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MATERIALS SCIENCE & ENGINEERING

MATERIALS SCIENCE & ENGINEERING

TEAM: 1

SPONSOR: Medtronic

ADVISOR: Dr. Rainer Hebert (UConn)

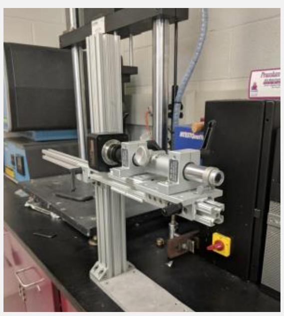
Darlene Nebinger, Michael Morsches (Medtronic)

Gabrielle Joseph, Amber Levasseur, Brian Whooley

Characterization of Tensile Mechanical Properties of Biodegradable Polymers

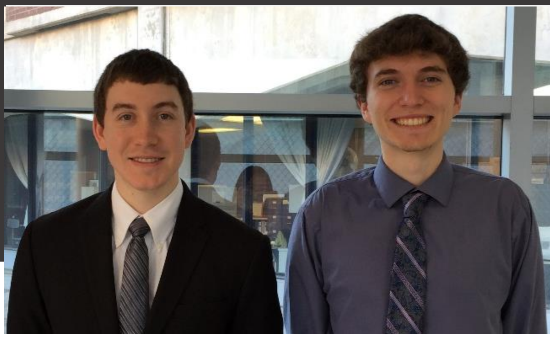
Medtronic is a global healthcare solutions and medical technologies company dedicated to improving lives. Medtronic's vast inventory of medical technology includes many products that utilize a variety of Medtronic proprietary biodegradable polymers, including hernia mesh tacks, biodegradable strips, ligation clips, and sutures. When considering medical implant devices, it is essential to fully understand the properties and expected behavior of the materials used. This is necessary in order to ensure proper function of the device *in vivo,* as well as patient safety. A misuse of materials could potentially result in premature failure of the implant which could cause further medical complications.

The purpose of this Capstone project is to further characterize the mechanical properties of the biodegradable polymers to have additional data as to how the polymeric materials will function in a clinical environment, and degradation behavior. To confirm and enhance data collected from the 2016/2017 Capstone project, the four proprietary Medtronic molding co-polymeric materials (L1, L4, L11 and L41) will be tensile tested initially and after in-vitro degradation. The data collected will give information regarding the mechanical properties, including yield strength and modulus of elasticity taken from the calculated true stress strain curve. This true stress-strain data, reflecting the intrinsic properties of each polymer, will then be used in finite element modeling to help Medtronic design injection molds and predict the mechanical behavior of degradable implant devices initially, after implant, and during degradation.



The 2016/2017 Capstone project team developed a non-contact video extensometer. The non-contact video extensometer will be used as opposed to using a tensile tester to get true displacement of the biodegradable samples. The video extensometer records the samples during tensile testing and is then able to convert pixel movement into displacement data, allowing for accurate true stress vs. true strain curves to be generated. This project will make use of *in vitro* standard operating procedures to induce hydrolytic degradation of polymeric tensile bar specimens to standardize specimen size and geometries to allow for data comparisons between the materials.

The core needs that will be addressed is improvement of the video extensometer by redesigning the mount to properly stabilize the camera during tensile testing. Another concern that will be addressed is replacing the grips with suitable grips that will show little to no slippage in the data prior to conversion of true-stress-strain data. If time persist, syncing of signals from the tensile test and camera operation will be researched to start operation of these devices at the same time.



Steven Churchill, Matthew Brown

MATERIALS SCIENCE & ENGINEERING

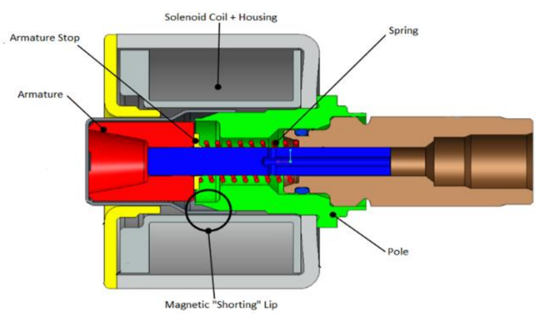
TEAM: 2
SPONSOR: Stanadyne LLC
ADVISOR: Dr. Serge Nakhmanson (UConn)
Richard Pellini, Angie Cheung (Stanadyne)

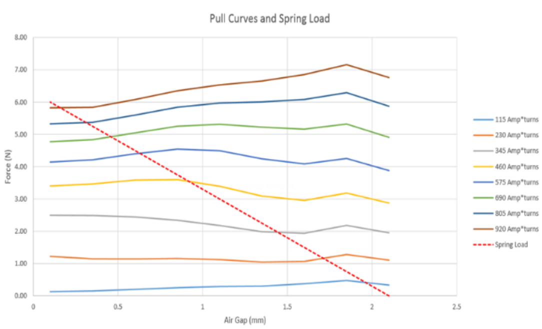
Finite-Element Modeling of Magnetic-Coil Operated Fuel Control Valves

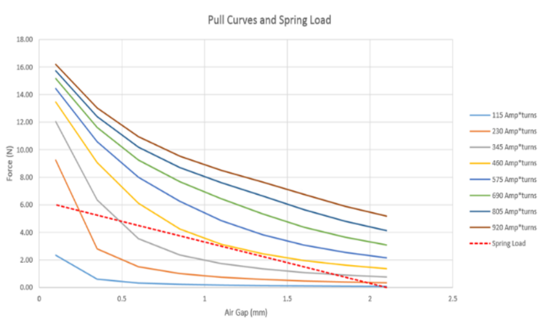
The highly competitive environment of fuel control valves continuously requires innovation to stay ahead of the pack. Engineers at Stanadyne LLC are always striving to optimize efficiency and ease of manufacturability. The pumps they manufacture utilize a solenoid to control the flow of fuel. As electric current passes through the solenoid, the magnetic attraction between the two stainless steel pieces, known as the pole and armature, increases. The armature is attached to a flow control valve spool. The magnetization of these two pieces will pull the armature towards the pole until equilibrium is reached between these attractive forces and a counteractive spring. The distance between the pole and armature is known as the air gap. The resulting equilibrium points will produce air gaps of varying distances. The air gap directly influences fuel flow through the device.

