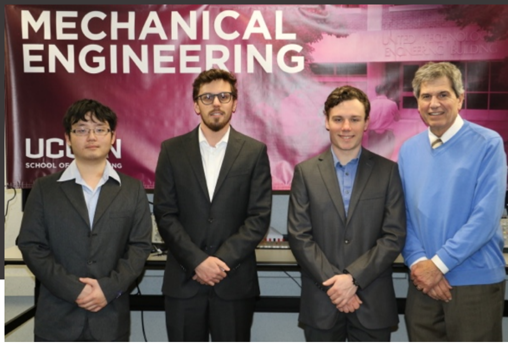


This process included the replication of prior test data for baseline consistency, the design, manufacturing, and refinement of an impingement ring and pressurized plenum, experimental data gathering and analysis, and the use of the acquired experimental results to validate the ANSYS FLUENT numerical CFD model. The final CFD models will be used to reduce the iterative design process that currently exists for impingement cooling systems within the aerospace industry.





Hyesung Lee, Christian Diaz, Skyler LaKose
Dr. Vito Moreno

MECHANICAL ENGINEERING

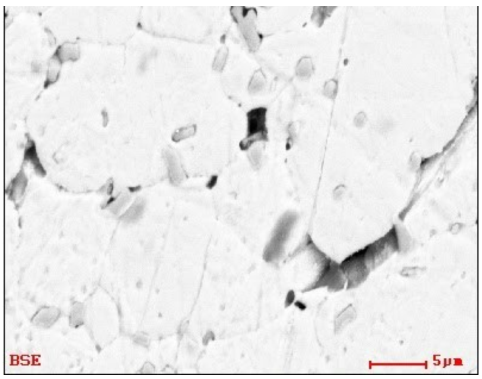
TEAM: ME 28
SPONSOR: Matei Alexandru
ADVISOR: Dr. Vito Moreno

TEAM 28

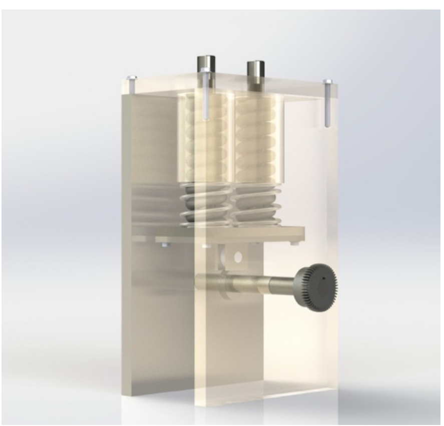
Diesel Engine Break Rocker Arm Pin Redesign

Jacobs Vehicle Systems®

Jacobs Vehicle Systems is an industry leader in engine retarding systems and valve actuation mechanisms. Their most popular product is the compression release engine break known as the Jake Brake. The Jake Brake enables heavy duty diesel truck drivers to maintain speed control and reduce the amount of wear on the foundation brakes. The braking system turns the power-producing diesel engine into an energy-absorbing air compressor. This causes high levels of cylinder pressure and thus correspondingly high loads on the valve train.



This project looked closely into the performance of the pin and roller of the brake rocker. The previous design was a force lubricated hydrodynamic bearing using a bronze pin and steel roller. JVS customers were unhappy with the performance of the previous bronze pin, so the project objective was to step away from cost and performance of bronze and find a new pin material. With the help of Material Science Engineering students, analysis of pin and roller materials, surface finishes, roughness and hardness values provided insight on competitors systems.

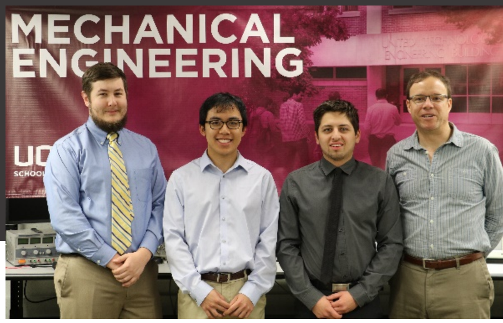


A simulation of the pin and roller was modeled in GT suite software. The model tested several different conditions including oil supply conditions, pin and roller clearances and material properties. Simulations revealed the effects of the boundary conditions on the oil film thickness and bearing pressure.

A test rig was designed and built to perform accelerated wear testing on several pin designs. The rig simulates actual engine conditions such as cam oscillation, oil supply and reaching maximum engine braking loads up to 10 kN. Different lubrication methods were tested including forced lubrication and splash lubrication to see which were sufficiently effective.

The end result of the project delivered the following to the sponsor: a conclusive overview of the tribology characteristics of the pin and roller surface interface, a functioning GT suite simulation model of the pin/roller system, a working benchtop test rig, and a pin material and design recommendation for JVS to optimize service life and production cost.

TEAM 29



James Mando, Henry Nguyen,
Sebastian Donoso, and Dr. Julian Norato.

MECHANICAL ENGINEERING

TEAM: ME 29
SPONSOR: Luke Ionno
ADVISOR: Dr. Julian Norato

Composite Flexure Beam Design for K1200 KMAX Helicopter

KAMAN
Aerospace

Kaman Aerospace is the only current producer of intermeshing-rotor helicopters, or “synchropters”. Their K-1200 “K-MAX” synchropter has seen use across the globe as a dedicated medium-lift external transport platform, and was produced from 1991-2003, with a second production run beginning in 2015. With the renewed demand for the K-MAX comes a desire to upgrade the decades-old rotor root design, which has relied on a spruce root flexure wrapped in composite. Because rotor pitch is effected by means of a trailing-edge flap on the outboard third of the rotor, the root of the rotor must sufficiently comply with this limited torsion, and also withstand the repeated changes in torsion due to the cyclic control.

In addition, because of the intermeshing rotor configuration, the root must remain stiff in both the lead-lag and flapping bending axes, to prevent potentially catastrophic contact between rotors. Finally, the rotor must withstand the high axial stresses due to centrifugal forces, and therefore the root must be axially stiff as well. Although a conventional metal pitch collar assembly is the more common choice for an upgraded rotor root design, such an assembly would be mechanically complex, heavy, and expensive.

The goal of this project is to develop a new flex-beam design to be used by Kaman Aerospace in their K-1200 “K-MAX” helicopter. The current design is a composite-wrapped spruce beam, and Kaman wishes to implement a replacement constructed of unidirectional long-fiber S-glass in epoxy, with ±45º S-glass wraps. Neither end-fixture nor aerodynamic considerations were within project scope.

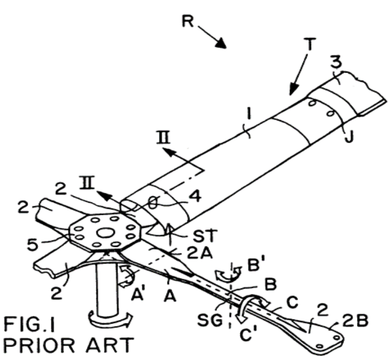
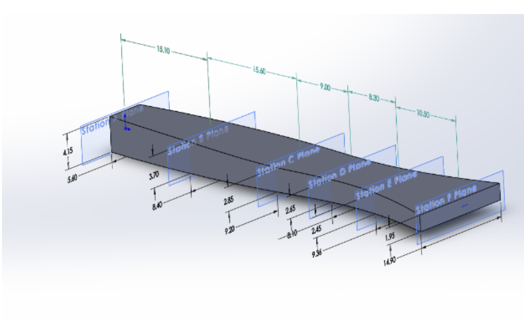
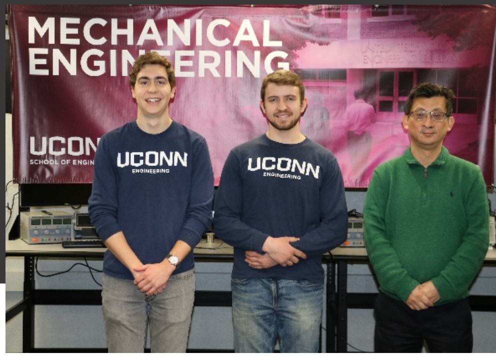


FIG.I
PRIOR ART

Our team, given flatwise and chordwise bending stiffness criteria for multiple stations along the flexure, designed unique cross-sectional designs for each station, modeled using non-linear moment of inertia systems and simulated as constant cross-sectional cantilever beams. Once designs were finalized for each station, they were blended into a final whole flexure design.



Simple geometries were found for each station individually, but the combined flexures did not exhibit acceptable torsional compliance, so further iterations with more complex geometries were required to surmount this obstacle. In addition, small-scale testing was conducted to validate the approach and verify the simulated material properties.



Nathan Baker, Ronnie Fierro, Prof. Jiong Tang

MECHANICAL ENGINEERING

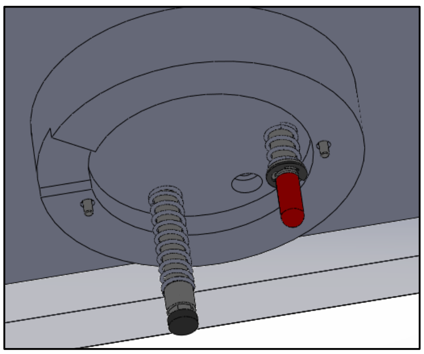
TEAM: ME 30
SPONSOR: Scott Carlson
ADVISOR: Prof. Jiong Tang

TEAM 30

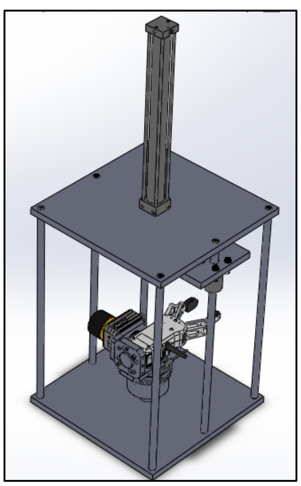
Automated Leak Test

KAMAN
Fuzing & Precision Products

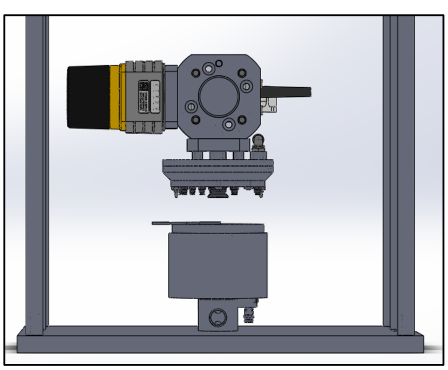
Kaman Fuzing & Precision Products (KPP) is a leading manufacturer of safe and arm devices for the military. One of their products, the Joint Programmable Fuze (JPF), is experiencing increasing demand, and KPP wishes to automate some of the manufacturing processes to keep up. The control panel of the JPF undergoes a laser welding operation, followed by a helium leak inspection to ensure impermeability of the welds. KPP wishes to begin by automating the leak inspection.



The automated leak inspection utilizes a UR5 robot manufactured by Universal Robots to load the JPF control panel to and from the automated test fixture. The automated test cell features two fixture halves that clamp the control panel within. The bottom half utilizes an O-ring to seal the outer perimeter of the control panel. This bottom half is where the vacuum chamber will be generated. Similarly, the top half incorporates two spring loaded rubber seals to seal off two holes that go through the entirety of the control panel. This top half is where the helium is sprayed once in place. The bottom fixture is in a fixed location while a pneumatic cylinder presses the top fixture over control panel when in the correct location—compressing the O-ring and spring loaded seals. The helium leak test software and measuring device used with the previous test system are used on the automated system.



A programmable logic controller (PLC) is used to communicate between the UR5, automated test fixture, helium leak tester, and various sensors & actuators. The PLC communicates with the helium leak tester by utilizing RS-232 serial communication in which this both sends and receives specific controls and data to and from the tester. The PLC communicates to the UR5 utilizing a Modbus protocol and initiates the UR5 to its own specific operations once certain sensor conditions are met. Many of the sensors used are based on proximity sensors, photoelectric sensors, and pressure switches. Some of the sensors selected are incorporated to ensure both part safety and proper operations. Similarly, a light curtain and safety guards are incorporated to ensure human safety. The UR5 has built in safety functions and limits; however, the light curtain is programmed to ensure human safety of the automated test fixture only when the fixture is moving.



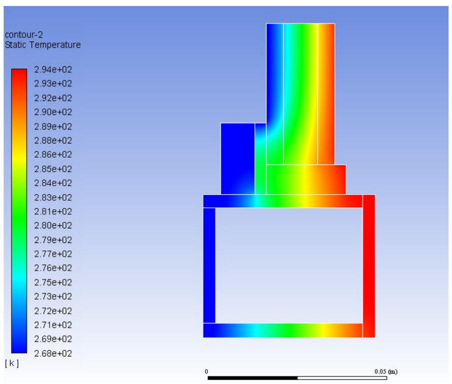
Michael Mezzio, Michael DiMaria, Matthew Labrecque, Dr. Ugur Pasaogullari

MECHANICAL ENGINEERING

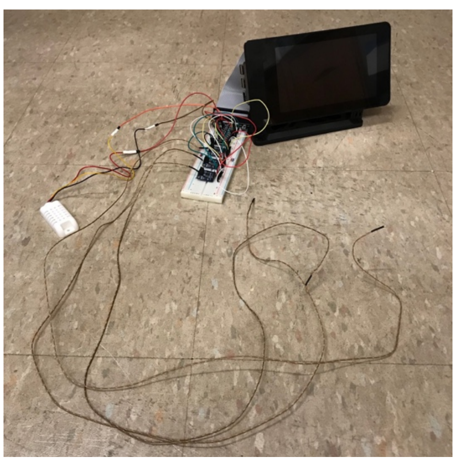
TEAM: ME 31
SPONSOR: Private
ADVISOR: Dr. Ugur Pasaogullari

Thermal Window Device

A house of Greenwich, Connecticut has windows that suffer from severe condensation during the winter. The condensation on the windows are causing deformations in the surrounding paint and wood, and even causing rust. The owner is seeking an aesthetically pleasing modification to the existing windows that would eliminate or reduce the condensation/ ice without replacing the windows. Testing and analysis is required to pinpoint the exact cause of the formation of condensation. Initial research leads the team to believe either the steel frame or the actual glass panes are the source of the condensation. Either one or a combination of both are dropping below the dew point temperature inside his house, which results in the formation of condensation on the surface of the window. The objective of this project to analyze, design and fabricate a modification to the existing windows that will reduce or eliminate the condensation.



An experiment using two raspberry pi devices programed to record temperatures of the steel frame and glass pane. At the same time a temperature and humidity sensor will record the ambient conditions next to the window. This will help determine which part of the window is critically dropping below the dew point temperature inside the house. A spare window the sponsor has is being used to take apart and study the cross section of the steel frame. The test rig being used to test the heat tape is comprised of a 1.1 cubic foot freezer with a 12x12 inch steel window frame with a glass pane inserted in the door of the freezer. This allows for a constant and controlled temperature on the window to mimic winter conditions. The heat tape is applied to the edge where the steel frame and glass meets to properly heat both and hopefully decrease and eliminate condensation.



Dustin Kaiser, Philip Anderson, Ben Strenkowski, Dr. Ryan Cooper

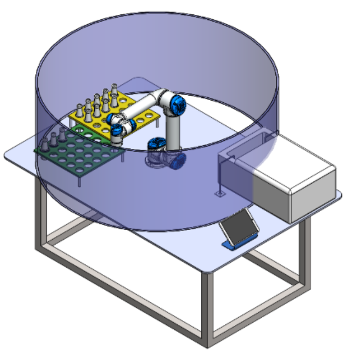
MECHANICAL ENGINEERING

TEAM: ME 32
SPONSOR: Matt Peterson
ADVISOR: Dr. Ryan Cooper

TEAM 32

Paramount Machine Automated Assembly Process

PARAMOUNT MACHINE COMPANY INC.

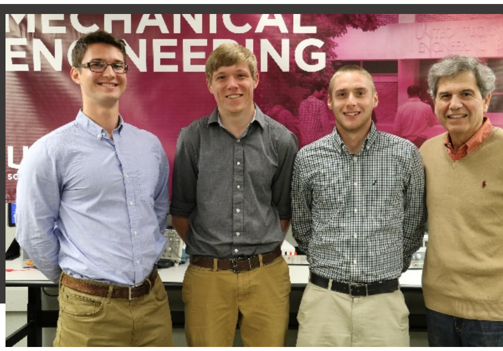


Paramount Machine Company, located in Manchester CT, is a 35-year- old company that specializes in precision machining and assemblies for the aerospace industry. A large portion of their customer base includes United Technologies Aerospace Systems (UTAS), and their various affiliated companies. Paramount currently manufactures a family of deaerators for aircraft engines. These deaerators consist of two main parts, an aluminum shaft and a steel gear, which are required to be assembled by heating the gear to room temperature and cooling the shaft in liquid nitrogen. This process produces the appropriate diameter change in both the shaft and the gear, which allows them to be fitted together without any damage occurring.

