SECS Senior Design
Available Projects – Winter 2021

Force measurement in sheet metal inflow

Project Sponsors: Sergey Golovashchenko, PhD (golovash@oakland.edu), Srecko Zdravkovic, PhD (szdravkovic@oakland.edu), Hongwei Qu, PhD (qu2@oakland.edu)

The proposed project targets the development of technology and instrumentation for measuring forces controlling sheet metal inflow into the die cavity. This effort is addressing the major need in automotive industry of minimizing variability in produced sheet metal components such as doors, hoods, decklids, fenders, etc. Typical deviation in dimensions of panels accepted by automotive industry is within 0.5 mm for outer skin panels and 1mm for interior panels. With general trend to make cars and trucks lighter and use more advanced Ultra High Strength Steels and Aluminum Alloys, the dimensional stability in sheet metal stamping becomes a more significant challenge. Even though all parts coming from a stamping line seem to be the same, there are phenomena such as die wear, variability in properties of sheet metal, non-uniform lubricant distribution on the surface of the blank, and accumulation of dust type particles separating from stamped panels on the surface of the stamping die. The project targets the development of sensors which would be able to capture significant deviations from normal stamping conditions in production dies.

The general concept is to develop a sensor design suitable for measuring loads in drawbeads of a stamping die. The development will include the following steps:

1. designing a testing fixture based upon the existing drawbead simulator in OU Sheet Metal Forming lab. The CAD of the drawbead simulator and the opportunity to see it in operation will be provided to the team/designated team members assuming the restrictions on COVID will allow it;

2. selecting the sensor candidate from industrially produced range of sensors, designing the method to incorporate the selected sensor in the fragment of experimental die, developing an electric circuit for amplifying the signal from the sensor and storing it in the computer;

3. developing the actual testing fixture to measure the loads in a fragment of a drawbead with actual dimensions used in production dies.

The resources to purchase the material for designed components and to purchase necessary off the shelf parts will be provided by OU Center of Advanced Manufacturing and Materials. The CAMM research group will be also helping in testing the designed fixture using the existing equipment.

IMPORTANT: Non-disclosure and assignment agreements are required before students can begin work on this project. This project will require time on campus during the Winter 2021 semester. If you are uncomfortable coming to campus or have issue with any of the procedures or requirements of being on campus (https://oakland.edu/return-to-campus/), please do not select this project.

Evaluation/Development of a Vision-Based Panel Defect Inspection System

Project Sponsor: Ford Motor Company (James Engle, jengle8@ford.com)

The stamping manufacturing process is influenced by many variables, including changes to the equipment operating parameters and the condition of the material being formed. The resulting product will show defects when the influences are not calibrated correctly.

Defective stamped panels contribute to millions of dollars in scrap each year. This is because there is no reliable, repeatable means of inspecting the panels for defects while the stamping process is running. Currently the process relies on manual inspection as the parts are placed into racks, requiring a human to visually inspect panels as large as 3m x 1m with panels coming out every 4 seconds. Before a vision system is selected to replace the manual inspection process, competing systems must be vetted for accuracy and reliability or the Plant will not trust them as a replacement.

Project Scope: Evaluate both acceptable and defective stamped panels using multiple vision system based analytical tools with differing machine learning protocols. Qualify the systems based on accuracy, ease of use, and model maintainability.

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Development of a Vision-Based Part Orientation/Identification System

Project Sponsor: Ford Motor Company (James Engle, jengle8@ford.com)

Design Challenge: Using an inexpensive webcam, develop a system to (1) identify correct blanks and (2) confirm blank location and orientation on pallets prior to stamping operations. The actual measured location is to be compared to Ford’s BPLS (Blank Pallet Locating Specification) to ensure the blank locations and orientations are within the specification and tolerance before advancing to processing. A material-handling pallet and blanks will be supplied by Ford.

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Development of a PAC Man Automotive Bushing

Sponsor: Airboss Flexible Products (Jeff Auten, Jeff.Auten@Airbossofamerica.com)

The project would include the production of a Pac man bushing for automotive. A bushing is an elastomeric product that has elongation properties. The company Airboss Flexible Products produces many varieties of bonded rubber bushing made for vehicle chassis such as swaged bushings.

The split/Pac Man bushing are utilized to reduce friction on the shaft and utilize a thin cross section. The split in the material allows for ease of installation of the bushing. This would be a new process that the company would be developing with the data from this project.

Aachievements and objectives include creating a double bonded metal to rubber. The functional requirements are to meet and produce a working bushing sample that performs against other companies, and the functional requirements met by Airboss flexible products. The design challenges are that the company has never made a product like this variant. Therefore, there are many unknowns with this project. CAD, FEA and prototyping will be provided by Airboss.