The current design utilized by Stanadyne features a lip on the pole piece which allows Stanadyne to greatly control the flow rate, but a lot of the magnetic force is wasted in the radial direction as the armature piece is attracted to the lip. This lowers the energy efficiency of the design. Stanadyne designed an alternative to the original design by removing the lip feature. With the new design, the forces between the pole and armature are all pointing downwards, but the magnetic force and counteractive spring force now come into equilibrium at two different air gaps. This makes it difficult to control the fuel delivery of the pump. Stanadyne would like to resolve the instability problem of their new fuel pump design, while also improving the efficiency of the old design. They wanted to develop a stronger understanding between the resulting magnetic field and the attractive forces that control the system operation. We planned on introducing incremental changes to determine what optimized the relationship between the air gap and pull forces.

All computations within this project were performed over the three-dimensional modeling software called ANSYS. Design changes were applied to a standard 2-dimension fuel control valve model provided by Stanadyne. Each new design was tested over a range of applied currents as well as multiple air gaps. Current results prove that changing the shape of the solenoid has little effect on the force vs. airgap curves, but alternative design changes, such as embedding a permanent magnet in the armature have shown promising results.







Zane Grady, Andrew Nguyen, Adam Wentworth

MATERIALS SCIENCE & ENGINEERING

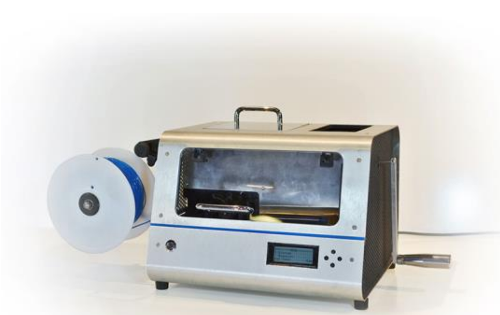
TEAM: 3

SPONSOR: NASA & Tethers Unlimited Inc.

ADVISOR: Adam Wentworth & Dr. Rachel Muhlbauer

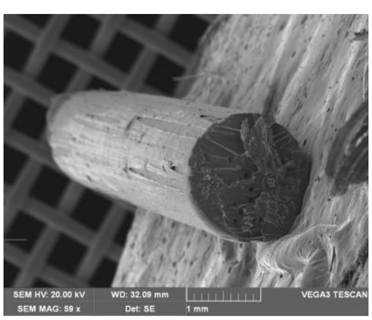
Polymer Reclamation for In-Space Manufacturing (PRISM)

Minimization of waste is of paramount importance in long duration space missions. One proposed method of optimizing material use is by repurposing plastic waste into 3D-printable filament, so that it may be used to manufacture new tools and structures. This project investigates Polymer Reclamation for In-Space Manufacturing (PRISM) through thermal, chemical, and mechanical characterization of various recycled thermoplastics for evaluation of potential in-space additive manufacturing applications.



The three candidate materials, Polyethylene (PE), Acrylobutadiene Styrene (ABS), and Polyethylene Terephatalate-glycol modified (PETG), were ground into fine pellets and extruded through the ReDeTec Protocycler system, resulting in spools of filament of specified diameters suitable for fused deposition modeling 3D printing. Using this recycled filament, mechanical testing dogbone specimen were printed and their properties were compared to those of raw material and the mono-filament prior to printing. Further, the thermal and chemical properties of these materials were also measured and compared against control, non-recycled, samples. The results of these tests offer insight into the iterative degradation of chemically distinct materials. These results are valuable to NASA (sponsor 2017) and Tethers Unlimited Incorporated (sponsor 2018) as these systems progress towards mission-ready technology readiness levels.

Tensile and impact strength of all materials in printed and filament geometries were obtained. Preliminary results suggest varying rates of degradation across the investigated materials. Congruent with the literature, the impact strength ABS decreases as the material is re-recycled, while the tensile strength remains relatively unchanged. The mechanical properties of the printed materials are also compared to recycled, but non-printed, mono-filament. These results delineate the effects of the printing and recycling processes for empirical assessment of the governing degradation mechanisms. Characterization of the recycled thermoplastics included thermal scanning methods, chemical measurements of molecular weight distributions, and microscopy of the surface topology/microstructure. Coupled with the change in mechanical properties measured, the gamut of characterization methods employed offers a holistic view the individual material degradation behavior, and consequently garners practical knowledge regarding the implementation of these specific, or chemically similar, material systems.