The current process is done manually, which allowed for improvement in areas such as efficiency, error reduction, technological advances, and costs. Initial experimental results allowed the team to create an accurate time constraint in which the entire process must be completed. With this time constraint, the team incorporated ideas put forth by Paramount into an automated cell which would not only reduce the human interaction of the assembly process to almost zero but also push Paramount into taking the necessary steps to further their development into the new technological age of manufacturing. The automated cell is able to complete up to 25 shaft-gear assemblies without the need for user interference. Each shaft will be cooled in the liquid nitrogen bath and pulled out automatically when needed and coupled with the gear. This coupled assembly will then be placed to dry and be collected by an employee when ready.

The design of the cell was built to efficiently use the least amount of space, yet allow for optimal shaft-gear assemblies to be produced. Paramount will be able to effectively optimize the production of future deaerators using the design that the team has developed.

TEAM 33



MECHANICAL ENGINEERING

TEAM: ME 33
SPONSOR: Pratt & Whitney
ADVISOR: Dr. Vito Moreno

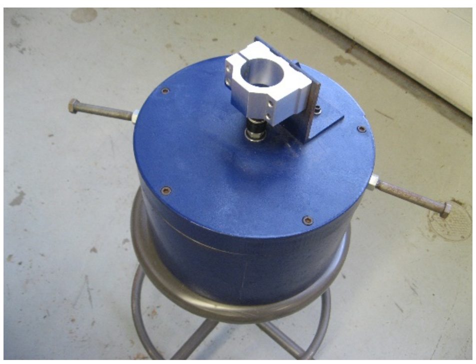
Luke Maloney, Evan Douglass, Matteo Diamond, Dr. Vito Moreno

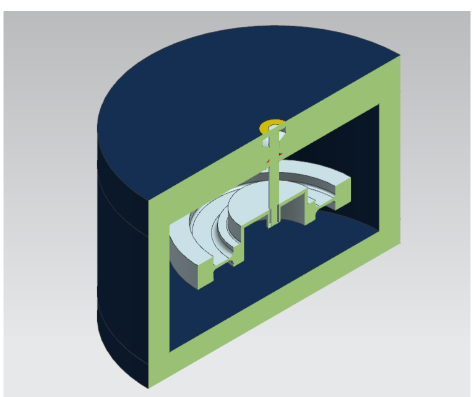
Pratt & Whitney
A United Technologies Company

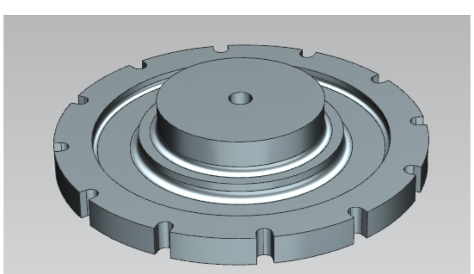
Low Cycle Fatigue Biaxial Stress Field Test Rig

As an OEM of large gas turbine engines, Pratt & Whitney produces world class low cycle fatigue (LCF) characterization of rotor grade materials. Understanding fatigue allows the company to accurately set the service limits for their product. Uniaxial specimen testing is efficient for many reasons (ie size, cost, etc.), however biaxial testing is much more representative of the product of manufacture and engine operating conditions. Biaxial testing is expensive and typically involves full size components. For this reason, we designed a smaller and more cost effective biaxial test rig.

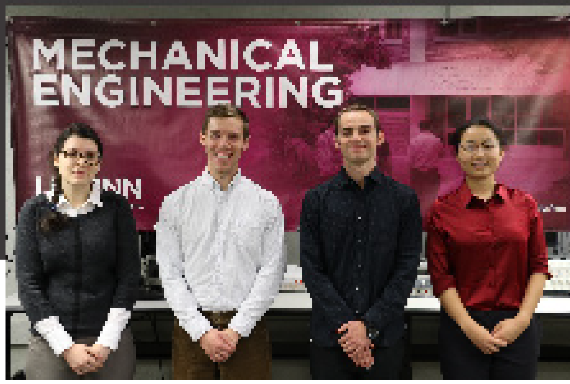
In order to create a benchtop sized LCF biaxial test rig, the team had to design a disk test specimen with a 1:1 radial to hoop stress ratio and a rig that can safely cycle said specimen between 5% and 110% of its yield stress. Challenges included creating a specimen geometry that satisfies our objective without having competing limiting locations. Due to the high yield strength of Titanium 6Al-4V and INCONEL 718, the design required a custom designed high speed motor/drive and gearbox system and still be able to fit on a workbench. Considerations for containment and rotor dynamics were crucial in the rig design to ensure safe operation through transverse and torsional vibrational modes as the rig cycles. The design had to be extremely durable as the rig must operate nonstop for up to 100,000 cycles.





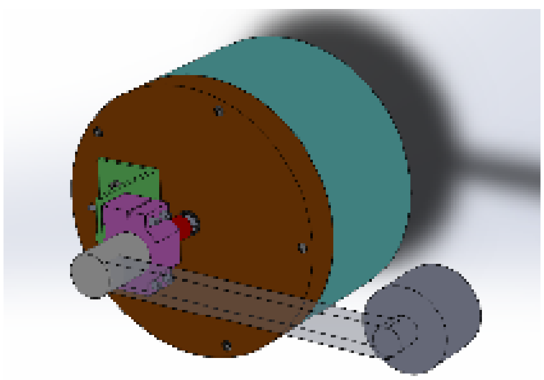


To meet our objectives, we utilized NX 3d Software, ANSYS, and MATLAB to design a safe spin rig. Specimen geometries, mounting designs, and motor considerations were developed in tandem as the availability and feasibility narrowed our options. We created a demonstration rig with an aluminum disk for proof of concept due to motor availability. One advantage to utilizing an aluminum specimen in our demonstration is that, in contrast to the designed rig, a thick concrete barrier is not necessary for operation. Using the team's recommendations, our sponsor will be able to create a spin rig capable of testing Titanium 6Al-4V / INCONEL 718.



Maria Rozman, Samuel Manzolillo, Hubert Sis,
Dr. Xinyu Zhao

Pratt & Whitney
A United Technologies Company



MECHANICAL ENGINEERING

TEAM: ME 34
SPONSOR: Pratt & Whitney
ADVISOR: Dr. Xinyu Zhao

TEAM 34

Rotating Disk Heat Transfer Coefficients

The objective of this project is to design and fabricate a rotating disk test rig which can be supplied with heat and used to measure the variations in heat transfer coefficients across the disk's surface. The purpose of these experiments is to generate data on how heat film coefficients change over time with varying rpm and distance to the static wall. Pratt & Whitney's current data is outdated, and testing on current spin rigs is expensive and time consuming. Currently, the spin rig at Pratt & Whitney's East Hartford location requires a ladder in order to view important parts such as the spindle. The supporting systems for the rig take up much of the room in which it's installed. Testing on a smaller, table-top rig would be advantageous in terms of space, cost, and ease of access. Data on heat transfer film coefficients is important information, as the failure of a turbine disk can put the aircraft as well as the passengers on board at serious risk.

The experimental design is based on a disk rotated at speeds up to 8400 rpm by a 220 W motor connected by a belt and pulley with a 2:1 ratio to the quill, consisting of a shaft and sealed ball bearings hub. The disk itself is composed of two pieces: a cast acrylic component of 0.25 inch thickness and a high emissivity coating, which is fit tightly into an aluminum retaining disk. The rotating components are contained in a steel housing to prevent injury in case of catastrophic rupture of the disk. Air is supplied into the housing cavity at such a speed that creates a turbulent boundary layer on the surface of the disk. The rotational Reynold's Number is determined using the rotational speed, which is varied for the purposes of the study. Compressed laboratory air is controlled using a rotameter with a rated mass flow rate of 2-20 liters per minute and is then heated using a heat coil before being input to the disk cavity. The temperature of the air is measured using a thermocouple at the exit point of the air input. The local surface heat transfer is determined by measuring the temperature gradient on the surface of the disk using a T650sc infra-red camera. The heat transfer coefficient is determined by estimating the temperature gradient on the surface of the disk using a classical one-dimensional response of a semi-infinite medium to the sudden step application of a convecting fluid.

The other component of the project is a simulation using the Ansys Fluent software. Heat transfer coefficients will be obtained from the analysis and measurements from the experimental rig will be used to validate the simulation. The simulation can then be stepped up to higher rotational Reynold's numbers that are consistent with real turbine engine conditions.

Edward Ostrowski, Kinga Wrobel, Dr. Ryan Cooper

MECHANICAL ENGINEERING

TEAM: ME 35
SPONSOR: Pratt & Whitney
ADVISOR: Dr. Ryan Cooper

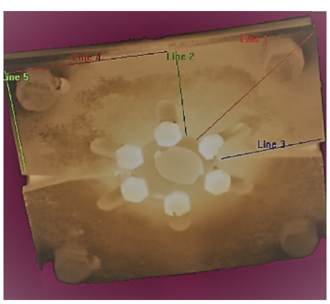
Pratt & Whitney
A United Technologies Company

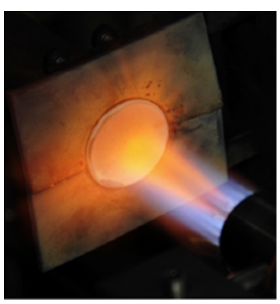
Thermal Gradient Rig Sample Holder Redesign

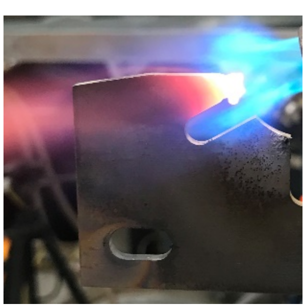
Pratt & Whitney, a United Technologies Corporation company, is a world leader in design and manufacturing of civilian and military aircraft engines. The Pratt & Whitney Thermal Gradient Rig (TGR) tests thermal barrier coatings used on aero-engines. The TGR provides an engine like environment in the lab setting to test the degradation of thermal barrier coatings, which is accelerated in the presence of molten siliceous debris and thermal gradients. While these test rigs have produced critical data used in the evaluation of high temperature coatings, the current sample holder design suffers from high cost consumable alumina bolts, severe thermal gradients induced at the bolt heads leading to edge-induced failure, and limitations on the durability of the holder due to the severe environment generated by the flame.

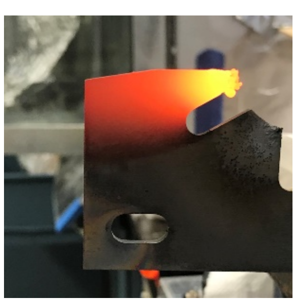
After analysis of failed sample holders, the team focused on simulating and predicting fatigue, internal stress concentrations, and deformation in current and future sample holder designs. Thermal profiles were analyzed with infrared imaging cameras and software to identify thermal gradients and hot spots within the sample holder. ANSYS was used to simulate and optimize a new geometry which reduced internal stress concentrations, while the new sample holder attachment method eliminated the need for costly alumina bolts. The team constructed a Mini-Rig with 80-20 steel beams and a Mapp torch to create a baseline for their simulation boundary conditions and validate their ANSYS simulations.

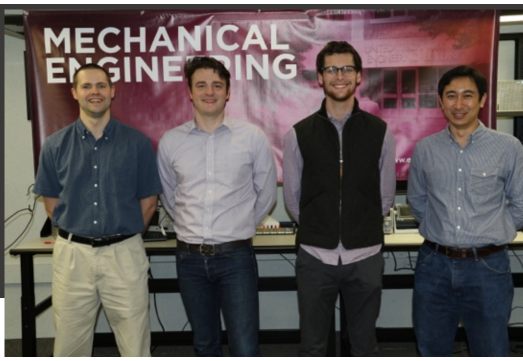
Once an optimal geometry was developed, a prototype was created with stainless steel, simulated in ANSYS, and simulation results were validated in the Mini-Rig. The team then went forward with creating a final prototype with a nickel-based superalloy with high oxidation resistance. The prototype was tested under cyclic thermal loading in the TGR to predict sample holder lifetime and degradation. A piece of the holder was analyzed in a Scanning Electron Microscope (SEM) to identify and predict oxidation amounts that would lead to failure.











MECHANICAL ENGINEERING

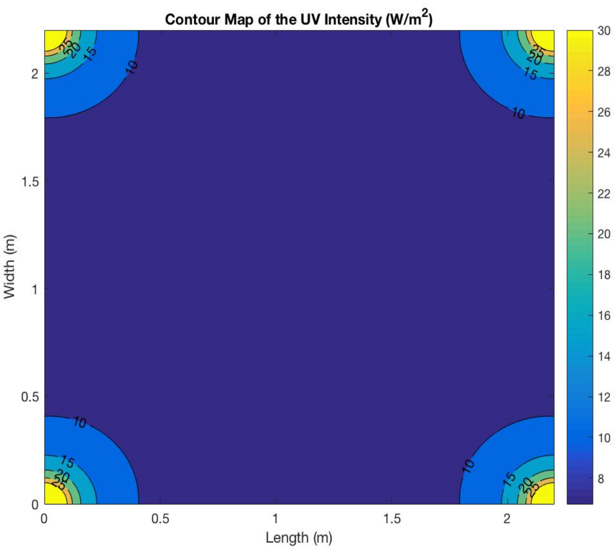
TEAM: ME 36
SPONSOR: Pratt & Whitney
ADVISOR: Prof. Jason Lee

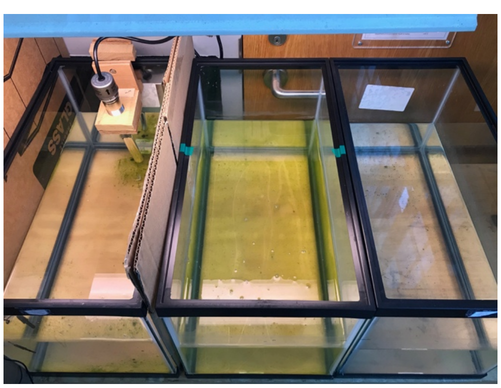
TEAM 36

Phillip Paulson, Thomas Underwood, Alexander Mair, and Prof. Jason Lee

Sonic Inspection Tank Algae Elimination

Pratt & Whitney
A United Technologies Company





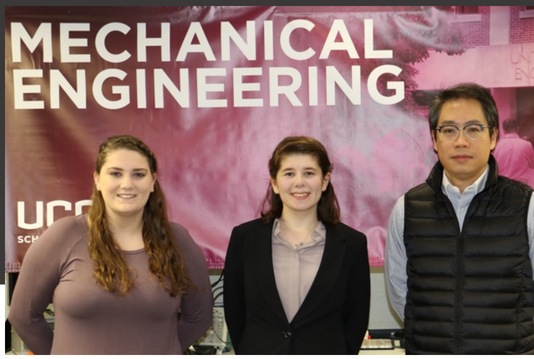
Algae Growth Experiment – 1st Tank: UVC light present in water with live algae culture. 2nd Tank: Control water

The Pratt & Whitney forging facility located in Columbus, GA is experiencing excessive downtime of their sonic inspection tanks due to water contamination resulting from algae growth. This facility is responsible for forging the raw materials for a number of parts. After the forging, the parts are inspected via ultrasonic inspection for defects that are not detectable via visual inspections. As a part of this process, the forgings are submerged in a 1500-gallon water tank with a transducer that scans over the part, transmitting ultrasonic waves. Both the parts and the sonic system are sensitive to the water chemistry so cleanliness and a stable chemistry is important. Algae that continually re-grows in the tanks creates a problem. As these algae builds up in the tank, it can become detached from the walls of the tank and float in front of the sonic transducer, giving erroneous readings.

The biggest culprit for floating algae/bacteria particles in the water stems from the pump being turned off. In order to minimize the down time of the pump, an automatic fill valve from the supply line to the tank will be installed. However, even with this solution the pump must be stopped at certain times. This can cause particles, bacterial biofilm, algae cells, dirt, and grime to be allowed back into the water due to a phenomenon similar to a hydraulic ram, forcing the particles back into the tank. To combat this a check valve will be installed between the filter influent and the tank to prevent ‘backwash’ from getting into the tank.

The filter being used also contributes to the water clarity issues. Although the filter, a 20-micron pleated fabric cartridge filter, filters out large debris, green algae (chlorella vulgaris) has a diameter between 3-10 microns and thus is largely unaffected by a 20-micron filter. A diatomaceous earth filter will work best at filtering out green algae from the water, capturing particles as small as 2-5 microns. This will be extremely helpful at maintaining clear water. Finally, in order to maximize the elimination and suppression of any biological growth, a model using submerged ultraviolet lights in the range of 254 nm (UVC) was created. All aspects of this system design do not intrude in any way on the operation of the ultrasonic test inspection equipment and will be fully automated.

