Senior Design Projects, Winter 2018

TARDEC – Leader/Follower Guided Vehicles

The Tank Automotive Research, Development, and Engineering Center (TARDEC) of the US Army Tank-Automotive Command (TACOM) has developed the following project, which will involve four multidisciplinary teams:

> Develop, build, test and demonstrate a small robot that will follow a non-contacting signal, such as a laser pointer projected on the ground or a line of breadcrumbs. A total of four robots will be designed and built, each that can be directed by the signal and produce a directing signal for a following robot. The goal is to have any one of the four robots be directed with a hand-held signal, while the other three robots, in any order, follow in line behind the first robot. Accuracy of following the signal as it moves forward, to the side, in reverse and stops, is paramount.

Because of the nature of the project and the potential need to visit the TARDEC installation, participation in this project is limited to US citizens.

Serapid - Cryogenic Chain Research

Serapid manufactures automated lifting and moving systems based on its Rigid Chain technology. Recently, we have been asked to operate with in temperature extremes. Extended temperature specifications require operation between -40°C to 125°C. More recently requests have been made for operation at military temperature extremes between -55°C to 125°C

At the cryogenic temperature range, materials may suffer embrittlement. The rigid chain is a complex assembly utilizing a few different materials. The Serapid telescoping mast product (Figure 1) is driven by a rigid chain, has been tested for operability at cryogenic temperatures and has not failed. The fact that the chain driving the system has not failed does not give any indication of the capability of the system.

The goal of this research is to determine the thermal embrittlement temperature of the chain assembly and to propose a method of derating the chain for cryogenic operation.

Equipment
For the project, the engineers will require access to an Oakland University tensile testing machine. Preferably this will include an extensometer or other method of measuring total elongation. Other test equipment, may be supplied by Serapid, if needed. This may include:

- Contact Thermocouple
- Thermocouple to USB interface
- Chain assemblies and chain plates
- Digital Storage Oscilloscope

The engineers will need to design appropriate test fixtures for easily attaching and exchanging chain sections in the tensile test machine.

Proposed Methodology

- Engineers will determine the appropriate test protocol to be approved by Serapid prior to commencement of testing.
- Chain sections may be cooled to cryogenic temperatures using dry ice (-78.5°C), liquid nitrogen (-196°C), or other cooling means. Selection of cooling method must consider safety in material handling.
- Cooled chain section may be placed into the tensile test fixture. Allow the chain to slowly warm to test temperature. Once at temperature, the tensile test is performed, recording load and chain elongation. Test is repeated at multiple temperatures from room temperature down to -55°C.

Results

Engineers should survey available test literature and commercially available material data to see if test results are consistent with available information. Explain differences. Upon completion of the research, the Engineers will:

- Design and build a test fixture.
- Perform tensile tests recording data
- Determine a cryogenic embrittlement temperature or behavior.
- Make recommendations concerning derating the chain for cryogenic operation.
- Make other recommendations (material, geometry, or other) for mitigating the
- effects of embrittlement.

Non-disclosure and non-compete agreements are required before students can commence work on this project.

American Axle and Manufacturing – Spider Fatigue Improvement

When testing spiders (the universal joints at the ends of driveshafts), there is a large amount of variation in test results (fatigue cycles to failure). There is a need to remove some factors from fatigue testing, i.e. bearing cup fit, misalignment of rotary actuators at RHTC, fatigue fixtures not maintained at RHTC, spider dimension variation from GMC, etc.

Scope of work:

- Design test stand and fixtures such that a single load can be applied to a single Spider Trunnion (1355 series)
- Working set of prints to make test stand
- Make fixture
- Perform FEA analysis of spider test, make prediction of fatigue life
- Design the DOE for fatigue test
- Order parts and perform measurement of test pc (dimensions and residual stresses, surface hardness, surface finish)
- Run DOE on fatigue test stand
- Make design improvements to spiders
- Run confirmation tests
- Generate final report

Non-disclosure and non-compete agreements are required before students can commence work on this project.

SECS Formula SAE Team - Active Aerodynamic Package

This project will develop an active aerodynamic package for the Formula SAE vehicle. An active aero package should improve handling, braking, and acceleration of the Formula SAE vehicle, ultimately improving the ranking of Oakland University in the global Formula SAE competition.