From left to right: Wei Fang, Francis Cielo, Florencio Topete, Claudia Chavez

MATERIALS SCIENCE & ENGINEERING

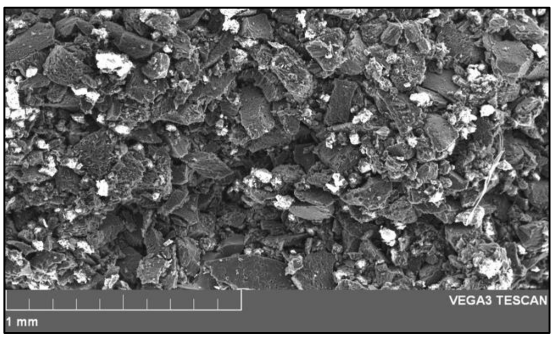
TEAM: 4

SPONSOR: KX Technologies

ADVISORS: Mark Stouffer, William Li, Peter Cook, Dr. Paul Nahass

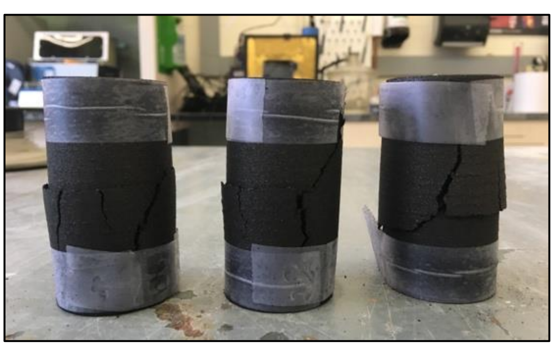
Investigation of Polymer Binders for Activated Carbon Blocks

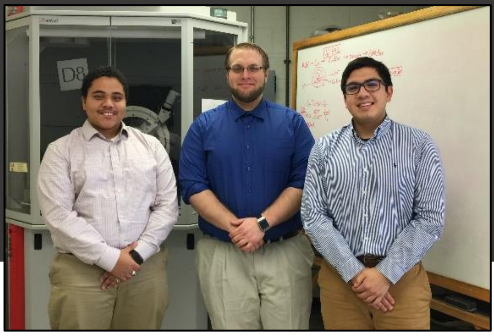
KX Technologies manufactures water filters in the form of activated carbon blocks. The water filters have applications varying from small household water filters, to refrigerator filters, to larger, more industrial water filtration. The carbon blocks consist primarily of two components: activated carbon and a polymer binder. The activated carbon serves as the means of filtration through adsorption. Adsorption is the adhesion of particles to a surface through a combination of Van der Waals forces, chemical and electrostatic interactions. Because of the extremely high surface area of activated carbon (about 3000 m^2/g), it is a perfect material for filtration by adsorption. The role of the polymer binder is to give structural integrity to the carbon block, which would otherwise just be activated carbon powder.



Due to the high availability of carbon blocks for filtration, they are viewed as a commodity. KX wishes to create a carbon block that stands out in the competitive market, and thus would like to compare a variety of polymer binder species to determine which optimizes the filtration process. That is, the combination of removal of undesirable species and consistent flow rate of water through the filter. Furthermore, it is of utmost importance to better understand the carbon-binder interactions in a carbon block, and how these interactions contribute to filtration performance. For this project, the goal is to understand how binder properties and carbon block microstructure correlate to carbon block filtration performance, so as to ultimately determine which binder is best suited for carbon blocks, the optimal composition of the carbon-binder mix, and the reasons for these conclusions.

Seven polymer binders were analyzed through their physical properties such as molecular weight, particle size, and melting point. The melt flow rates of the binders were found to examine the viscosity of the polymers. Additionally, ten activated carbon blocks, composed of one or more polymer binders, were analyzed. The compressive and beam strengths, capillary flow porometry, and SEM images of the carbon blocks were compared. The ten carbon blocks underwent chlorine and organic removal performance testing at KX Technologies' facilities. The polymer binders and carbon blocks' properties were correlated to the blocks' filtration performance, to find trends and identify the most promising polymer binder.





From left to right: Francis Almonte, James Doppes, and Michel Santivanez

MATERIALS SCIENCE & ENGINEERING

TEAM: 5

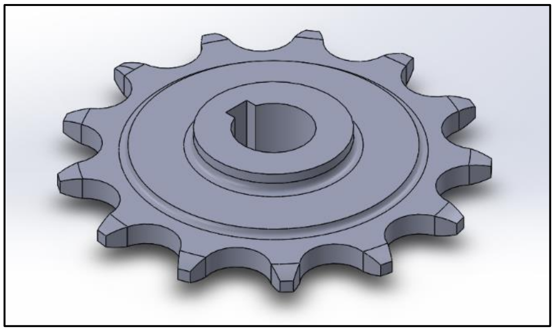
SPONSOR: Electric Boat

ADVISOR: Prof. Bryan Huey, Stephen Thomas. Peter Chomowicz

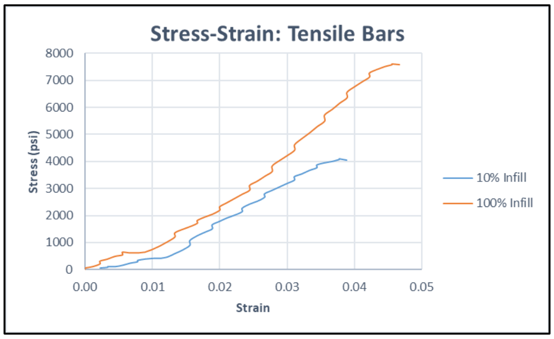
Qualification of 3D Printed Polymer Parts

Additive manufacturing of part replacements is an area of ongoing interest for many industries worldwide. For example, General Dynamics - Electric Boat is exploring this processing method as a complement to traditional machining. But without approved testing standards and qualification procedures, Electric Boat and others will find it difficult to convince major clients such as the Federal Government and the United States Navy to incorporate this still somewhat experimental approach.