TEAM 37



Kori Salvietti, Carolynn Pahner, Dr. Tai-Hsi Fan

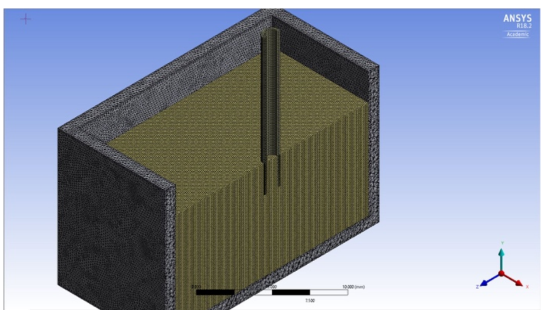
Pratt & Whitney
A United Technologies Company

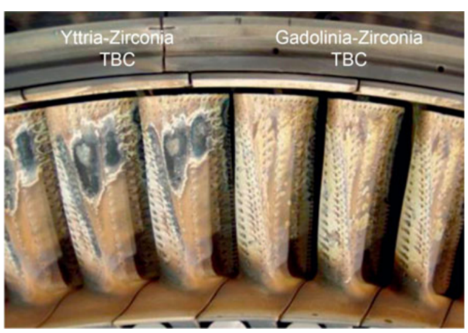
MECHANICAL ENGINEERING

TEAM: ME 37
SPONSOR: Pratt & Whitney
ADVISOR: Dr. Tai-Hsi Fan

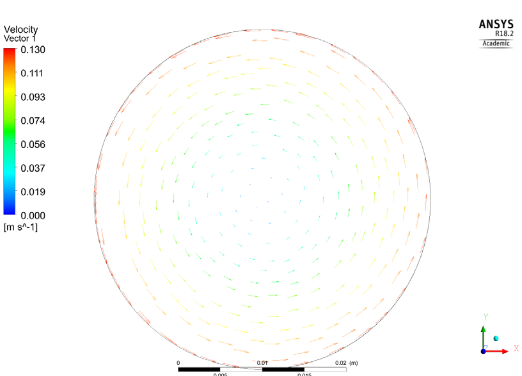
CMAS (Calcium Magnesium Aluminosilicate) Infiltration

Commercial jet engines ingest debris including sand particles, while in operation. Post operation examination of the jet engines has shown the thermal barrier coatings (TBCs) are spalling off the metallic components. Ceramic coatings can provide thermal insulation to the metallic turbine components from the high temperatures in the gas-turbine engine, as well as a protective barrier against corrosion and wear. When the temperature of the airfoil exceeds the melting point of the ingested debris, the sand will change phase from a solid to a liquid (now called "CMAS" for calcium magnesium aluminosilicate). Capillary forces cause this liquid to infiltrate the pores of the coating. As the engine cools, the infiltrated CMAS freezes within the TBC thereby reducing its strain tolerance and contributing to the early spallation of the coating. Reducing the depth of infiltration will reduce the extent of the damage induced within the TBC. The goal of this study is to simulate the infiltration process of CMAS into an electron beam-physical vapor deposition (EB-PVD) TBC for various temperatures and viscosities. This will yield an understanding of how different compositions of CMAS and different temperatures cause the infiltration depth of CMAS to vary. In order to reach the goal of simulating the infiltration process, a simulation of a viscometer will provide the viscosities of various CMAS compositions at different temperatures. The goal is to provide the infiltration depths and the simulation software to help Pratt & Whitney understand the infiltration process and damage progression of CMAS on their hot section components.





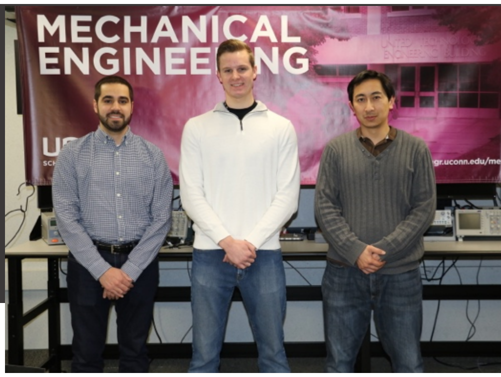
Six compositions of CMAS were synthesized. Samples were heated in a tube furnace to temperatures between 1100°C and 1200°C (most compositions of CMAS have a melting point in this range), and their experimental viscosities were measured from approximately 0.50 log(Pa*s) to 10 log(Pa*s) using a viscometer. The viscosity data and other physical properties of the synthetic CMAS were then implemented in computational fluid dynamics simulations, using the software ANSYS, in order to produce models of the infiltration process based on the known structure and properties of an EB-PVD ceramic thermal barrier coating. The simulation was designed to be a periodic boundary condition showing the CMAS infiltrating the pores of the ceramic coating over time. Other important considerations in the design of the model included the effects of capillary action. The aim was to realistically model infiltration within 5% error in terms of viscosity and penetration depth.



MECHANICAL ENGINEERING

TEAM: ME 38
SPONSOR: Pratt & Whitney
ADVISOR: Dr. Jason Lee

TEAM 38



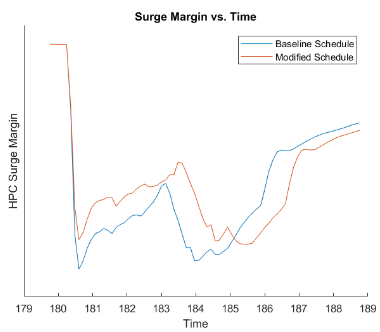
William Adams, Stephen Matyas, Dr. Jason Lee

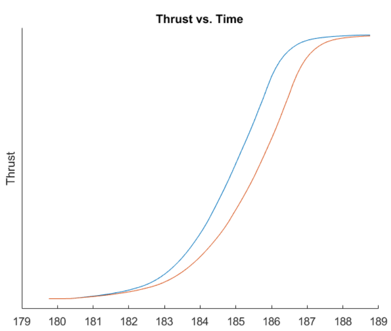
Pratt & Whitney
A United Technologies Company

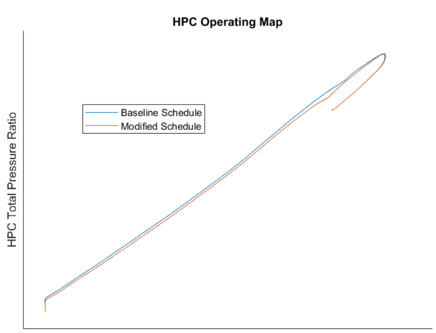
Optimization of Gas Turbine Engine Transient Response

In the design of gas turbine aircraft engines, it is common practice to use optimization tools and algorithms to achieve the best possible steady-state engine performance. There are well defined processes for optimizing steady-state operation, but there are not widely publicized approaches for optimizing engine performance during transient operation. The goal of this project was to define an approach for optimizing transient engine performance, and to demonstrate the feasibility of this approach for developing transient operating schedules using a gas turbine simulation.

During the transient operation of a gas turbine engine, the Full Authority Digital Engine Control (FADEC) is responsible for controlling various engine effectors (fuel flow, stator vane position, bleed flow actuation, etc.) so that the engine accelerates and decelerates as desired. The FADEC controls these engine effectors using transient schedules that are typically developed using engine simulation tools such as Numerical Propulsion System Simulation (NPSS). This project focuses on varying these engine effector schedules to maximize the stall margin in the high pressure compressor during accelerations. The optimized engine effector schedules would maintain engine stability while also producing the target thrust within the time limit prescribed by the Federal Aviation Administration. Increasing the stall margin during accelerations can reduce the amount of engine maintenance required.







An NPSS based gas turbine simulation was used to generate the engine effector schedules and calculate the resultant available stall margin. Initially, fuel flow rate was the only engine effector considered. To generate modified schedules, each node in the fuel flow schedule was perturbed by a small percentage. The resultant stall margin was then used with an optimization code to fine tune the schedule. This process was repeated, with the percentage of the modifications changed as required after each iteration, until an optimal schedule was reached. Any schedule produced by the optimizer that didn't meet the requirements was discarded. After fuel flow, other effectors such as stator vane angle and bleed actuation, were evaluated. The same process was used to refine these schedules to further optimize the transient response.

TEAM 39

Dylan Bravo, Chitra Nidadavolu, Nathan Seibert, Dr. David Giblin

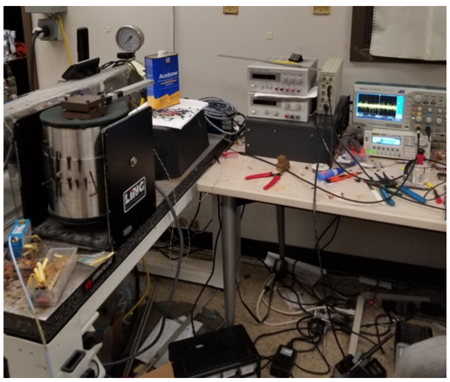
MECHANICAL ENGINEERING

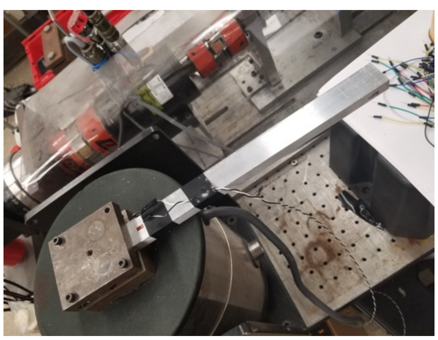
TEAM: ME 39

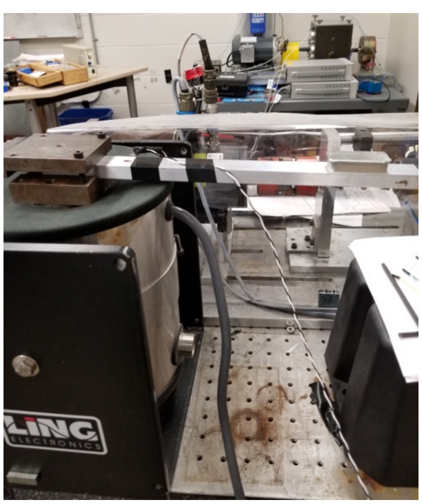
SPONSOR: Dave Hunter

ADVISOR: Dr. David Giblin

Sikorsky In-Blade Damper



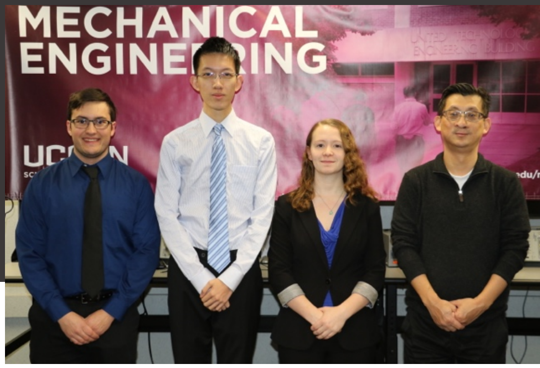




In a world of constant innovation Sikorsky's S-97 Raider helicopter stands out as a leader in aviation technology. Aiming to be the fastest, most maneuverable rotorcraft in history, this aircraft has been equipped with twin, coaxial sets of rotor blades that rotate in opposite directions. As a result, the conventional design of external dampers placed at the base of the helicopter's blades cannot be used in the design of the S-97 Raider. Therefore, Sikorsky patented the idea of utilizing an in-blade damper to lessen the vibration of the helicopter blades. Sikorsky presented group ME39 with the problem of developing and testing an effective in-blade damper design. This project aimed to proof of concept the patent and determine the feasibility of further research into an in-blade damper. The goal of this study is not solely for implementation in the S-97 Raider helicopter, but for use in further designs lacking external dampers.

Following extensive research of effective damping mechanisms, group ME39 was capable of designing functional prototype dampers. The damping models were implemented in a small scale beam and their effectiveness measured. This was done through the use of a shaker table in one of the labs on campus, where the beams were shaken at frequencies that are representative of the vibrations felt during flight. The dampers demonstrated the ability to lower the damped natural frequency of the beam and therefore would act to expand the operational range of the blades. Throughout testing, several unique designs of dampers were examined and modified over a variety of parameters. The overall maximum damping for each model was determined and compared amongst the designs. Once an ideal design was determined, the best prototype was optimized and theoretically scaled to a full size model. The cost, containment, and maximum effective damping of the model was returned to Sikorsky for further analysis.

Ultimately the purpose of this project determined the feasibility of future investment by Sikorsky in an in-blade damper. The work developed through this project has the potential to be implemented on both current and future helicopter designs to expand their operational ranges and lifetimes.



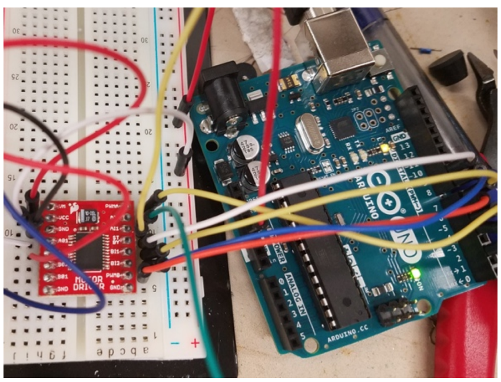
Ryan Hyatt, Zhe Zhou, Jennifer Bennett, Dr. Jiong Tang

MECHANICAL ENGINEERING

TEAM: ME 40
SPONSOR: Bill Welsh
ADVISOR: Dr. Jiong Tang

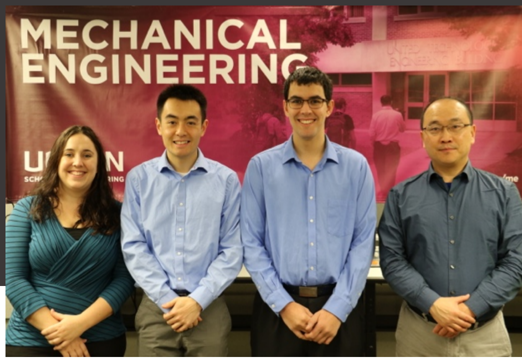
Wireless Automatic Shaft Balancer

Sikorsky Aircraft is a manufacturer of commercial and military rotary aircraft recently acquired by major defense contractor Lockheed Martin. The tail rotor drive shaft of a helicopter plays an important role during the power transmission from the main engine to the tail rotor. In the installation process of the shaft, some unbalance is created. Sikorsky currently balances shaft segments manually by adjusting the position of weights placed on the surface of the shaft. This is a tedious process causing a waste of time and money. The goal of this project is create a wireless shaft balancer which can move the eccentric mass to the desired position during operation of the aircraft. Each adjustment should be complete in less than 20 seconds, the device structure must survive centrifugal forces and 20g vibration at 100 Hz, and it must fit within a 5.5 inch diameter envelope without marking or affecting the shaft.



After identifying requirements, the team provided conceptual designs of this device. Research showed that no similar device was created for a similar form factor. The team then selected by analyzing risks associated with each design and conducting a trade study. The central design involves using 2 motors fixed to the shaft via clamping collars to move concentric geared rings with eccentric mass. The relative angular positioning of the masses can therefore be adjusted to control phase and magnitude of balancing. Servo motors were researched and selected in a small form factor and inline gearbox to allow passive locking of the device and high precision of motion control. The design is 3D printed initially to test basic functionality. In order to make sure the device can work as expected, a risk reduction test will be done before the prototype been manufactured. The device will be clamped on a hollow pipe of the same diameter as the actual helicopter shaft. The shaft will be driven by a speed-controlled motor. Initially, the device is tested operating under the 2000 RPM in order to guarantee the device can work at low RPM. This step is used to verify the eccentric mass can move to the desired position as expected. Once this project is finished, we will increase RPM up to the nominal 4000 RPM of the aircraft.

TEAM 42



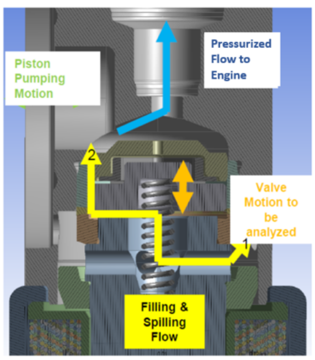
Marissa Gaylord, Brandon Loo, Patrick Dolan, Dr. Tianfeng Lu

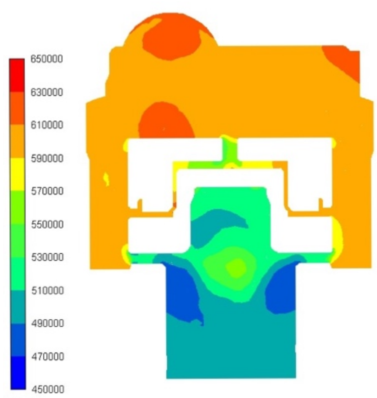
MECHANICAL ENGINEERING

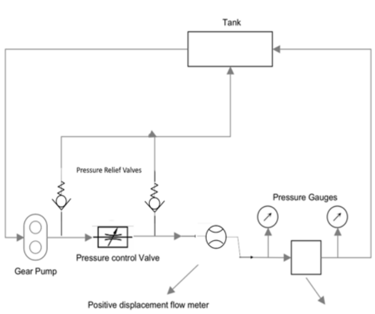
TEAM: ME 42
SPONSOR: Richard Pellini
ADVISOR: Dr. Tianfeng Lu

Control Valve Snap Shut Investigation.

Stanadyne





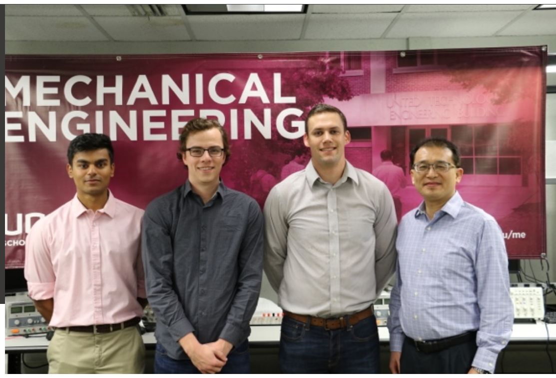


Stanadyne is a global technology leader in fuel systems with corporate headquarters in Windsor, CT, and a global presence of manufacturing and development centers. Stanadyne engineers and produces fuel pumps for gasoline and diesel engines used in a variety of applications including commercial automobiles, motorsports, farm equipment and heavy construction equipment.