The project will focus on the front and rear wings of the Formula SAE vehicle reacting to a driver's input during braking, acceleration, and turning. The active aerodynamic package will have mechanical, electrical, and computer engineering aspects to its implementation:

- Mechanical - mounting of the hardware, simulation and calculation of necessary wing movement for maximum performance gains, CFD and FEA simulation to determine wing movement and the supports needed for this design
- Electrical - wiring of and power supply of the stepper motor/linear actuator for wing movement and the sensors needed for driver input
- Computer - program the components to work in unison

The design of the entire system will be determined by the project team and approved by the Formula SAE team. The core components to be implemented are a brake pressure sensor, throttle position sensor and a steering angle sensor. The movement of the actual wings will be controlled by either a geared stepper motor or a linear actuator. The hardware that will be used to collect and transfer data will either be an Arduino or a Raspberry pi and the programming will be written by the design team. Any suggestions on changes of the design with be put into a design matrix and decided on by the Formula SAE team.

Wave Water Works – System Modeling

In the past year, several senior design teams have focused on developing a working prototype of a small water-wave electrical generation system that centers around the Oscillo Drive®, a patented mechanical rectifier that converts the oscillations of the wave motion to a unidirectional rotation suitable to drive an electric generator. This effort culminated in the successful deployment of the physical prototype in December 2017. To generalize the results of the physical test and as a useful guide for future applications, detailed modeling of both the mechanical and electrical systems is necessary.

Mechanical subsystem

- Develop alternative ways to transfer low-speed, high-torque mechanical water wave energy to the Oscillo Drive®, including (but not limited to) mechanical linkages and hydraulic actuator/motor systems
- Parametrically model the complete mechanical system to accommodate and predict the performance in various applications with various wave heights and frequencies, and to drive various electrical generators
- Determine a list, including costs, of readily available mechanical components that can be used to construct the mechanical systems modeled

Electrical subsystem

- Develop alternative ways to produce, store and deliver useful electrical energy, given the low-speed, high-torque output of the water-wave driven Oscillo Drive®
- Parametrically model the complete electrical system to accommodate and predict the performance in various applications with various wave heights and frequencies, driven by various mechanical actuators
- Determine a list, including costs, of readily available electrical components that can be used to construct the electrical systems modeled

The goal of this phase of the project is to be able to identify and input the characteristics and specifications of a potential installation (average wave height and frequency, water depth, distance from shore, power requirements, etc.) into a software tool that would produce the appropriate number and type of mechanical and electrical system components for successful implementation.

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Lear Corporation – Wire Harness Installation II

Wire harness products are extremely labor intensive to assemble and install. Correct installation is critical to the performance of the vehicle over its entire lifecycle. Many new technologies have been developed for installing complicated parts to vehicle assemblies, however, wire harness products have found very limited gains from these technologies. Commonly when asked the question "what would make the harness easier to install?" most auto workers will respond with "make it install itself".

Project Objectives

- Understand challenges of wire harness assembly, packaging and installation
- Understand how these challenges can affect the product performance in the final installed position
- Develop enhancements to overcome these challenges for improved product performance with reduction of installation time

Project Deliverables

- Detailed definitions of product enhancements with supporting documentation of experiments conducted
- Prototype product/s samples with the defined design enhancements
- Time trial studies of before and after enhancement products around areas of assembly, packaging and installation

A team of students looked at various technologies in the Fall 2017 semester, and made progress in developing techniques that would assist the proper installation of wire harnesses. Lear wants to build on this progress and continue to explore assistive techniques and technologies.

The Fall 2017 team was able to

- Develop concept of using memory shaping metals
- Prove out concept on small bench-level scale

- Complete a prototype of the Nitinol Wire Harness using a mix of super elasticity and plastic recovery properties

Goals for the Winter 2018 team:

- Collect and analyze data on Nitinol performance - heat to movement to time, etc.
- Develop overview of product cost and weight analysis

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Lear Corporation – Energy Harvesting II

Energy harvesting from vehicle electromagnetic field (Non-stable Energy) passing through a loop area (wires) which in turn induces current that can become an energy producing source. These electromagnetic Non-Stable Energy sources can come from electrical/electronic circuits, lighting, RF transmitter, high speed data, electric motor, video displays, engine coils, near high frequency PWM electronics etc.