The ultimate project goal is to prove additive manufacturing is a viable alternative to traditional processing methods through mechanical and microstructural testing. The specific objectives are to: i) design and optimize an additively manufactured component that is crucial to a dynamic mechanical system, ii) test the integrity of this component as a function of cyclic loading including under real-world conditions; and iii) propose a qualification sheet for efficient assessment of additively manufactured parts to be implemented in this or related systems.



The first project stage involves assessing additively manufactured ASTM D638 type- IV tensile bars via tensile testing and fracture analysis. Specimens are prepared with a range of infill percentages and layup directions. As indicated in the figures, a sprocket design is also additively manufactured for direct comparison with the conventional metal component it will replace. Endurance testing is performed with a drive motor and adjustable tension chain to evaluate the strength and reliability of the critical teeth. Failed teeth will be assessed as a function of load magnitude, load duration and additive layup design. Both tensile bars, as well as sprockets, are furthermore tested following environmental exposures common to US Navy applications, specifically saltwater, cleaning solvent, and UV radiation.



Generally, sprockets are critical components to the functionality of many mechanical systems, for which additive manufacturing provide a reasonable emergency or even long-term solution in terms of customizable demand repairs. However, to guarantee reliability of such replacement parts necessitates documenting manufacturing parameters and testing procedures to serve as standards for future development and applications of additively manufactured components. This study will thereby contribute to libraries of additive manufacturing standards, being developed by academics and industry nationwide, to accelerate confidence in 3D printing for real-world, mission critical applications such as those inherent to the systems manufactured by Electric Boat.

MATERIALS SCIENCE & ENGINEERING

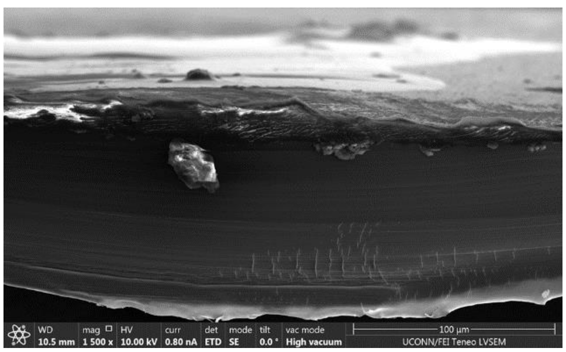
TEAM: 6
SPONSOR: Web Industries
ADVISOR: Dr. Montgomery Shaw, Sarah Ware

Mariel Colby and Tony Dean

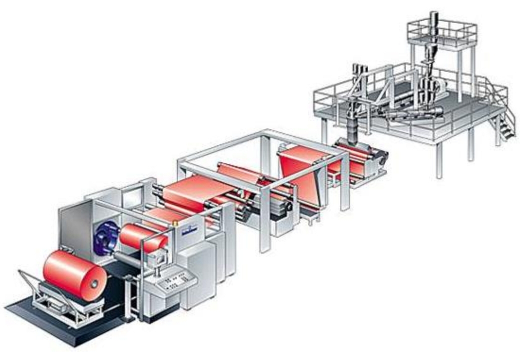
High-Density Polyethylene Product Development through Cast Film Extrusion

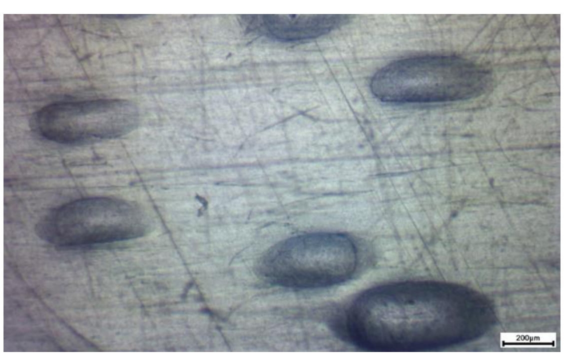
webindustries

Cast-film extrusion is a polymer extrusion process that has been performed since the 1930's. Polymer pellets are mixed in a hopper, which then feeds into a heated rotating screw inside of a metal barrel. As the polymer melts it is moved towards the die of the extruder through a screw motion. The die will shape the polymer melt into a sheet as it leaves the extrusion portion. A chill roll is placed under the path of the solidified sheet to extract heat from the melt and solidify it. Many different polymers can be processed in this way. High-density polyethylene, HDPE, is a common material choice for extrusion due to its preferable properties and manufacturability. It is a very simple polymer with a carbon chain with hydrogen atoms that is defined as a thermoplastic, meaning it can be reprocessed to minimize waste.



A variety of complications can occur when introducing a new thermoplastic mix to an extrusion process. The possible sources of problems are usually extrusion speed and temperature profile within the barrel. On the sponsor's industrial-scale extruder, bubble-shaped inclusions are occurring in the cast-film extrusion of the HDPE mix. This could have an adverse effect on the mechanical properties of the film and is not acceptable for applications after production. The goal of this project is to identify the inclusion through materials characterization methods and propose a solution to this problem. There are specific criteria that guide the final solution. These criteria include the speed at which the resin can be produced and the capabilities of the industrial extruder available.





Tests using the specified HDPE mix were performed on a small-scale laboratory extruder. Pressure readings inside the barrel, screw RPM and temperatures were recorded during trial runs. This information was used to find the shear pressures experienced during the extrusion on the sponsor's industrial-scale extruder. Micrographs were taken using a scanning electron microscope of a cross-section of the bubble defect. Energy dispersive X-ray spectroscopy was performed on this cross section to establish the elemental makeup of the bubble inclusions. This information was then compared to available literature to find possible sources of the problem.