Our team was tasked to model and diagnose a snap-shut condition occurring in a control valve for a gasoline high-pressure pump. The pump's objective is to keep the engine's fuel rails sufficiently pressurized. A control valve meters the direction of the fuel flow. During the pumping cycle, the control valve is kept open "spilling" the inlet flow back to the low-pressure supply; when a required fuel volume is to be pumped out, the control valve closes and high-pressure fuel is then supplied to the rail. Stanadyne determined that at certain operating conditions the control valve closes during the spill cycle without command, and fuel will unintentionally be delivered to the rail, known as snap-shut.

Our team was able to model the control valve using ANSYS Fluent as shown in the figures. With this model, we were able to attribute the snap-shut phenomenon to the Bernoulli principle. Bernoulli's principle states that an increase in the speed of a fluid occurs simultaneously with a decrease in pressure. During the spill cycle, fuel is going through the control valve there is a large increase in speed, creating a localized low-pressure zone that drives the valve shut. The geometric simulation was changed to determine what changes could be made to prevent snap-shut.

A testing rig was built to show the snap-shut. The schematic of the fluid circuit is shown in the figures. Fluid flows through a pressure control valve regulating the fluid flow, then through a flowmeter able to measure the flow rate, the control valve, and the return to tank. Pressure gauges are in place before and after the control valve. Our team tested the control valve in its initial set up and then changed its geometric set up to determine what may be causing snap-shut. Testing results rig were then compared to the ANSYS simulation to verify and validate the simulation results and properly diagnose the issue.



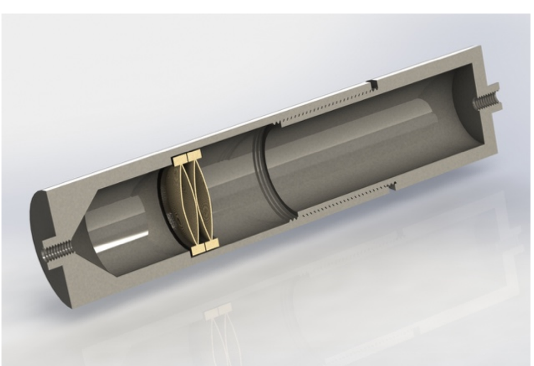
Mohit Patel, Thomas McMorrow, Mitchell Glasgow, Dr. Chih-Jen Sung

MECHANICAL ENGINEERING

TEAM: ME 43
SPONSOR: Michael Curtis
ADVISOR: Dr. Chih-Jen Sung

TEAM 43

Development of a Biogas Desulfurization Filter



Quantum Biopower utilizes anaerobic digestion to convert waste organic material into renewable energy in the form of biogas. One byproduct of this process is hydrogen sulfide ($H2S$); a compound which chronically deteriorates internal combustion engines and is hazardous to the environment. Before utilizing biogas as a source of energy, its hydrogen sulfide content must be diminished. Quantum Biopower currently uses a bacteria culture system to digest the hydrogen sulfide in the gas. The system is costly and requires constant maintenance by personnel to support the health of the bacteria. The Chemistry Department at the University of Connecticut is developing a metal-oxide material that is highly sorptive of $H2S$. The material also has the capability to regenerate; extending the life of the material as it is saturated. The project goal is to develop a desulfurization filter using the cutting edge metal-oxide material. The filter is intended to be a lower cost solution than current options.

The filter was designed using cartridges that housed the metal-oxide material and allowed the gas to make contact with the material as it flows through. The cartridges were easily replaced which allowed for rapid testing of various filter geometries. A test rig was designed to demonstrate the effectiveness of the filter and its regenerative capabilities with unconditioned biogas samples from Quantum Biopower. Experimentation was conducted by varying filter housing temperature and biogas particle residence time, the amount of time the biogas is in contact with the filter media. The pressure of the biogas was held slightly above ambient pressure to simulate conditions of Quantum Biopower's facility. Temperatures ranged from room temperature to 750 F to determine the optimal sorptive performance of the metal-oxide material. Residence time of the biogas was used to demonstrate the scalability of the prototype filter. Upon completion of the project, Quantum Biopower will have another option to consider in the desulfurization of biogas.

TEAM 44

Kevin Roberts, Josiah Butler, Isagani Palacpac, and Professor David Giblin.

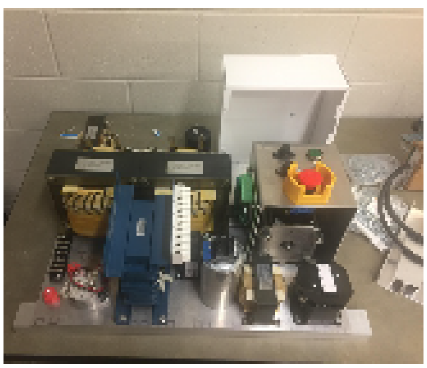
MECHANICAL ENGINEERING

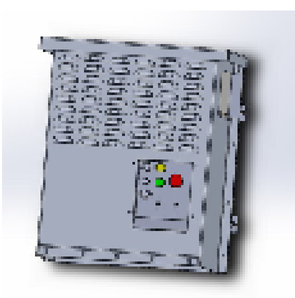
TEAM: ME 44
SPONSOR: Julian Watt
ADVISOR: Prof. David Giblin

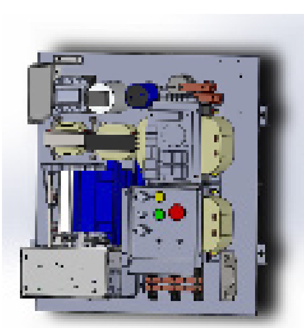
28 VDC Regulating Power Supply (RDC Mini)

Superior Electric is a market leader in the manufacturing of voltage and power control equipment, and also provides more specific offerings for customers with unique project requirements. The objective of this project is to effectively package components required to build a power supply, designated RDC Mini, in order to meet Military Specification Qualification Testing. The RDC Mini is comprised of a 450V input and a regulated 28V DC output and is designed for specific electronics testing as well as general purpose battery charging applications. Using the provided electrical system the team worked to design a unit to safely house the system while optimizing for ease of manufacturing and maintenance. The entire package must pass MIL Specification shock, vibrations, and water drip tests, with additional goals of reducing size, weight, and cost where possible.

Using several older units as a starting point, the team designed both a 3D model in Solidworks and a physical prototype. The 3D model was used in conjunction with simulation software to examine the performance of the design when undergoing the MIL Specification tests, with heavy emphasis on shock load and vibration testing. The physical model acted as a proof-of-concept for determining real-world limitations in the design, with changes being made to account for considerations such as ergonomics, unit mounting, and manufacturability. The design itself underwent multiple iterations to increase performance and respond to changing parameters, such as new size constraints and preferred locations for electrical components. Following satisfactory performance in simulations, a final prototype has been built for testing using the materials and components that will be included in the final product. The prototype has been shipped and is now undergoing testing in a third-party lab. In the meantime, a second unit has been prepared to undergo sea trials once the first unit has passed the requisite tests.







Analise Giobbi, Lucas Dombroski, Thomas Dykstra, Dr. Jason Lee

MECHANICAL ENGINEERING

TEAM: ME 45

SPONSOR: Mark Lillis

ADVISOR: Professor Jason Lee

TEAM 45

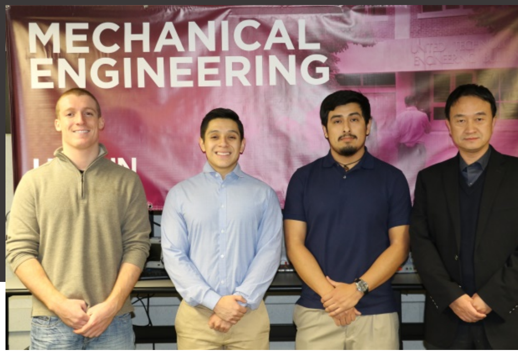
Alternative Measurements for Fuel Control Valve

Triumph Group, Inc.

Triumph Engine Control Systems (TECS) is a group that specializes in manufacturing fuel pumps, fuel metering units, fuel controls, and electronic engine control systems for the aerospace industry. This includes military, commercial, regional as well as business aircraft. Our project was to research, test, and recommend an alternative to TECS current LVDT measurement device. LVDT stands for Linear Variable Displacement Transducer and is a sensor that converts the linear movement of an object into electrical signals. TECS currently uses an LVDT to measure the deflections of the piston in their gear pump system. Our recommended system needed to be small, low cost, rugged, as well as accurate. It will be measuring piston deflection of 2 to 10 mm and requires a measurement resolution better than 0.1% of the full stroke. Finally, the system needs to withstand the high temperatures and pressures of a jet engine fuel control, with temperatures reaching 300°F and pressures reaching 1000 psi.

We tested two different types of sensors; a linear encoder and a magneto-inductive linear displacement sensor. These tests were done on a test rig consisting of the sensor, a linear motor, and a replicate metering valve machined by TECS. These tests were done by calibrating our sensor in relation to the valve's closed position, and then providing the motor with a set displacement to move the piston. This displacement was then read by the sensor and recorded. We evaluated accuracy by comparing our input displacement signal to the output displacement reading of the sensor. We were then able to calculate percent error and accuracy of the sensor. Early in our research we calculated accuracy based on the supplier specifications of the sensors. We were able to compare our test results to these calculated results. Our next task was to calculate accuracies and errors for TECS current LVDT system, and compare these results with our chosen sensors. Our last task was to recommend an alternate sensor to the LVDT and specify any modifications that need to be made to the sensor or housing in order for the sensor to withstand the harsh fuel pump environment. Through our tests and extensive research, we were able to recommend a sensor to Triumph Engine Control Systems that improves on both accuracy and cost complexity.

TEAM 46



Kevin Debacher, Erik Molina, Jesse Jumbo Jara, Dr. Chengyu Cao

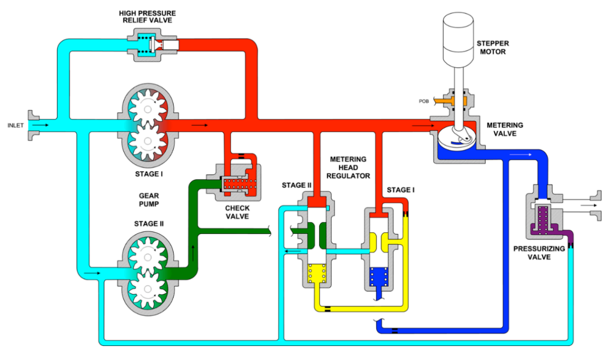
MECHANICAL ENGINEERING

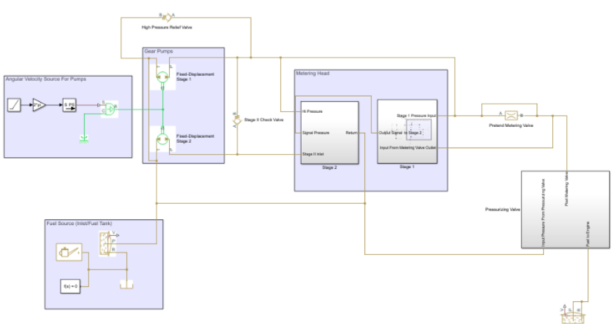
TEAM: ME 46
SPONSOR: Ted Busky
ADVISOR: Dr. Chengyu Cao

Triumph Group, Inc.

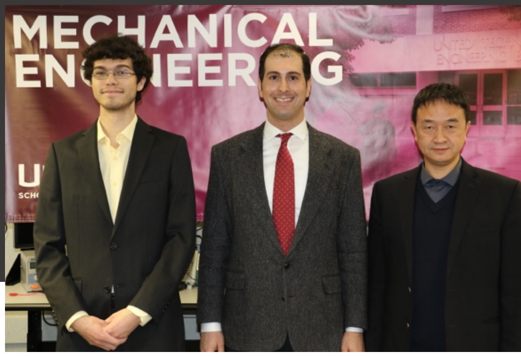
Thermally Efficient Gear Pump System

In this project, we are working with Triumph Engine Control Systems to design, build and test a two stage gear pump. The inclusion of the two separate stages acts to improve the efficiency of the system. The gear pumps shown in the schematic to the left, are MFP-297 fuel pumps, which will be provided by Triumph Group. All other components shown in the schematic will be produced by our group, which will act to control the switching off and on of the two stages which correspond to the required fuel output for a jet engine depending on whether it is being started, accelerating, or at cruising speeds. The start to finish design process will include making CAD models in SolidWorks of all the valves, then determining how to arrange and plumb them together by doing fluid dynamics analysis and integrating the physical concepts that govern the system into simulation software to optimize pump efficiency. We will be using Simscape Fluids, a part of SIMULINK software made by MathWorks, to complete this analysis. Then a manifold to house all of the valves in this arrangement will be machined from aluminum. Triumph is providing the valve hardware, such as springs, pistons, bolts, etc. which will be placed in the housing we design, and this system will be tested using one of their test rigs. Data will be collected to determine the system's efficiency and where improvements can be made. Possible malfunctions in the system include leakage, failure to maintain a constant pressure drop across the metering valve, and improper signaling of the stages of the metering head regulator. For this reason, extensive theoretical and simulation analysis is a very important requirement to precede the manufacturing of the manifold.





With the help of TECS we developed a modified 2 stage gear pump which at high flow/velocity conditions, both pumps are required to operate to start the engine. Stage I of the metering head regulator senses change in pressure across the metering valve and signals stage II to adjust the return flow in order to maintain a constant change in pressure across the metering valve. As more flow returns, eventually the second pump gets checked off from the main flow, and recirculates back to gear inlet at low pressure, thus reducing excess heat generation due to the low pressure. Results showed that for low flow/velocity conditions the 2 stage gear pump with 1 stage turned down was more thermally efficient than a single stage gear pump.



Dennis Scheglov, Richard Goldman, Professor Chengyu Cao

MECHANICAL ENGINEERING

TEAM: ME 47
SPONSOR: Dr. Janine Caira
ADVISOR: Professor Chengyu Cao

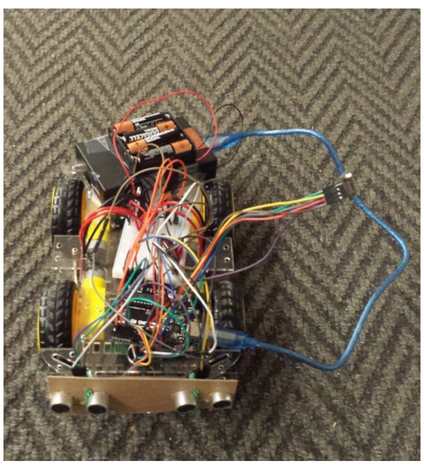
Army Ant Emulation

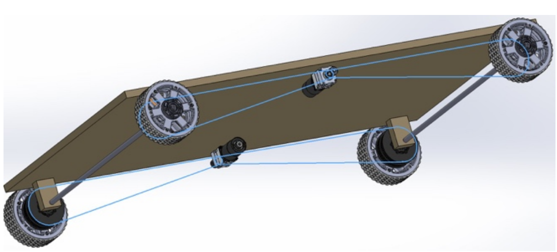
For 55 years, Carl Rettenmeyer and his wife collected hundreds of specimens of army ants as part of their lifelong research at the University of Connecticut. Their samples remain with the Ecology and Evolutionary Biology Department at the University of Connecticut to this day, and Dr. Rettenmeyer's work continues to inspire and educate. To that end, Dr. Janine Caira (a world-renowned parasitologist at UConn) has organized the AntU project in order to inform and educate the public on the fascinating world of army ants and their behaviors. A number of army ant statues have been placed on exhibit around the UConn campus; each ant is over a meter long and weighs about 28 lbs. Dr. Caira has sponsored this Senior Design project to create a robotic platform that can carry such a statue around in paths reminiscent of actual army ant behavior.

To start with, the team investigated the controls of such a robot using a smaller mock-up construction driven with an Arduino microcontroller. The mock-up could successfully move forwards, backwards, and turn in place, and incorporated ultrasonic proximity sensors for obstacle avoidance. Commands could be sent to the robot from a laptop using a pair of radio frequency transceivers.

The full-scale robot consists of a ½" plywood platform on which the ant statue is mounted, and DC brushed motors run a belt drive system with four wheels operable in either direction and within a range of speeds. Like the smaller mock-up, this robot includes ultrasonic obstacle avoidance and radio frequency communication capabilities. The robot follows specific instructions to move along a pre-orchestrated path as the user intends.

The ultimate goal for the project in future years of Senior Design is to construct about 20 robotic ant platforms which can all follow pre-made paths and interact and behave together in the same way real army ants do (e.g. executing bivouac formations), using the current design as a base.