OBJECTIVES

- Understand specification drivers for: Power requirement, Safety aspect, Reliability and
- Sustainability
- Understand the potential of the flux and to what extend that can be used as a source solution of
- power
- Understand other potential power source innovation

DELIVERABLES

- Illustrate and demonstrate captured EMI field measurements (EH sweet spots) conducted in a
- vehicle (electromagnetic disturbances)
- Show key components that are vital to the functioning of an energy harvesting system
- Energy to Voltage conversion mechanisms
- Demonstrate energy storage mechanism and energy storage element
- Quantify energy generated and power management energy captured efficiency

A team of students looked in detail at the available excess electrical energy within a small sample of vehicles in the Fall 2017 semester, and developed prototypes to capture and store some of that energy. Lear wants to build on this progress and continue to explore automotive electrical energy harvesting.

The Fall 2017 team found:

- It was determined that an extremely small amount of energy could indeed be harnessed but due to the electromagnetic shielding a car is designed to have, the energy that was harnessed was far too small to offer any sort of advantage.
- The use of a communication signals such as the ISM band of frequencies is not the ideal band to target to begin with due to the low power they produce and the potential for interfering with sensitive information.
- The gain acquired from the circuit is not able to power any sensor continuously nor efficiently.

Goals for the Winter 2018 team:

Using a vehicle with higher voltage, such as a GM Volt (fully electrical vehicle), be able to

- Illustrate and demonstrate captured EMI field measurements (EH sweet spots) conducted in a vehicle (electromagnetic disturbances)
- Energy to Voltage conversion mechanisms & demonstrate energy storage mechanism and energy storage element
- Quantify energy generated and power management energy captured efficiency

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L&L Products - Weight and Cost optimization of PA glass and carbon content

Develop design optimization of B-pillar Reinforcement based on weight and cost for different filler content of PA66. To be evaluated 30% short glass (baseline), 30% long glass, 10% carbon fiber, 20% carbon fiber, 40% carbon fiber. The design optimization must maintain good molding characteristics, including consistent wall thicknesses, reasonable injection pressures and meet the design requirements.

The baseline requirement for this project will be based on a three-point bend test with both force and energy requirements. The optimization weighting shall be 2/3 cost and 1/3 weight. Skills necessary include CAE analysis, design optimization, injection molding feasibility, injection molding manufacturing cost estimation

As a confirmation run, the lightest solution shall be evaluated as designed, but with a 3D printed material. The part will be printed and tested in a 3-point bend with predictions based on the design and 3D printed material.

Objectives and Desired Achievements

1. Analyze the characteristics of each type of fiber
2. Collect pricing information for each
3. Compare and contrast the material properties and price points
4. Recommend which option(s) would be a cost-effective fit for L&L and how these could be incorporated into a part design
5. Present the results

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L&L Products - How to evaluate wear on screws

L&L Products currently manufactures parts using reciprocating screw injection molding machines. One of the materials that are molded are 30% glass fiber reinforced Polyamide (Nylon). The nature of the material and process are that the screw wears over time. This project will be to determine a test method to rapidly simulate this wear, optimally in 2-3 weeks instead of 2-3 years. Skills necessary include material characterization, machine design and build, and creativity.

Objectives and Desired Achievements

1. Observe injection molding processes
2. Analyze various ways to determine wear on screws

3. Choose the best option
4. Build Test fixture and do initial correlation work on 2 different samples.
5. Present the results

Non-disclosure and non-compete agreements are required before students can commence work on this project.

Room-Temperature Molding of Various Polymers

In the Winter 2017 semester, a team of students began to explore leveraging the 3D printing capabilities of the SECS to produce parts in polymers that are not available to 3D print. The group ultimately designed and 3D-printed a two-piece, reusable mold, then successfully used the mold to cast several copies of a complex part in liquid silicone rubber (LSR), all for total cost of under $100.

We will continue to explore this technology, and develop techniques to mold other polymers that cure at room temperatures, such as urethane and epoxy. Such rapid and flexible manufacturing techniques are possible only with 3D printing, and many manufacturing companies are very interested in exploring and developing these types of techniques.