Pictured from Left to Right: Ryan Vernlund, Truman Strodel, and Drew Cietek

MATERIALS SCIENCE & ENGINEERING

TEAM: 7

SPONSOR: United Technologies Aerospace Systems

ADVISOR: Dr. Rainer Hebert (Faculty Advisor); Diana Giulietti (Industry Advisor)

Additive Manufacturing of Ceramic Molds for Complex Titanium Castings

Current mold manufacturing techniques for rapid prototyping of titanium alloy castings are quite expensive and time consuming. The current industry standard is investment casting, which involves diecast wax forms, extensive manual labor, and approximately six months from design to final part. If successful, this cutting-edge process will permit the omission of virtually every step between the technical drawing and mold curing and decrease total processing time to a few days.

This project is focused on the development of an additive manufacturing process to fabricate ceramic molds for casting titanium alloys. These molds must incorporate complex inner geometries - with tight tolerances - capable of withstanding the harsh environment of centrifuge casting.

The major objective is to formulate the entire process from raw materials to ceramic mold ready for casting. UTAS will seek a partnership with Austrian company, Lithoz, that fabricates advanced ceramic powder additive manufacturing machines. Therefore, a material system and printing routine compatible with Lithoz's technology must be developed. The complexity and scope of the project requires two primary phases, to be completed across multiple Capstone Senior Design projects.

Phase I constitutes selecting ceramic powders and a photo-curable binder system to make up the slurry, then optimizing print parameters on a desktop version of the Lithoz machines. Once samples are successfully printed, they will be characterized by surface roughness, density and porosity. Next, samples will be subjected to an extensive post-process routine involving a long, low temperature exposure to burn out the cured polymer matrix; then immediately ramping temperature to sinter the ceramic particles for a number of hours to ensure consistent consolidation. The final objective is to characterize mechanical strength of the as-sintered specimens to correlate slurry composition and print parameters with mold strength.

Phase II goals will be more focused on transferability to the Lithoz machines as well as optimizing the process based on conclusions reached in Phase I. Potential adjustments to the constituents and ratios in the slurry may be made, as well as investigation into, or adoption of, new post-processing methods and parameters. Finally, it will be essential to the project to select or develop a face-coat primer for the interior surface of the mold in order to achieve minimal surface contamination specifications established by UTAS.

UTC Aerospace Systems

MATERIALS SCIENCE & ENGINEERING

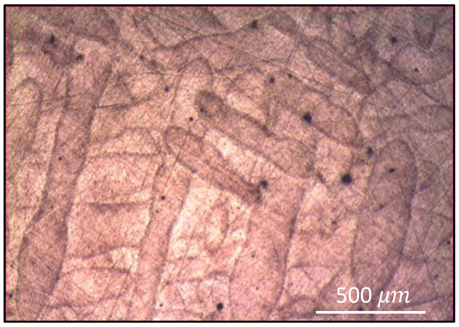
TEAM: 8
SPONSOR: Lockheed Martin Sikorsky AM
ADVISOR: Dr. Seok-Woo Lee
Tom Derko (Sikorsky)

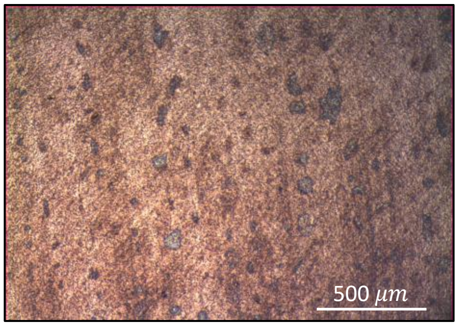
Left to right: Carl Rizzo and Carissa Dibattista

Optimized Post Processing Treatment of Additive Manufactured AlSi10Mg

AlSi10Mg is a growing choice of material in additive manufacturing for industry as it exhibits excellent bonding during the DMLS process. These high strength bonds in the sintering process are due to a relatively small coefficient of thermal expansion compared to other metallic powders due to the relatively large composition of silicon. However, the large silicon content and internal porosity reduces the mechanical properties of the alloy. Through this study our group will design a post processing treatment in aim to optimize the mechanical properties of DMLS produced AlSi10Mg parts. By designing an optimized post processing method our group will expand AlSi10Mg applications for Sikorsky AM while reducing production time and costs compared to traditionally fabricated parts.

Today there is a strong need for additively manufactured parts in industries across the globe. 3D- printed parts waste less materials, are faster to manufacture, and are cheaper compared to casted parts. Sikorsky AM desires to achieve Aluminum 6061 T6-like mechanical properties for AlSi10Mg additive manufactured parts. These parts were produced using Direct Metal Laser Sintering (DMLS) with the powder bed fusion process on an eos machine. The DMLS process is known to cause internal pores in the part which hinder the mechanical properties and act as stress concentrators under loading. Through hot isostatic pressing we will measure the change in porosity compared to the as built part.





In order to quantify the post processing treatment design mechanical tests were performed including tensile and hardness testing coupled with microstructure characterization. Testing was conducted on dog bone samples received from Sikorsky printed on two different machines. To incorporate multiple printers in our design increases to reach our solutions have on translating in an industrial setting. Mechanical properties of interest are yield strength, ultimate tensile strength, Young's modulus, and elongation at break compared to the as received AlSi10Mg and Aluminum 6061 T6 well known properties. Images to the left: (Top) brittle fracture surface of an as received sample, (middle) microstructure plane perpendicular to the z-axis (z-axis is the build direction), (bottom) microstructure plane perpendicular plane to the z-axis of heat treated sample at 530°C for two hours.