Gabrielle Grossi, Nicolas Mower, Albert Miller III, Dr. Ying Li

UTC Aerospace Systems

MECHANICAL ENGINEERING

TEAM: ME 48

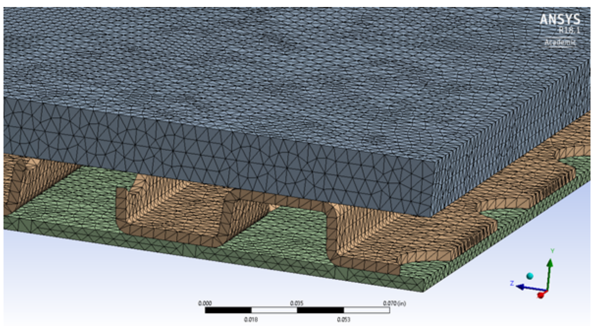
SPONSOR: Mark Zaffetti

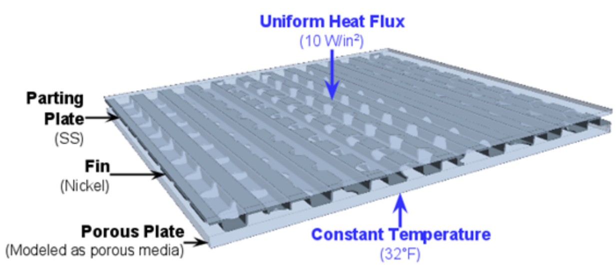
ADVISOR: Dr. Ying Li

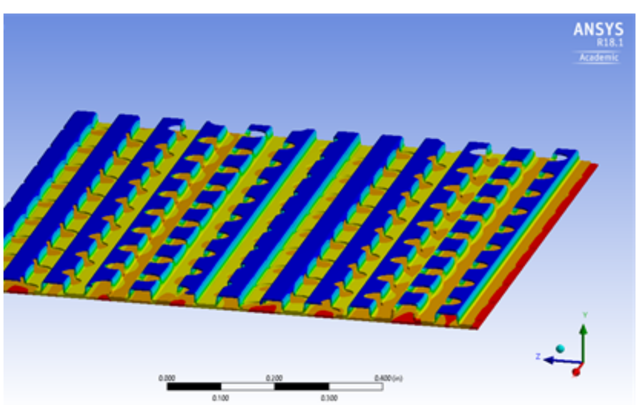
Alternate Method for Sealing Porous Plates

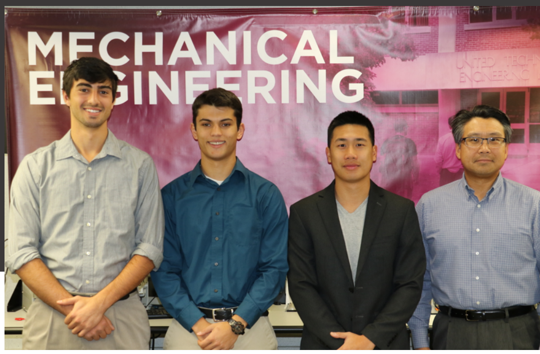
UTC Aerospace Systems (UTAS) is a world supplier of technologically advanced aerospace products. They design and manufacture various components for aircrafts, helicopters and spacecrafts. One component UTAS is responsible for is the Environmental Control and Life System Subsystem (ECLSS). A subsystem of the ECLSS is the Active Thermal Control System, whose liquid cooling loop is comprised of a pump package and a sublimator heat rejection device. Sublimators utilize the vacuum of space to expel heat from the spacecraft. The porous plate is located between the vacuum of space and a source of water. The heat is released in the form of water vapor through the porous plate, forming the ice layer on the opposite side. The edges of this porous plate must be sealed to prevent water vapor from escaping through the sides as it goes from one side to the other. If the water vapor were to leak through the edges of the porous plate, ice would form and hinder the function of the entire assembly.

Currently, UTAS utilizes a brazing process to seal the edges of the porous plates. UTAS desires a faster and less expensive method for sealing the porous plates. After much research, the team has developed two possible methods. The first being laser cladding, a process where material is added to the plate using a powder and a focused laser beam. The second method being thermal spraying, a process in which molten material is sprayed onto the plate to create a sealed perimeter. To test the porous plates, feedwater fin and parting plate sections were attached using the appropriate epoxy for the given test and closure bars are applied around the perimeter. Two configurations were not sealed, allowing the team to gather controlled data to give a baseline. Each configuration has been tested to ensure that it has the same thermal conductance and structural strength as UTAS's current configuration. Additionally, each configuration has been tested to ensure no leakage from the edges of the sealed porous plates. The testing data was compared to the FEA simulations created in ANSYS. Each of the sealing methods were found to be successful. With this information UTAS will be able to reduce the time and cost of sealing the porous plates.









Brian Abedon, Nicholas Jayakar, Tyler Sundara, Dr. Wilson Chiu

MECHANICAL ENGINEERING

TEAM: ME 49
SPONSOR: UConn Electric Motorsports
ADVISOR: Dr. Wilson Chiu

TEAM 49

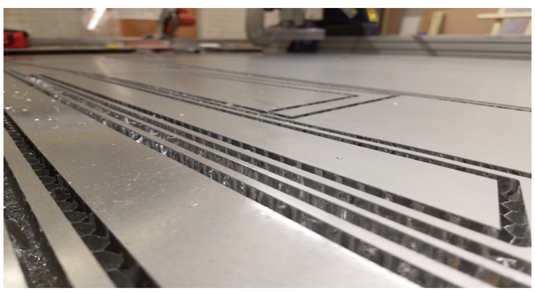
Formula Electric Racecar Chassis

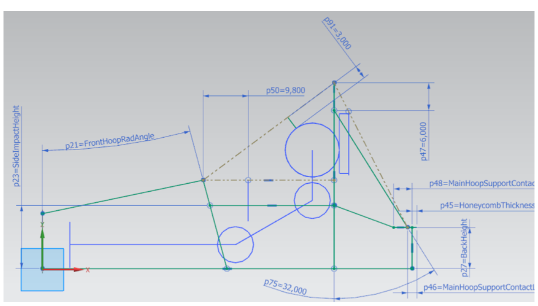
UConn Electric Motorsports (UCEM) is an on campus club sponsoring four separate senior deisgn teams, each tasked with building an integral component of a single-seat electrically powered formula-style racecar. From design to production 11 students have brought together the best components sourced from around the world integrated into a single vehicle. North America's first electrically powered aluminum honeycomb chassis is capable of accelerating from 0-60 mph in under three seconds.

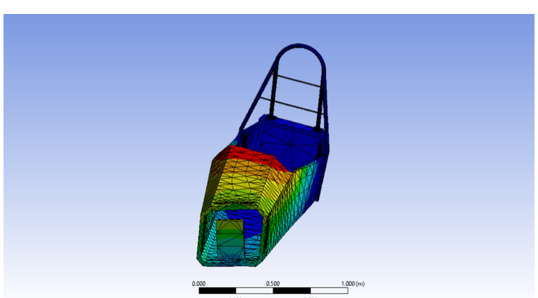
The mechanical team was tasked with the design and construction of the chassis for the 2018 UCEM vehicle. An an aluminum honeycomb monocoque was chosen as an alternative to the conventional steel tube spaceframe to optimize cost and weight. Simpler construction that required minimal welding and allowing dependent systems to have extreme flexibility in mounting and integration. Additionally this novel material use and design allows UCEM to gain a competitive marketing advantage.

Research as well as in-house testing was performed on the honeycomb was used to prove structural equivalency to steel. The unique structure of the material gives it vastly different properties under different conditions. As expected, the honeycomb material shows maximum strength under distributed load, as the honeycomb cells work together to support extraordinary forces. This heavily impacted not only the design of the chassis, but all component mounts. Both the industrial-strength epoxy and rivets that are used to attach honeycomb panels were tested to ensure that they will not be the weakest link.

Once the design and manufacturing of the chassis was complete, we continue to push for full integration with all other functioning systems on the vehicle. This entails customized mounting points for all atachments, ensuring the chassis is able to accomadate all aspects of the electric vehicle.







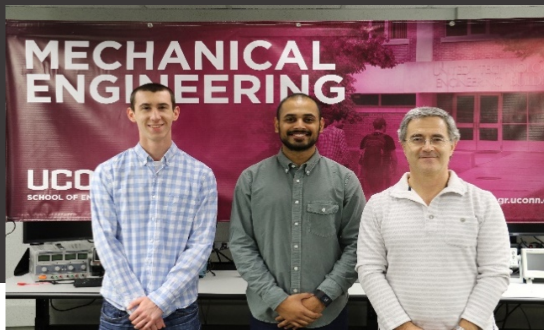
TEAM 50

MECHANICAL ENGINEERING

TEAM: ME 50

SPONSOR: University of Connecticut

ADVISOR: Dr. George Lykotrafitis

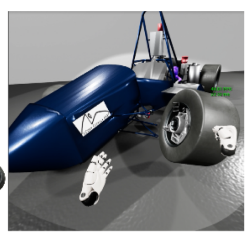


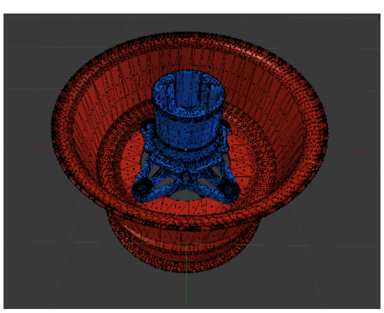
Thomas Ressler, Ayush Rathore, Dr. George Lykotrafitis

UCONN
UNIVERSITY OF CONNECTICUT

UCONN FORMULA SAE

Race Car Design Visualization in Virtual Reality





The main sponsor of this project is the University of Connecticut, specifically the Cellular Mechanics Laboratory directed by Dr. George Lykotrafitis and the FSAE Club. While most of Dr. Lykotrafitis's research revolves around creating true-to-life simulations on the molecular and cellular scale, he is interested in applying this same approach to a variety of different applications. One such area of interest is to demonstrate the utility of Virtual Reality (VR) in the Industrial/Educational frontier.

Virtual reality (VR) is a computer technology that utilizes a wearable headset to generate realistic images, sounds, and other sensations to simulate a user's physical presence within a unique environment. A person using virtual reality equipment can view and interact with objects in a simulated world. VR today is most prevalent in the gaming and entertainment industries to create richer experiences. As the technology continues to develop in serving these purposes, it has evolved into a tool with the potential to enhance other areas, such as the engineering industry and education. Specifically, VR can be a powerful tool in product design simulation and education by offering highly programmable and true-to-life digital workspaces.

The central objective of this project is to prove the utility of virtual reality for industrial and educational applications by creating an interactive true-to-life representation of the FSAE car in VR. The team's accomplishments include a framework for processing all CAD models into the VR programming environment (Unreal Engine), creation of a modular part-to-part mating mechanism and steering simulator, and development of realistic virtual surroundings.

The CAD Model Processing framework is a piece of documentation highlighting all steps and parameter settings needed to import SOLIDWORKS CAD models and files for use in Unreal Engine. The Part-to-Part Mating Mechanism forms the basis for connecting objects to one another, granting a user the ability to place wheels and panels on a car only if they are within a proper range of positions and orientations. This is accomplished by relating the 6 degrees of freedom of each part in 3-dimensional space.

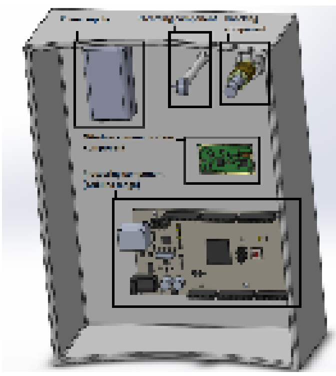
Completion of this project's objectives will provide the FSAE team and the Cellular Mechanics Laboratory with a powerful tool for product design simulation.

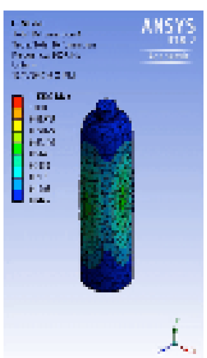
MECHANICAL ENGINEERING

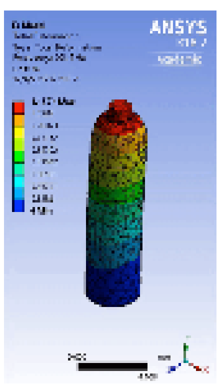
TEAM: ME 51
SPONSOR: Marcin Piech
ADVISOR: Dr. Xu Chen

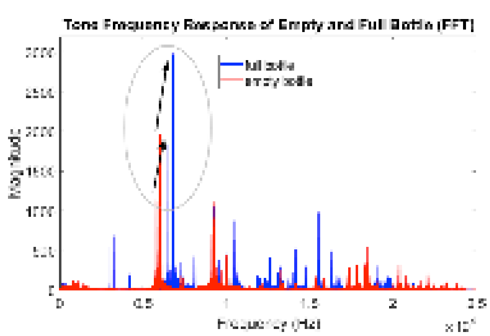
Alex Barrera, Harshal Patel, Le Yu, Dr. Xu Chen

United Technologies
Climate | Controls | Security









Fire Suppression Tank Mass Detection Sensor System

Team 51 has designed a remote mass detection device in conjunction with UTC Climate, Controls & Security. CCS manufactures and implements fire suppression systems across all disciplines of UTC. The suppression tanks used in many of these systems need to be inspected biannually to ensure each tank has sufficient fluid levels. If the fluid level within a tank is reduced by 2.5% it must be replenished. This inspection process is manual and extremely time consuming; weighing the tanks is currently done by detaching each tank from the hoses, lifting it onto a scale, and comparing the value to the one previously recorded. CCS is seeking to automate this process to improve the accuracy and mitigate the costs of this inspection.

These tanks are an integral part of fire suppression systems in buildings all across the country, which are critical to the safety of everyone inside. As such, a robust, reliable solution is being designed to meet UTC's high level of excellence. Additionally, it is important to have redundancy and make it easy to use, while still keeping the solution cost effective.

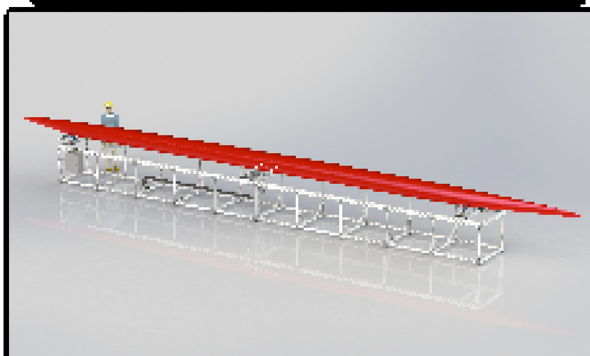
Many different sensors were considered in this project, including load cells, sonar actuators, and hammer impacting. The design we have gone with includes the use of ultrasonic sensors as well as a knocking device that hits the tank with a constant force. The knocking device vibrates the tank and the ultrasonic sensors act as microphones that can determine the frequency of this vibration. This frequency change from when the tank was originally full can determine when the tank has lost 2.5% of its original mass and needs to be refilled. This system is in use 24 hours a day 7 days a week so whenever there is a leakage in a tank it can be refilled by a UTC employee.

TEAM 52

MECHANICAL ENGINEERING

TEAM: ME 52
SPONSOR: Martin McElroy
ADVISOR: Mr. Tom Mealy

Tegh Terrell, Dillon Johnson, Anthony Pizzolo, Mr. Tom Mealy

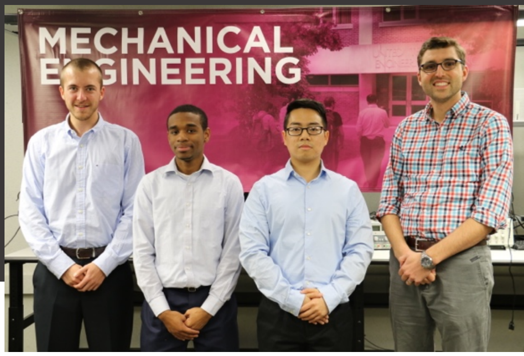


Racing Shell Stiffness Measurement Method and Apparatus

Vespoli USA Inc. is an Olympic-Level rowing shell manufacturer in New Haven, Connecticut. The objective of this project was to produce a testing apparatus and method that determines the torsional and bending stiffness for all of the racing shells that Vespoli produces. When a boat deflects, some of the rower's energy is lost. Therefore, the stiffer the boat, the faster the shell will move. The current procedure for testing the bending stiffness of the shells involves hanging weights from the bow and observing the deflection This method is not accurate nor precise enough and it does not test the shell's torsional stiffness. Vespoli require a testing apparatus that will give reliable, consistent results that they can use for design improvement validation, quality assurance, and marketing.

In order to fulfil this need, a testing apparatus was designed and built that would universally be able to test the bending and torsional stiffness for all of Vespoli's current and future racing shells. The apparatus uses automated components to perform the stiffness test with minimal to no operator intervention. Using laser measurement devices, the apparatus takes the stiffness measurements and exports the information for data logging. In addition, common modules were utilized in order to increase manufacturability and transportability of the apparatus.

Using ANSYS finite element analysis software, the apparatus's own stiffness was simulated to ensure it would not deflect enough during a testing procedure to impact the shell stiffness measurements. For more accuracy assurance, the apparatus uses a programmable logic controller (PLC) and a human machine interface (HMI) to allow any user to easily and reliably test all of Vespoli's shells. During the testing procedure the operator will receive shell model specific instructions via the HMI and clamp the shell to the apparatus accordingly. Through the touch screen HMI, the operator will conduct the test by a simple press of a button. All of the testing data produced will be available for an engineer to export.



Kyle Sanford, Andre Bent, Tri Nguyen, Dr. Bryan Weber

MECHANICAL ENGINEERING

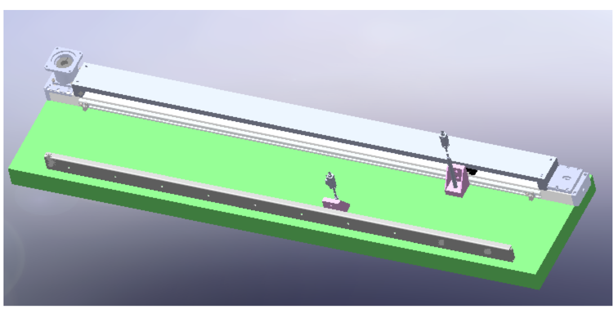
TEAM: ME 53
SPONSOR: David Morgan
ADVISOR: Bryan Weber

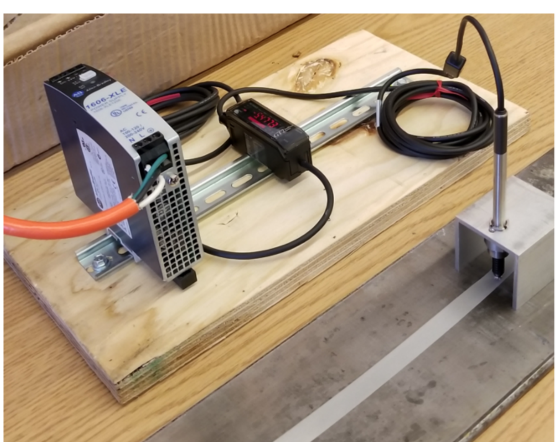
Extrusion Line Thickness Scanner

Web Industries is a global leader in flexible material converting and end-product contract manufacturing. The Hartford branch of Web Industries is a leader in the printing, coating, laminating, and extrusion of flexible, narrow materials. Currently, Web Industries is using an eddy current sensor in their polypropylene plastic extrusion line to perform thickness measurements. This measurement sensor needs to be manually moved to various segments along the width of the plastic in order to provide a thickness measurement. Although this method works to control the plastic’s thickness, it creates a lag in their process control. Due to this, Web Industries is looking for a modern thickness measurement system that is capable of continuous scanning and real time readouts of the extruded web thickness at any time. The benefit of this will not only be insured quality compliance, but it will greatly aid the machine operators in adjusting the extrusion die to maintain the desired web thickness.

To accomplish this goal, our team conducted extensive research to determine the optimal measurement technology that not only ensured continuous scanning and real time readouts, but also accuracy, precision, and durability. From this research, we arrived at the conclusion that Linear Variable Differential Transformers (LVDT) would be the best thickness sensor to use in the polypropylene extrusion line.

The final design uses two types of LVDT probes to provide the most accurate results while remaining user friendly. The standard spring type LVDT probe is mounted on a linear actuator that constantly traverses the web, creating a thickness profile of the entire web. The second LVDT probe used is a pneumatic probe. This probe is air actuated and mounted on a linear guide rail so that the operator can move it to any position along the web, take a spot measurement, and then retract the probe so that it is out of the way again. These two probes styles, when used together like this, offer maximum accuracy while remaining user friendly.





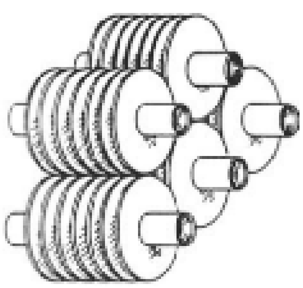
TEAM 54

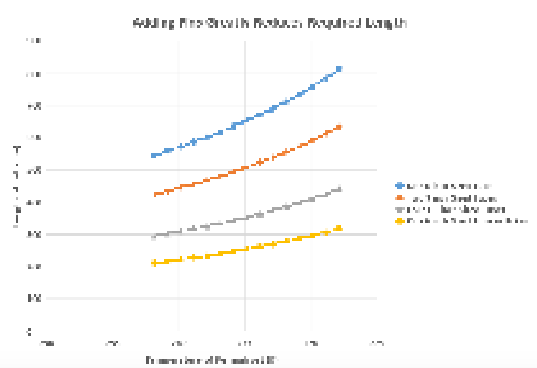
Vincent Schiro, Patrick Couperthwaite, Andrew Lavigne, Dr. Ugur Pasaogullari

MECHANICAL ENGINEERING

TEAM: ME 54
SPONSOR: Yasir Arafat
ADVISOR: Dr. Ugur Pasaogullari

Westinghouse Geothermal Heat Exchanger





Westinghouse Electric Company LLC is the worlds leading supplier of nuclear technology. In 1957 they introduced to the world the first commercialized pressurized water reactor in Shippingport Pennsylvania. Westinghouse technology is behind approximately half of the worlds 430 nuclear power reactors, providing a true "powerhouse" of nuclear technology and innovation. Westinghouse Nuclear is currently developing a concept power conversion system. Using supercritical $C0_2$ as the working fluid, and a nuclear reactor for heat generation, they hope to provide efficient power in a smaller package to regions in the northernmost territory of Canada, Nunavut. This group has been recruited to design the heat rejection device for this concept power cycle. The idea of using the environment to reject 3MW of heat is not only realistic, but the ultimate goal of Westinghouse and our group.

One of the biggest parts of this project is understanding the ambient conditions of Nunavut, Canada; and how they can be used to our advantage while designing a heat exchanger. Through research of the environmental cooling routes, and understanding of each (air, water, and permafrost), the group optimized and controlled many variables, to establish the most cost effective, and efficient design. Through our research, it was established a water-cooled heat exchanger in this specific region of the world was not only unreliable, but could not effectively meet the cooling needs. In air-cooling, a massive system was necessary, and lead to an unrealistically sized cooler. In the end, permafrost (a region underground where the soil is a constant cool temperature) was established to be the best cooling route for this system. A design has been developed and iterated to become the ideal heat rejection system Westinghouse desires. Finned tubes are at the core of the system, maximizing surface area while remaining realistic in terms of size and environmental impact. In the end, an optimized design and list of sensitivity of variables are the ultimate goals of the project and both have been completed through extensive research and quality analytical analysis.

MECHANICAL ENGINEERING

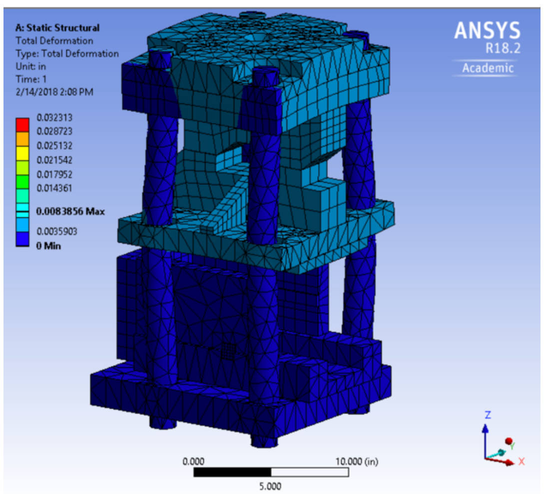
TEAM: ME 55
SPONSOR: Allen Roy
ADVISOR: Dr. Horea Ilies

TEAM 55

Brandon Steeves, Mateusz Sroka, Lucas Marcouiller, Dr. Horea Ilies

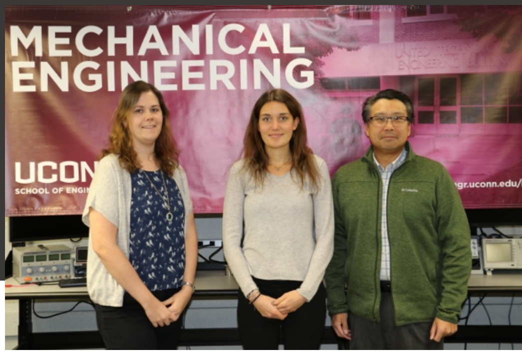
Design, Development, and Fabrication of a Right-Sized Compact Press Rolling Machine

Whitcraft LLC—located in Eastford, CT—is a world leader in lean manufacturing, specializing in the production of formed, machined, and fabricated sheet metal aerospace components. They tasked us with the design, development, and fabrication of an improved roll press machine utilized in forming turbine compressor stator vanes. We utilized the principles of Kaizen, or continual improvement, to enhance existing press designs. Improvements include a "right-sized" press design (75% reduction in machine footprint on the shop floor), addition of a mechanical locking mechanism during the rolling phase, and addition of a hands-free loading/unloading device.



Future demand for stator vanes will require several operational roll press machines, and the current press takes up over 30 ft^2 of floor space. Reducing the floor space required per machine would allow for more machines to be built and put into use, increasing production per square foot. This ties into the idea of building the press "right sized" which means using no more space or energy than absolutely necessary. Downsizing the machine is a step in the right direction, however there is still wasted energy during the rolling process. For that, a mechanism was designed that mechanically locks the press, so the hydraulic pressure need only be applied during the initial stages of the process. The final improvement was the development of a small device attached to the roller assembly which will load and unload parts without the need of an operator to put their hands inside the machine. This increases productivity and safety.

Our approach to improving these areas of the machine were based in lean principles. Simplicity of design, and iterative tinkering and testing allowed for verification of the modeled data and improvements upon the physical design through *moonshining*. Moonshining is the process of working with your hands, and physically trying new and creative approaches to solving complex problems. The hands-free loading/unloading device started as pieces of cardboard, and through moonshining, became a workable and serviceable piece of the roll press. Design of the locking mechanism focused on minimizing moving parts. This made the press more rigid, decreased energy usage, and requires less parts and maintenance. Overall, we are proud of the work we have done and we are honored to have been a part of the continual improvement taking place every day at Whitcraft LLC.



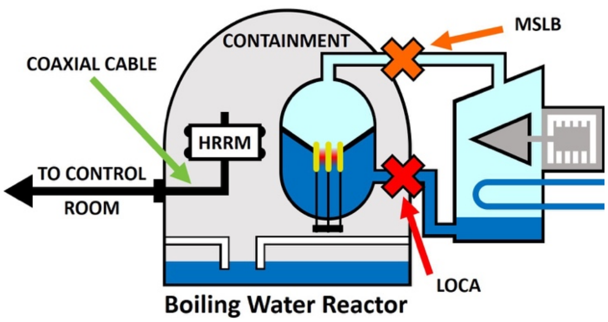
Kelsey Bushkoff, Charlotte Veitner, Dr. Wilson Chiu

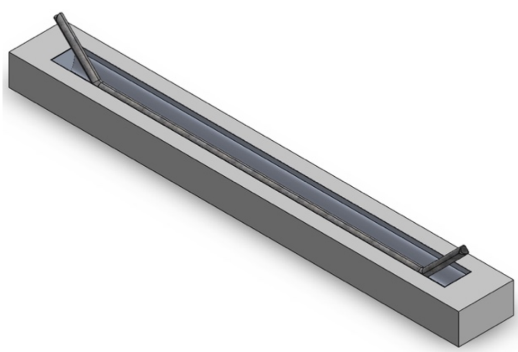
MECHANICAL ENGINEERING

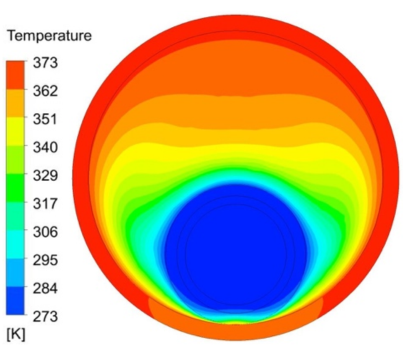
TEAM: ME 56
SPONSOR: Shane Williams
ADVISOR: Dr. Wilson Chiu

Study of Thermally Induced Currents in High Range Radiation Monitor Cables

ZACHRY







Zachry Nuclear Engineering, headquartered in Stonington, CT, provides engineering and design services for the nuclear power industry. Inside the containment building of a nuclear power plant, coaxial cables are used to transmit signals from high range radiation monitor (HRRM) sensors to indicators located inside of the control room. During an accident, such as a Loss of Coolant Accident (LOCA) or a Main Steam Line Break (MSLB), or any other operational transients, HRRMs provide operators with radiation level readings so that they can properly diagnose and respond to the event. A thermally induced current (TIC) can be generated in the HRRM coaxial cable due to rapid temperature changes within the containment building, such as those which occur during a LOCA. Currently, within the nuclear power industry, training is necessary to help operators determine when to ignore HRRM readings brought on by TICs during known temperature gradients.

Since most nuclear power plants use different coaxial cables and cable-in-conduit configurations, the purpose of this project was to understand the TIC effects on different coaxial cable-in-conduit configurations used in HRRM systems, and to provide potential suggestions for improving or upgrading HRRM systems to eliminate the TIC problem. This project involved designing, constructing, and operating a safe and financially feasible test rig to measure TICs on the scale of picoamperes and nanoamperes, as well as performing transient two-dimensional (2D) thermal analysis of one cable-in-conduit configuration used in testing.

The experimental test rig consisted of two 7 ft troughs, constructed out of aluminum gutters insulated with Styrofoam. To create a temperature gradient on the surface of the cable, 6 ft of coaxial cable inside a water tight galvanized steel conduit was moved from one trough, filled with ice water, to the other, filled with boiling water. An electrometer, connected to both ends of the cable, measured the current that was generated in the cable due to the temperature gradient. Multiple thermocouples were placed along the surface of the cable at various locations, allowing us to obtain a transient average temperature reading across the cable surface, which was then used to validate our 2D thermal analysis model.

Nico Wright, Dr. Michael Pettes

MECHANICAL ENGINEERING

TEAM: ME 57

SPONSOR: Pettes Thermal Transport Lab

ADVISOR: Dr. Michael Pettes

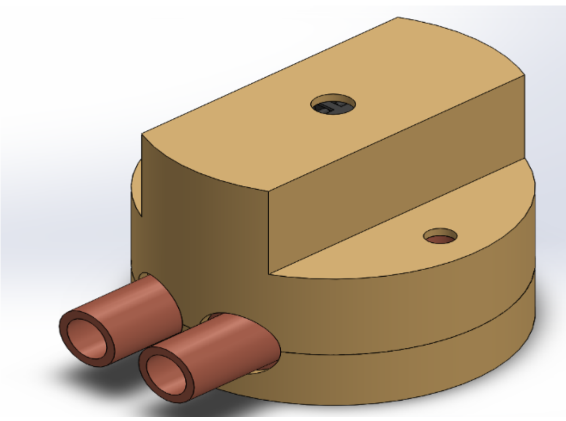
TEAM 57

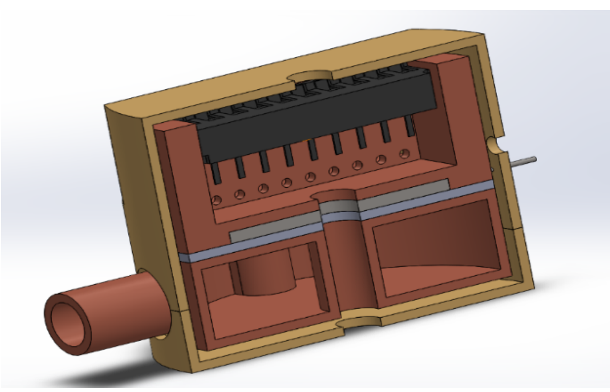
Design of a Variable Temperature Optical Cryostat for Optothermal Property Measurements

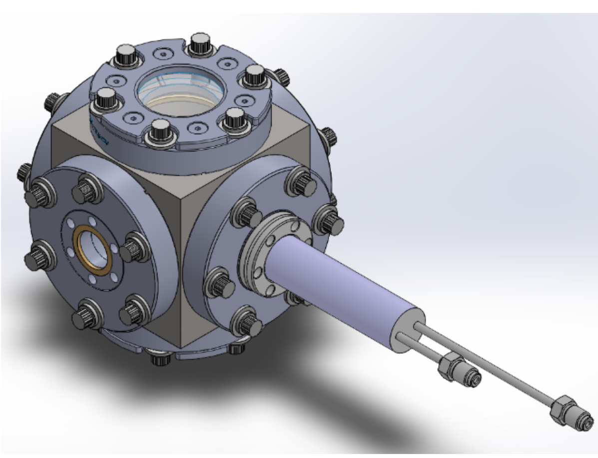
The Pettes Lab conducts research mainly in the areas of nanoscale heat and energy transport. 2-Dimensional semiconducting metal dichalcogenides are a class of materials that exhibit desirable properties for uses in next generation electronic and optoelectronic applications due to their extraordinary electrical, optical and mechanical properties. Future devices are envisioned to bend and stretch and large changes to the properties of these materials have been predicted in the presence of strain.