MATERIALS SCIENCE & ENGINEERING

TEAM: 9

SPONSOR: Sikorsky Aircraft

ADVISOR: Rainer Hebert (UConn)

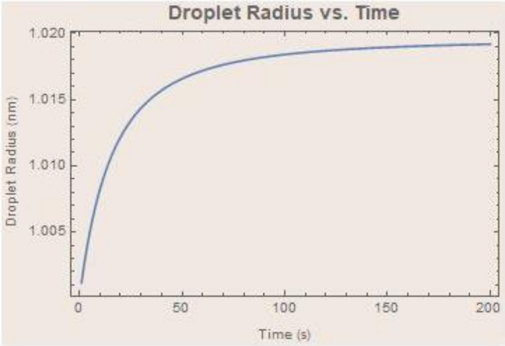
Karen Williams & Kingsley Iwu (Sikorsky)

Keara Frawley, Courtney Dawless, Rainer Hebert

Paint Adhesion Modelling and Evaluation

Sikorsky is an aircraft manufacturer that produces both commercial and military helicopters. This project deals with improving the process of paint selection. There are two main reasons for applying paint to an aircraft: protection and visual appeal. Aircraft are painted in order to prevent damage from corrosion, and the quality of the painted surface is key to the performance and the longevity of the aircraft. If the paint begins to peel or the surface corrodes, valuable time and money must be spent stripping and repainting the aircraft. If these defects are not fixed, the aircraft will degrade faster due to corrosion. Appearance is also an important factor. For example, some aircraft are painted with a camouflage pattern or with radar-absorbing paint for military purposes while others are painted with a company logo as a form of advertisement. Peeling paint is unattractive to customers and affects the performance of paint designs such as camouflage. Some of the factors that are important when selecting a paint are: adhesion capabilities, compatibility with substrate & with other coatings, coating thickness & weight, processing time including application & cure time, cost, and Environmental, Safety, & Health considerations.

The first objective of this project is to create a model to calculate whether a paint will adhere to a substrate using the values of material properties provided to Sikorsky by their suppliers. When a new paint distributor sells their product to Sikorsky, the company should be able to determine if the paint will adhere adequately by plugging in a few material properties. The model's output should be simple: either a "yes" or "no" regarding whether the paint will adhere. The second objective is to evaluate the performance of the model. Constraints on this model are that it should be relatively simple and easy to use, it should have a short calculation time, and it should only use variables that are available from Sikorsky's suppliers.



The proposed solution is to create a graph of droplet radius versus time. As a paint droplet lands on the substrate, it spreads from its original shape and becomes flatter. At a certain time, the radius reaches its maximum value, where spreading no longer occurs. If, at a designated time, the droplet has achieved its maximum radius, adhesion between the paint and substrate will be considered satisfactory.

TEAM 10: Ryan Dibiase, Michael Gingrave, Greg LaDestro
SPONSOR: Pratt & Whitney
ADVISOR: Professor George Rossetti, Dr. Elisa Zaleski

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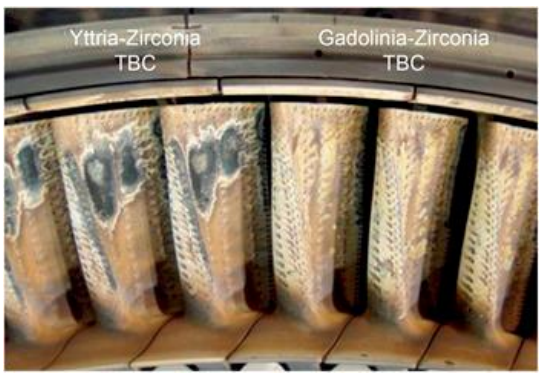
From left to right: Greg Ladestro, Ryan Dibiase, Michael Gingrave

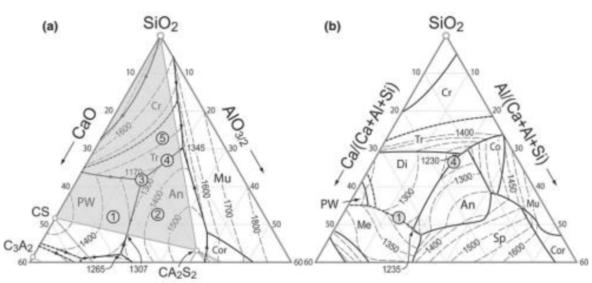
Design of a Method for Better Predicting CMAS Infiltration into Thermal Barrier Coatings

Pratt & Whitney
A United Technologies Company

Aerospace industry is a multibillion dollar industry with a significant impact on military and civilian life. In term of plane and jet engines, thermal barrier coating are integral to their operation. The thermal barrier coating allow for increased durability of engine parts, by reducing the max temperature that the parts reach. While in flight the gas turbine engine will ingest sand, dirt and ash and this siliceous debris is what is known as CMAS. The high temperature environment that this CMAS enters causes it to melt and infiltrate into the thermal barrier coating causing significant degradation of the coating. This degradation of coating is inconsistent and causes the part to be pulled from the engine earlier. This costs the airline and maker of the engine a lot of time and money to remove the engine from the plan and repair the parts. Currently there are no existing models to accurately predict the CMAS infiltration into the TBC coatings. If a sufficient model can be created life of the engine parts can be more accurately calculated and further CMAS preventative measures can be made by understanding its flow into the coating.