There are certain properties of materials that only become apparent at very low temperatures and pressures. The aim is to design an apparatus to produce the conditions to study these emergent properties. Commercial instruments (such as those manufactured by Janis Research Company, Oxford Instruments, or Montana Instruments) exist but inherent limitations in the design prohibit precise or accurate multi-property measurements, and knowledge of the exact sample temperature is unknown. A solution is needed to effectively produce the environments necessary for analysis of these emergent properties, which includes a full finite element modeling approach to identify parasitic heat loss channels and predict the exact sample temperature under realistic operating conditions.

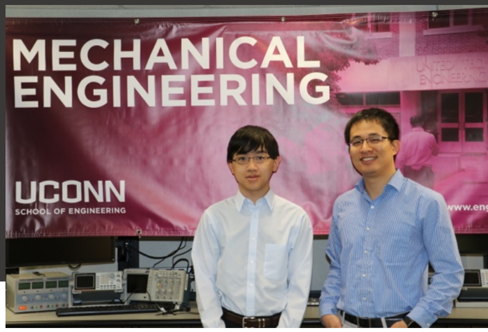
The sample mount consists of two halves machined from solid copper. The bottom half serves as a cold trap for liquid nitrogen. The cold trap works in conjunction with the disc cartridge heater to control the temperature at the surface of the sample. ANSYS simulation software is used to examine the effectiveness of several design iterations and to identify the major areas of parasitic heat loss.







TEAM 58



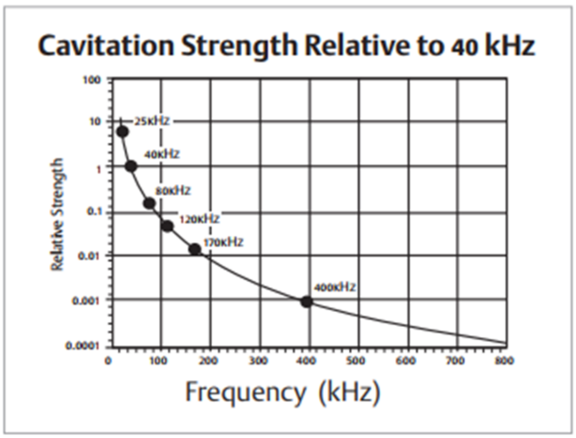
Howard Ho, Professor Xu Chen

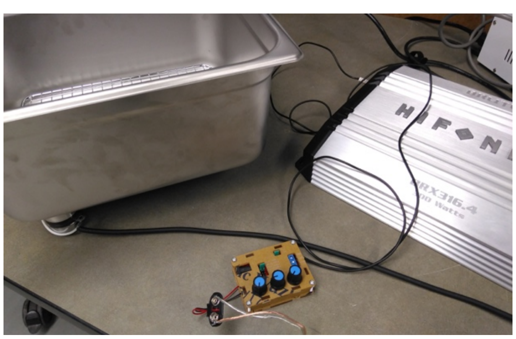
MECHANICAL ENGINEERING

TEAM: ME 58
SPONSOR: UTC Aerospace Systems
ADVISOR: Professor Xu Chen

Ultrasonic Cleaning Enhancement and Optimization

UTC Aerospace Systems





Gyroscopes are the primary sensor that helicopters and missiles use to guide themselves. It goes without saying that being able to reliably control a plane, or direct a missile at the right target, is always of utmost importance. UTC Aerospace is one of the world's largest manufacturers of aerospace products ranging from completed jets, missiles, and helicopters down to magnets, sensors, and of course gyroscopes. To ensure a gyroscope's reliability and longevity, UTC Aerospace routinely cleans out any debris during the assembly process using an ultrasonic cleaner, a specialized cleaning machine that utilizes cavitation.

Cavitation is a phenomenon that occurs in fluids when they are subject to high frequency pressure waves. The pressure waves essentially pull the fluid molecules apart, forming spherical regions of empty space. These cavities promptly implode, and the resulting shockwave blasts debris off any surfaces submerged in the fluid while the pressure waves are applied. The shockwaves vary in strength depending mostly on the frequency of the applied pressure waves.

Most ultrasonic cleaners operate at a single frequency, typically a weak one, to ensure the integrity of all parts being cleaned. When cleaning larger more durable pieces, this makes the process lengthier and more expensive than it already is.
This project explores the potential of building a cleaner with adjustable frequency to adapt most optimally to the piece being cleaned, as well as integrating a control system to monitor and partially automate the cleaning process.

MECHANICAL ENGINEERING

TEAM: ME 59
SPONSOR: UCONN
ADVISOR: Dr. Amir Faghri

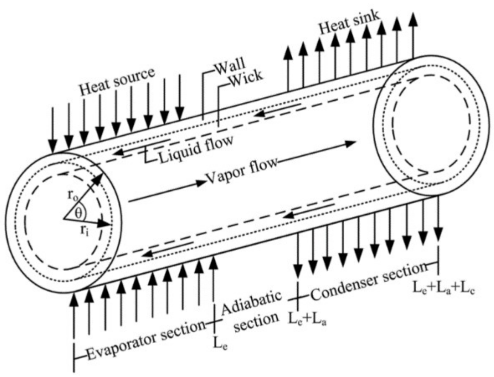
TEAM 59

Sara Klockzo, Dr. Amir

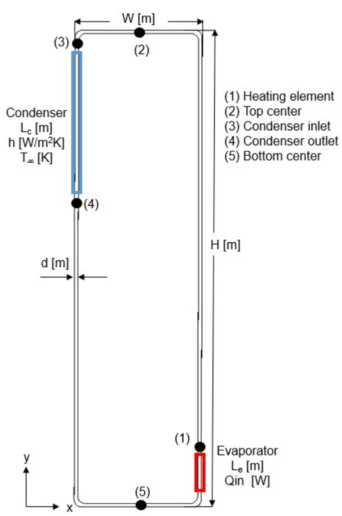
UCONN UNIVERSITY OF CONNECTICUT

Non-Phase Change Heat Pipe Design and Analysis

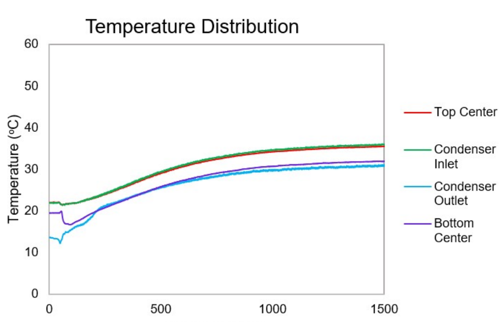
A heat pipe is an effective and well-established device which transfers energy from two solid surfaces through thermal conductivity and phase change with a small temperature drop. A non-phase change heat pipe (NPCHP) is a recently developed heat transfer device yet to undergo extensive testing. The device consists of a heated section (evaporator) and cooled section (condenser), which are connected by an insulated (adiabatic) section. The heat transfer in a NPCHP depends on a pressure increase from the temperature increase of the working fluid, rather than phase change and volume response to temperature increase as in conventional heat pipes. As working fluid temperature increases from the heat source, the pressure inside the pipe increases. The pipe is filled with enough liquid to limit volume expansion and thus suppress phase change. Since the NPCHP is not dependent on phase change and does not contain a wick structure, many limitations of conventional heat pipes do not apply.



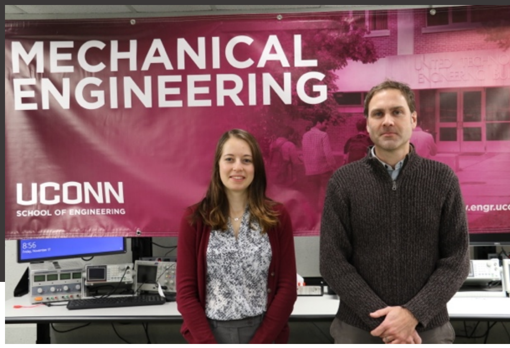
The objective of this project was to first determine if the proposed NPCHP experiment is an effective heat transfer device. This was done by performing experiments on an initial design and comparing the thermal response time to that of a copper rod. The thermal response time for the same heat input was significantly faster for the NPCHP than a copper rod of equal length and diameter. Next, the effects of changing system parameters on the overall operation and effectiveness of the heat pipe were determined. This was done by creating a computational model of the experiment in ANSYS FLUENT. Aspects of the computational model were changed to determine the effects of varying parameters on the heat transfer performance. These effects were verified by replicating the changes in the physical experiment.



Thermal resistance and thermal response time were used to compare performance between different configurations in ANSYS FLUENT. Thermal resistance is the resistance of a system to the flow of heat and is determined by dividing the temperature difference between the evaporator and condenser by the heat input. The design with the lowest thermal resistance has the best performance and the system with the fastest thermal response time is the most effective because is takes the least amount of time for the system to reach steady state operating conditions.



TEAM 60



Lauren Marshall, Dr. David M. Pierce

MECHANICAL ENGINEERING

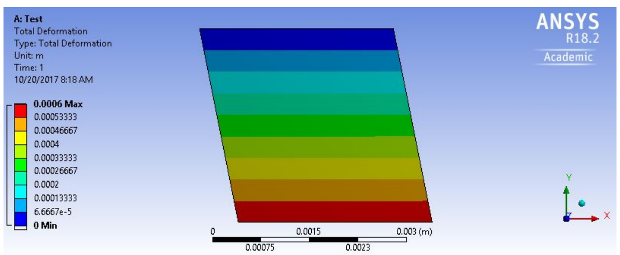
TEAM: 60

SPONSOR: Interdisciplinary Mechanics Laboratory

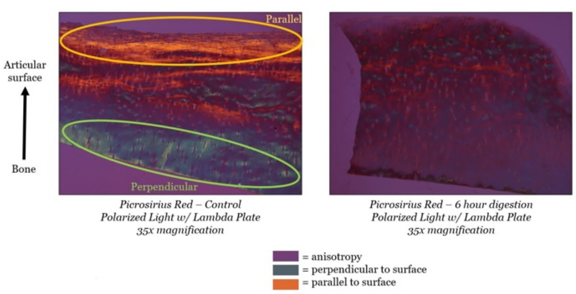
ADVISOR: Dr. David M. Pierce

The Large-Strain Shear Responses of Collagen-Digested Human Cartilage

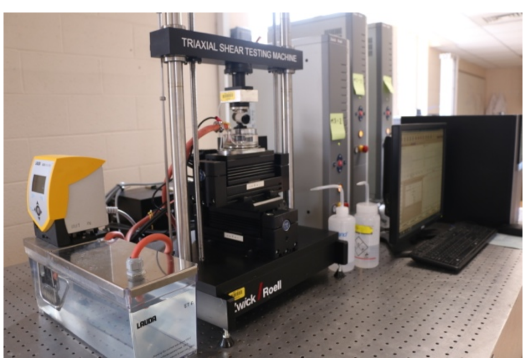
The Interdisciplinary Mechanics Laboratory at the University of Connecticut combines imaging, experimental testing, and computational modeling across disciplines to understand and predict the mechanics of soft tissues, particularly human articular cartilage in the knee. In the human knee joint, a one to six mm thick layer of dense connective tissue known as articular cartilage forms the articulating surfaces which provide low-friction surfaces between the relatively rigid bones and distribute contact pressure to the underlying bone structure. To meet the *in-vivo* mechanical loading demands, cartilage is a highly specialized, complex tissue consisting of a fluid-saturated porous material. The tissue is reinforced by a network of viscoelastic type II collagen fibers, a load-bearing protein intimately connected to the tissue's mechanical function.

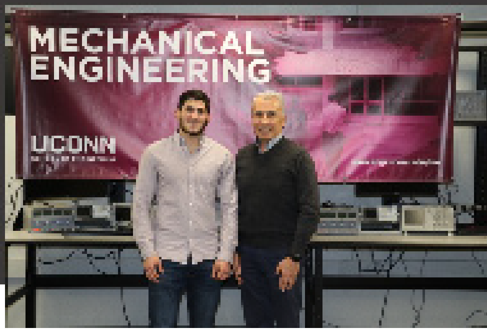


During disease or medical treatment, the structure and volume of cartilage adapt to the changing mechanical environment, presenting a grand challenge for cartilage modeling: hence, an urgent need to develop computational models capable of simulating the evolving properties of cartilage, such as the remodeling that occurs during the progression of Osteoarthritis. Such a computational model requires a detailed understanding of the tissue's mechanical behavior under a variety of loading scenarios closely representing *in-vivo* conditions. The objectives of this study are to (1) digest collagen fibers without proteoglycan loss; and (2) measure the shear stress-strain response of collagen-digested samples; and (3) fit the shear stress-strain data with a suitable material model. We hypothesize that the shear stress-strain response of collagen-digested samples is more homogeneous compared to untreated samples.



We explored several viable options of collagen fiber digestion. Histology, a tissue staining process, and second harmonic generation imaging confirmed complete digestion. We applied maximum shear strains of ±5, ±15, and ±25% to the cartilage cuboids (3 mm x 3 mm) and measured the corresponding reaction forces in time. Additionally, we imaged the spatial distribution of the shear strain using a Digital Image Correlation system. The primary objective of this project was to devise a method for digesting collagen type II fibers from human articular cartilage and characterize the shear stress-strain response. Additionally, we generated a baseline dataset using bovine knee cartilage tested at ±5, ±10, and ±15% shear strain.





Ross Pallenberg and Dr. Baki Cetegen

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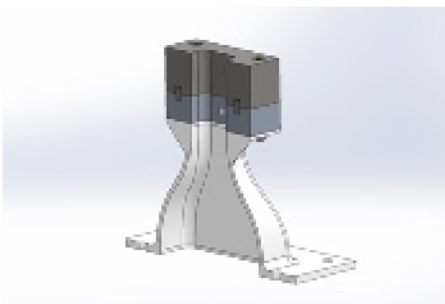
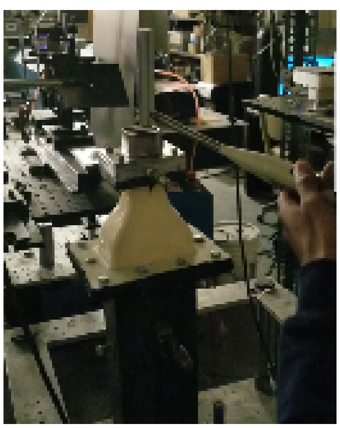
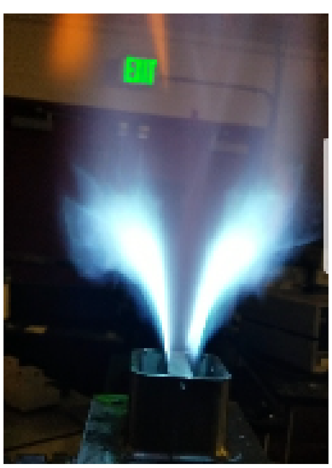






MECHANICAL ENGINEERING

TEAM: ME 61
SPONSOR: UConn Combustion and Gas Dynamics Laboratory
ADVISOR: Dr. Baki Cetegen

TEAM 61

Assessment of static flame stability of turbulent, bluff-body stabilized premixed flames in a two-dimensional configuration

All practical combustors are operated using turbulent inflows, as the turbulence aids the mixing of the fuel and oxidizer directly prior to combustion. The turbulence also has a large effect on flame stability. In addition, emissions regulations have pressured the industry to design devices optimized for use with a lean, premixed fuel and oxidizer mixture, which also influences flame stability. Maintaining the flame in these devices is extremely important to their operation, so understanding the blowoff characteristics of different fuels will aid in the future design of combustion devices. Little work has been done to systematically determine how turbulent flow affects flame stability for specific combustor configurations. As a continuation of Prof. Cetegen's previous work involving conical bluff-body flame holders, this project explores the near blowoff flame utilizing a rectangular bluff-body flame holder over different levels of inflow turbulence intensity, free stream velocities and fuels including methane, propane, ethylene and prevaporized liquid fuels.

Characterizing blowoff involves several experimental techniques such as Particle Image Velocimetry (PIV), Planar Laser Induced Fluorescence (PLIF), and Matlab code for post processing. Before studying blowoff, a robust, stably burning flame must be lit. For the purposes of this experiment, this is defined as a flame that is anchored at the bluff body plane and has a fully developed velocity profile at the burner outlet. To measure the flow profile, particle image velocimetry (PIV) is used. This technique involves adding small tracer particles to the fluid. It is assumed that these particles have the same characteristics of the flow itself. By taking hundreds of images of these particles over a small given time span, the velocity profile can be resolved. Once a fully developed profile is confirmed, the anchoring of the flame is the next piece of interest. The anchoring of the flame at the bluff body plane must be visually verified. Once these are satisfied, blowoff studies can be performed. The quantity of interest is the blowoff equivalence ratio, ϕ_{bo}. The equivalence ratio is defined as the actual mass-basis ratio of fuel to air in the mixture divided by the stoichiometric ratio of fuel to air in the balanced combustion equation. To perform the blowoff experiment, a stable flame was ignited and the equivalence ratio was linearly decreased until blowoff occurred. Results showed that ϕ_{bo} increased with increasing turbulence intensity and free stream velocity for each fuel.