Our team is investigating the effects of one specific family of contaminants called calcia-magnesia-aluminosilicates (CMAS). In particular, our focus is on how composition affects the viscosity of CMAS. An experiment using a Rheotronic viscometer on multiple CAS and CMAS compositions to gain a wide range of viscosity data. This viscosity data is to be compared to the Giordano model, a model that predicts the viscosities of molten oxides. We are using common data analysis, the student T test, to compare the experimental data and model predicted viscosities. Additionally, isothermal infiltration tests will be done to see how the target CAS and CMAS samples affect engine relevant samples. These test are used to characterize the degree of infiltration and extrapolate viscosities role in the infiltration of the barrier coatings. We are trying to find a correlation between the predictive and experimental data in hopes of improving a model that is being generated by a corresponding mechanical engineering design team that is modeling infiltration of the TBC systems.



Haley Hubbell and Alexa Wilcox

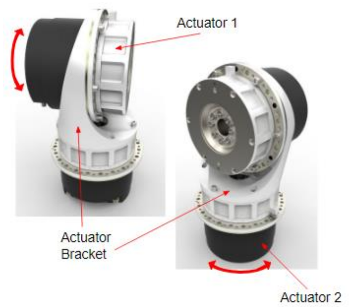
MATERIALS SCIENCE & ENGINEERING

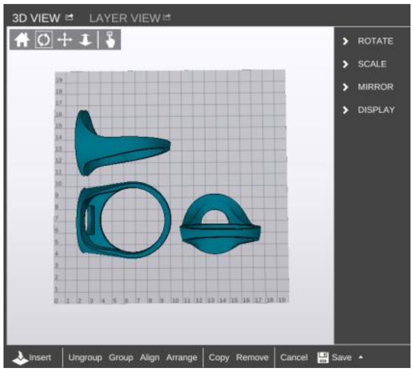
TEAM: 11

SPONSOR: Ensign Bickford Aerospace & Defense

ADVISORS: Rainer Hebert, John Graham, Robert Morlath

Investigation of Additive Manufacturing Design, Processes, and Variables to Enhance a Ti-6Al-4V Actuator Bracket

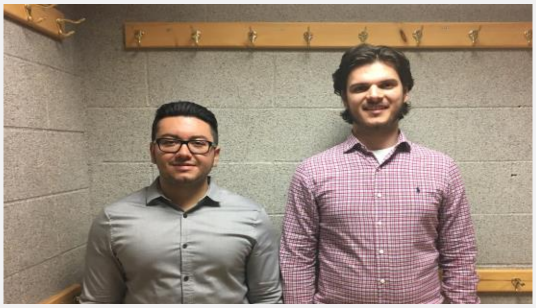




Additive manufacturing is a process by which objects are formed by layering material, as opposed to traditional subtractive manufacturing. Additive manufacturing of metals has become increasingly popular due to its ability to produce intricate components and assemblies in a timely manner without the use of traditional metal joining methods such as brazing or welding. In addition, pieces with complex geometries can be produced due to the precision additive manufacturing brings, more so than traditional methods such as casting.

As technology continuously improves and more production methods become available, it is very important to study their different aspects and how they affect not only materials characteristics but also time and cost. The purpose of this capstone design project is to investigate additive manufacturing techniques, specifically electron beam melting (EBM) of Ti-6Al-4V and fused deposition modeling (FDM) of polylactic acid (PLA). From these findings we hope to determine the best way to additively manufacture titanium spacecraft actuator brackets for Ensign Bickford Aerospace and Defense. These brackets are used to secure two actuators together at a 90° angle to promote a wide range of motion for mechanisms, pointing the antenna and solar arrays in the proper direction as a spacecraft is in orbit. This multi-axis platform will permit precise motion encompassing the Ensign Bickford values of being best in class and having the highest standards of reliable peak performance.

The main focus of the bracket is a scalable design that has high structural stiffness, yet low in weight once 3D printed. In addition, the design must have a relatively low cost when compared with a machined bracket. The main stress points will be identified through digital simulation and mechanical testing, as well as identifying highest strength orthogonal print direction. As a team, we will be advancing our personal studies in additive manufacturing, but we will also be creating a baseline of 3D printed Ti-6Al-4V mechanical performance as manufactured by UConn's equipment. We hope to return to the Ensign Bickford facility to perform unique and environmental testing to simulate the actual stresses the bracket will undergo in use.



Sebastian Salazar & Kenan Jasavic

MATERIALS SCIENCE & ENGINEERING

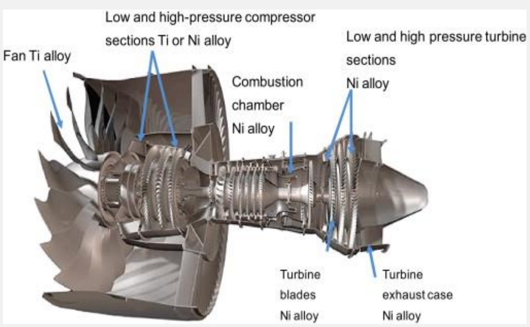
TEAM: 12

SPONSOR: Pratt & Whitney

ADVISOR: Dr. Brody (UConn),
Dr. Thomas (Pratt & Whitney)

Modeling the Flow Stress Behavior of Inconel 718 Under Hot Forging Conditions

The flow stress of a material could be defined as the value of stress that is required to keep a metal flowing, or plastically deforming. As you might imagine this is a very important property to understand, especially in the aerospace industry, where raw material is converted into various parts and shapes everyday. Hot forging is one of the most common techniques used to shape metal parts. At temperatures above a material's recrystallization temperature, the raw metal is compressed via the use of dies. These dies are required to plastically deform the metal, so the amount of stress applied must be equal to the flow stress.