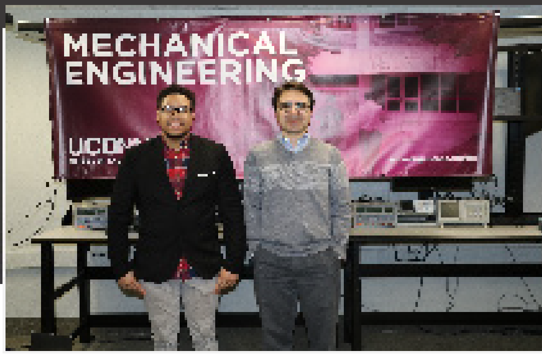
TEAM 62

MECHANICAL ENGINEERING

TEAM: ME 62

SPONSOR: Center for Clean Energy Engineering

ADVISOR: Dr. Ugur Pasaogullari

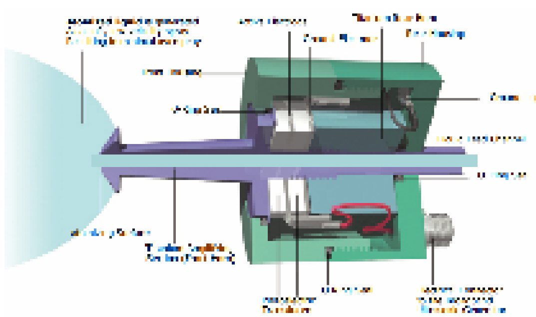


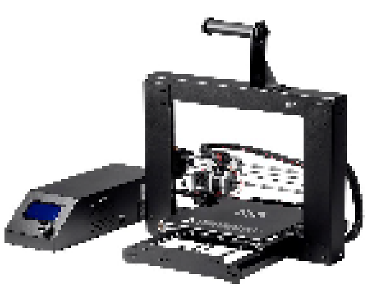
Orvy Polanco, Dr. Ugur Pasaogullari

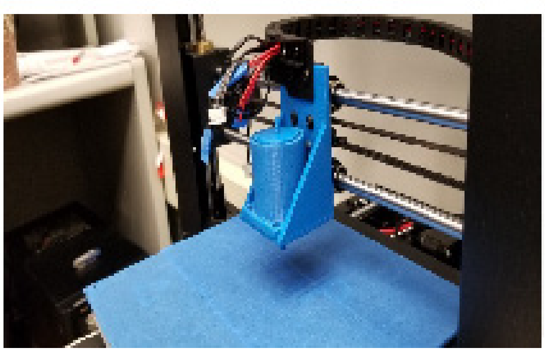
Fabricating a High-Performance Membrane Electrolyte for Fuel Cells

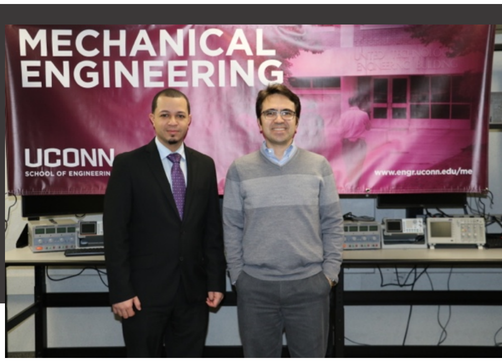
An ultrasonic spray catalyst deposition machine was built to improve the repeatability and consistency for fabrication of a Membrane Electrode Assemblies (MEAs) used in polymer electrolyte membrane (PEM) fuel cells. The purpose of the membrane electrode assembly is to separate the hydrogen from the oxygen (with the membrane), and to help drive the reduction, and oxidation reactions with the help of platinum catalyst supported on carbon nanoparticles. The catalyst is deposited onto the membrane from an ink solution of isopropanol, water, carbon and platinum. The amount of platinum in the catalyst coating is called platinum loading, which is crucial to the performance and durability of the fuel cell.

The machine uses a 3D printer for the X, Y and Z axis computer numerical controls (CNC), allowing for precise controlled movement with an accuracy of 0.1 mm. The printer is heavily modified. Replacing the plastic extruder, an ultrasonic narrow spray atomizer nozzle was used in combination with an ultrasonic generator to deposit the catalyst ink onto the membrane. The ultrasonic nozzle uses frequency energy to atomize the fluid, leading to consistent sized droplets controlled via the supplied frequency to the nozzle, through which we controlled the deposition pattern and platinum loading. The bed of the 3D printer will be removed in order to use a heated porous vacuum plate assembly, which will heat and secure the membrane in place during the spray process. The fabricated membranes were used in a fuel cell and tested for performance and reliability. The results will be used to improve the manufacturing process of the catalyst coated membrane. This project will continue to master's thesis research focusing on the design of novel fuel cell catalyst and structures.









Bryan Aponte, Dr. Ugur Pasaogullari

MECHANICAL ENGINEERING

TEAM: ME 63
SPONSOR: UConn Center for Clean Energy
ADVISOR: Dr. Ugur Pasaogullari

TEAM 63

Evaluation of Novel Catalyst Support for PEM Fuel Cell

CENTER FOR Clean Energy ENGINEERING
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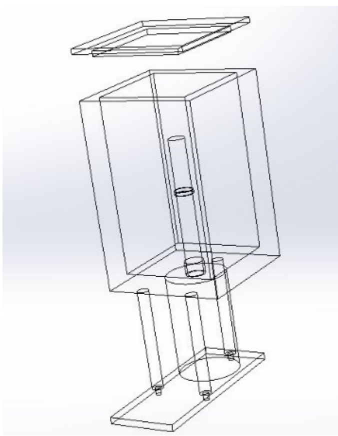
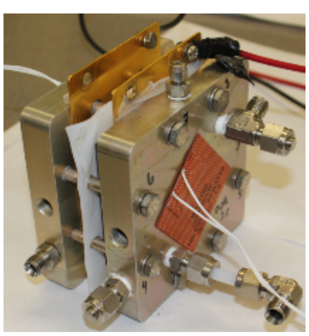




The goal of this project was to provide a way to fabricate repeatable high-yielding rotating disk electrode (RDE) films and to evaluate the durability of the catalysts with titanium oxide and without. Electrode films fabricated at ambient conditions, show inconsistent results when tested in a controlled environment. These tests were also repeated using a temperature-controlled chamber that was built to provide a constant temperature environment while drying the catalyst ink. This setup provided better results compared to films fabricated in an ambient temperature environment. The chamber setup yields higher quality and consistent films that were uniform across the RDE surface area.

The measurements that were taken and evaluated where the electrochemical surface area, mass activity, specific activity, and durability of the catalysts. The evaluation of these measurements provides the needed information to start testing the best performing catalyst in a fuel cell environment.

Catalyst including titanium oxide showed improved durability, compared to conventional catalyst design in RDE experiments. Catalysts where subsequently fabricated into membrane electrode assemblies for testing in fuel cell environment. When tested in a fuel cell environment, the results showed that catalyst containing titanium oxide had greater durability overall.

Pauline Menoret, Prof Julian Norato

MECHANICAL ENGINEERING

TEAM: ME 64
SPONSOR: UConn Structural Optimization Laboratory
ADVISOR: Prof Julian Norato

User Interface for Topology Optimization

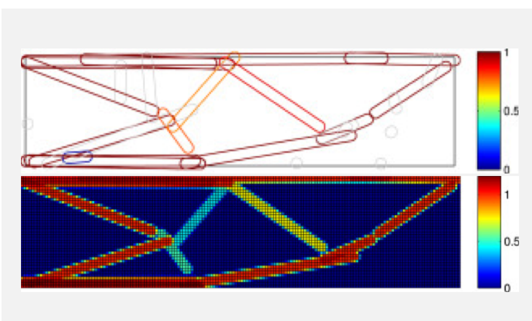
STRUCTURAL OPTIMIZATION LABORATORY

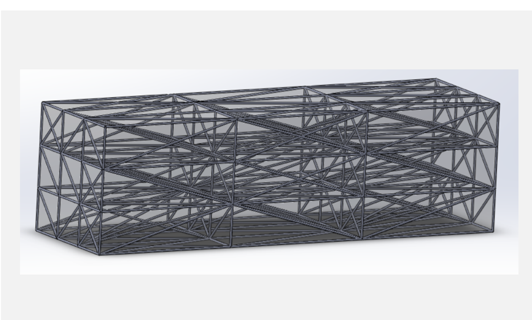
The UConn Structural Optimization Lab researches and develops topology optimization methods that take into consideration the challenges of manufacturing, cost, geometric constraints, and localized failure mode criteria. Their aim is to rapidly obtain, during the early concept design stage, drastically different designs for different fabrication systems and materials.

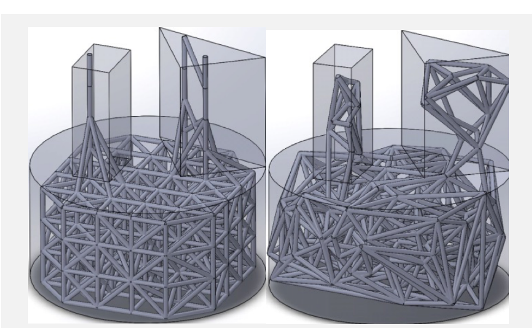
Currently their methods are difficult to use and visualize without substantial knowledge of their optimization code. Therefore, in order to improve this and better understand the effects of initial designs on topological optimization, a Graphical User Interface (GUI) for the lab's methods has been developed as a part of this senior design project. Specifically, this project developed an interface for optimizations which employ the geometry projection method with linearly elastic bars.

The GUI developed achieves three main functions within the ABAQUS environment. First, it automatically creates a regular or random initial design within a STEP file of a design space to seed the topology optimization. The team developed original methods in Python that take advantage of mathematical models such as Delaunay Triangulation in order to achieve this. Second, the GUI gathers all the inputs required for the optimization and sets-up the optimization problem to then easily launch the lab's existing optimization code. The inputs are collected through ABAQUS dialog boxes that were customized for this application. This means that the input method automatically checks for user errors in order to avoid confusion when running the optimization later on. Also, it automatically creates standardized input files which include detailed explanations of each variable for the optimization. Third, the GUI reads the optimization's output files and visualizes the results. The visualization uses clear color codes in order to make the variables associated with each bar extremely clear.

In order to finalize and test the topology optimization user interface as well as demonstrate the project, an example topology optimization was run with the interface and the optimization methods developed by UConn's Structural Optimization Lab.







Samuel Soifer, Professor Horea Ilies

MECHANICAL ENGINEERING

TEAM: ME 65
SPONSOR: UConn Computational Design Lab
ADVISOR: Dr. Horea Ilies

TEAM 65

UCONN
SCHOOL OF ENGINEERING

3D Printed Printing Robotic Arm

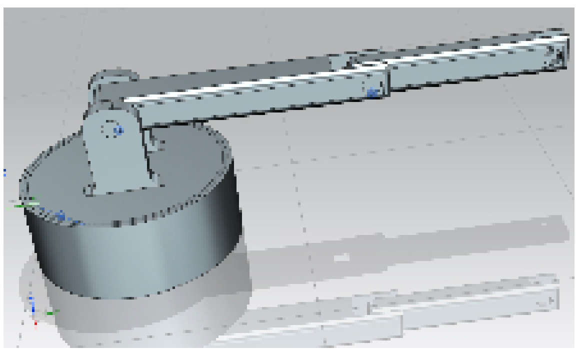
Over the past several decades robotics have successfully been integrated into many fields such as manufacturing, appliances, and more. Robots have been increasing efficiency and precision while decreasing cost. With 3D printing technology available to the general public at an affordable price, robotics has become even more prominent. Creating a robotic arm that can autonomously self-replicate is part of the future of robotics.

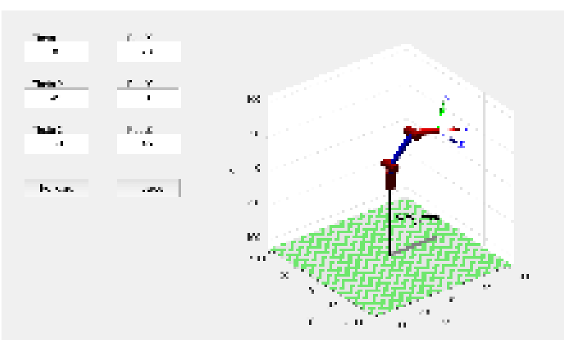
The primary objective is to design, spec, build and test a 3D printed robotic arm, actuated by servos, connected to a computational platform and whose motion can be controlled via a user interface that could eventually be used to 3D print other versions of itself.

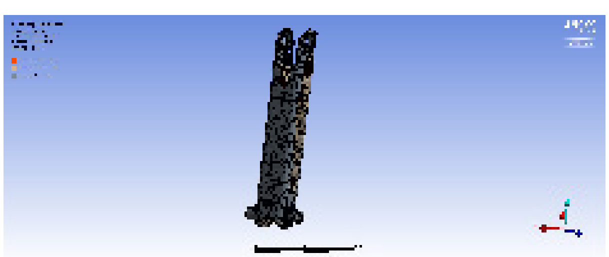
The objectives of this project have been established based on a central idea: The development of new engineering models, representations, algorithms and design semantics to enable systematic and efficient design, analysis and manufacturing of engineering artifacts. The University of Connecticut Computational Design Lab is in need of a robotic arm that can test the ideas of self-replication and 3D layerless printing.

This project was completed by first writing the forward and inverse kinematics for a 4-degree of freedom robotic arm. Subsequently, the robotic arm was designed and modeled in NX and simulation including topology optimization was assessed using ANSYS. Once the preliminary design was complete a design review was conducted to assess vibration mitigation, weight, power distribution, and mounting of electrical and mechanical components. The robotic arm was then modified, printed out of Carbon Fiber and assembled. Next, the kinematic code was uploaded to the robotic arm and programmed using MATLab. Finally the robotic arm was tested and validated.

As this is an accelerated masters project, the goals for the first year is to deliver a working robotic arm while second year will explore the ideas of self replication. Additionally, the project has open-ended goals that are adaptable based upon research and data collected. Other ideas that will be tested will include putting the robotic arm on a moving platform and creating multiple print heads for the end effector.







TEAM 66

MECHANICAL ENGINEERING

TEAM: ME 66
SPONSOR: UCONN Combustion Diagnostics Labratory
ADVISOR: Dr. Chih-Jen Sung

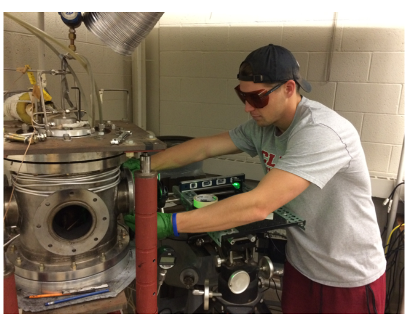
Peter Vannorsdall and Dr. Chih-Jen (Jackie) Sung

UCONN COMBUSTION DIAGNOSTICS LABORATORY

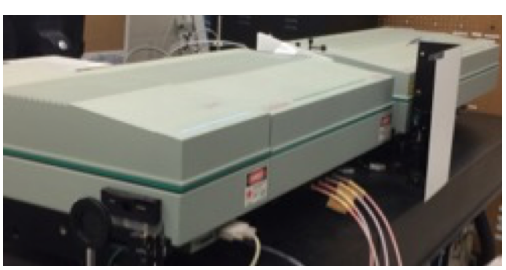
Soot primary particle sizing using laser-induced incandescence in counterflow non-premixed flames

The Combustion Diagnostics Laboratory at the University of Connecticut focuses on enhancing the efficiency and eco-friendliness of various combustion phenomena. The objective of the present study was to investigate the feasibility of using laser-induced incandescence (LII) as a method of determining soot primary particle size in counterflow non-premixed flames. An Nd:YAG laser (depicted) provided the 532nm excitation beam needed for LII measurements. Three candidate LII methods were investigated, namely the Decay-Rate, Wavelength-Ratio, and Gate-Ratio methods. While all three methods demonstrated potential, the latter two methods were of particular interest, as they could be applied to unsteady flames in addition to steady flames. LII signals were calibrated using a variety of methods, including a scattering-extinction technique that produced quantitative particle size measurements. Once the feasibility of the three LII techniques was determined, the Decay-Rate method was then used to conduct particle size measurements in a steady counterflow flame (depicted), while the Wavelength-Ratio and Gate-Ratio methods were used to measure particle size in a turbulent flame (not depicted), although with limited success.

The aforementioned LII counterflow burner experiments were coupled with laser-induced fluorescence (LIF), with the ultimate goal being to expand the combustion community's understanding of the formation of incipient soot particles, whose diameters are less than 10nm. Unlike the turbulent flame that was investigated using the Wavelength-Ratio and Gate-Ratio methods, which represents a more practical combustion flame, the counterflow flame represents a purely theoretical flame with no real-world application. However, this unique flame configuration is critical to the understanding of soot inception and growth as its centerline represents a one-dimensional flame. That is, simulations of the centerlines of counterflow flames require only modest run times to execute extremely complex chemical kinetic models when compared to their two- and three-dimensional counterparts.



As an Accelerated M.S. student, the research that I conducted for Senior Design will continue beyond Demo Day. Namely, I plan on expanding the application of my LII particle sizing techniques to flame configurations that represent practical real-world combustors. Additional work will be dedicated to improving the LII signals from the previously discussed turbulent flame, as well as to collecting soot particle size (and volume fraction) data from the lab's Rapid Compression Machine (RCM).



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Tom Mealy

Steve White

Mark Bouley

Peter Glaude

" Science can amuse and fascinate us all but it is engineering that changes the world."

Issac Asimov

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