Three main parameters are discussed when dealing with flow stress: temperature, strain rate, and strain. All of which can vary when dealing with different materials and different processing techniques. For our project we were tasked with the mission to connect these parameters to flow stress and have that connected to the hot forging of Inconel 718, a material commonly used in engine mounts due to its impressive elevated temperature properties. A model would help predict the amount of flow stress required to plastically deform the metal, but also show the upper limits attached to the stress. Understanding these higher limits is important to help prevent crack formation in parts during cracking. Having a constitutive model would help to optimize the parameters that can be controlled during a forging and thus improve the process as a whole.

To do this project, a number of tests were done on a thermalmechanical simulator called the Gleeble 3500. This machine allows us to control certain parameters such as temperature, strain, strain rate, and cooling rate so we can better simulate what a part would go through during forging. An initial set of tests were completed first to give us data to analyze and model. After selecting a model, extra testing was done to validate the accuracy of the constitutive model. In addition to this, microstructural characterization was done via optical microscopy and scanning electron microscopy to ensure a fine grain size after the process which would lead to better performing parts.

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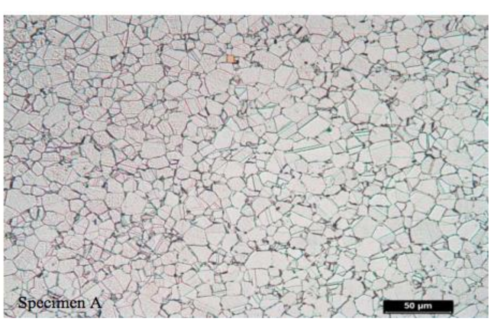


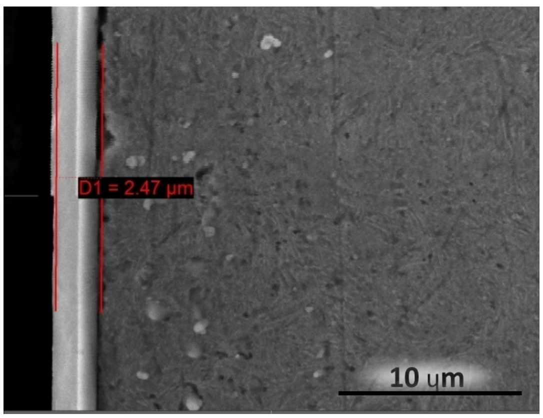
MATERIALS SCIENCE & ENGINEERING

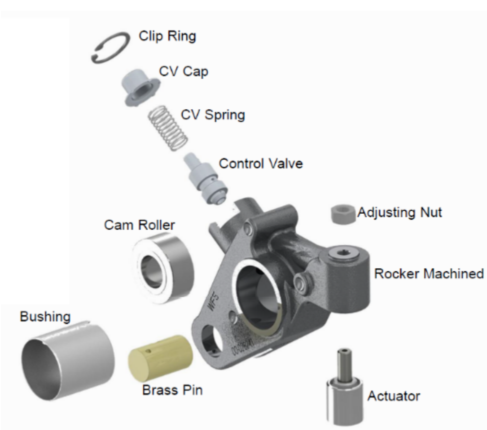
TEAM: 13
SPONSOR: Jacobs Vehicle Systems
ADVISOR: Matei Alexandru

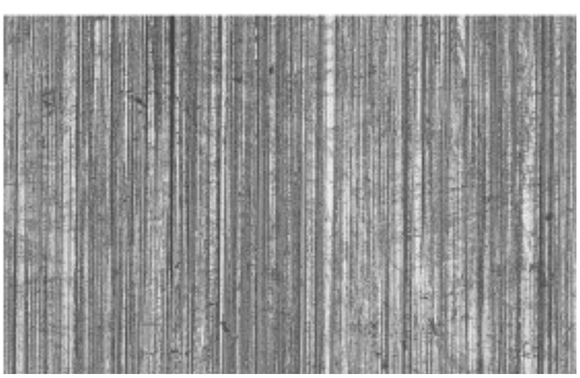
Gavin McCarthy (left) and Manjoor Vahora (right)

Rocker Engine Brake Roller Pin Development

Jacobs Vehicle Systems™







Recently, the development team of the rocker engine brake roller and roller pin have noticed a need for more information regarding the selection of the specific materials, for the roller pin component, and the impact they have on the performance of the rocker brake engine system. This information will allow them to redirect their energy and resources towards an efficient solution of selecting which material would be more suitable for its application in an operating diesel engine. Their need for this project arose from the negative environmental effects of using their primary alloy blend as the material for the rocker brake engine roller pin, its low abrasive tolerance, and low operational lifespan. The necessary material analyses on the roller pin components need to be done in order to learn more of the pin's surface morphology and physical properties and determine what factors are important to consider while developing an alternative design. In providing a detailed understanding of how the roller and pin materials interact with their surroundings within operating condition in regards to their wear/abrasive resistance, fatigue resistance, oil contamination, fracture toughness, and mechanical loss. Furthermore, the goal is to find out whether a cheaper, safer, yet efficient option is available since their primary alloy blend is expensive, harmful for the environment, and not on par with the current global standards.

The experimentation involves a pin-on-disk arrangement of our proposed alloy blend, AISI 52100 with a DLC coating applied with chemical vapor deposition, against a standard stainless-steel alloy blend with oil lubrication in between the two contact points. The two contact points will be under a constant load ranging between 8-14kN, at a temperature of 150°F, and for prolonged periods of time to simulate actual operating conditions. This set-up tests our proposed alternative material design for the wear and fatigue resistance, the extent of oil contamination, and the friction coefficient. Afterwards, the tested samples are analyzed with a scanning electron microscope to determine the extent of wear and the associated wear mechanisms and the composition of the contaminated oil to ensure no environmentally harmful particles broke off from the pin material.