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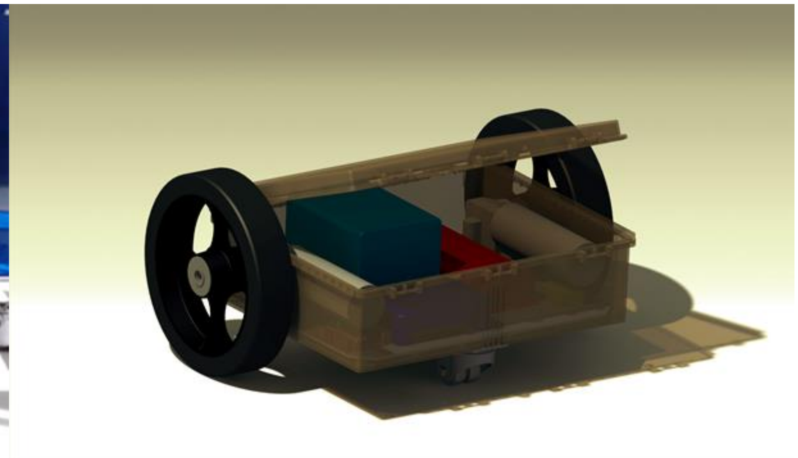
Afreecar E-Kit

Project sponsors: Christopher Borroni-Bird (chris@afreecar.org), Richard Saad (rich@afreecar.org)

Afreecar seeks to achieve its mission to provide sustainable power and mobility for all the world's people by providing a universal e-kit that can retrofit to an existing non-motorized vehicle (e.g. wheelchair, tricycle, wheelbarrow, hospital bed, linen cart, etc.), providing power assist and enabling the vehicle to become a mobile power source. Afreecar sponsored a project in Fall 2020 with OU SECS that led to both improvements in a solar electric cart (left image below) and to a design for the universal e-kit (right image below).

The Winter 2020 project can build off both these accomplishments in the following way:

1. Testing the solar powered e-cart in an urban farm environment for range, performance, load carrying capability, user interface, etc.. This work is necessary for determining the utility for its intended rural Sub-Saharan Africa operation. Testing results will be compared with Altair’s software simulation. Areas for improvement will be identified and, time permitting, design solutions can be devised.

2. Finalizing the e-kit design by developing the attachment mechanism that allows it to integrate easily with a variety of different non-motorized vehicle types. The final e-kit will be assembled (from purchased components) and unique parts will be fabricated (e.g. 3d-printed). Time permitting, the e-kit will be tested on a bench and/or integrated into one or more agriculture and healthcare type vehicles (e.g. wheelchair, wheelbarrow).

https://afreecar.org/pages/inspiration

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Electro-thermal and mechanical designs for MEMS actuator

Project sponsor: Hongwei Qu, PhD (qu2@oakland.edu)

Researchers in the SECS have used dedicated software tools for modeling, design, FEM verification of MEMS devices. A variety of MEMS devices have been fabricated and tested. After the SECS obtained and deployed COMSOL, a multi-physics FEM tool widely used in industries, use of the previous software ended. Students will learn the basics of MEMS design; apply the concepts of structural design, material science and mechanics to analyze the MEMS devices; and use COMSOL to verify the design.

For more information: Design and Verification of Micro Electrothermal Actuators for MEMS Switches

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Design of a solar system for residential homes in SE Michigan

A startup company in SE Michigan is looking to design a solar array system to be mounted on roof tops of 2-story, colonial homes with square footage of 3,000 sq. ft. This system will provide direct or auxiliary electrical power to the home. The system will also be able to store excess power to a battery system on site and/or deliver excess power to the grid as authorized by the local utility company.

The team is tasked to design this solar array system for the startup company. The analysis most include a cost/benefit analysis that considers average sunlight, tree shading and other environmental issues that may limit the efficacy and/or efficiency of the installation. The design must include all the necessary electrical, mechanical and computer control systems to install, operate and maintain the system, including those that integrate with the local utility infrastructure. Also necessary is an analysis for the payback period of such a system as a marketing tool to be shared with potential customers.

Design and performance of an electromechanical shock absorber

With the increased replacement of combustion engines with electric drives on applications such as automotive vehicles, lawn-care, earth moving equipment, there is a similar trend in designing new electromechanical devices to replace the traditional all-mechanical components. One of these components is the electric shock absorber.

The team will be tasked to select an application that utilizes mechanical shock absorbers and convert the design to an electromechanical system that is computer controlled to achieve similar or better performance characteristics. Performance should be demonstrated through modeling of the electromechanical system using modeling software such as SolidWorks and/or Simulink.

Test Fixture for Asymmetrical Heating/Cooling of a Lithium Battery Module

Project sponsor: Stephen Bazinski, PhD (sbazinsk@oakland.edu)

The purpose of this project is to design a laboratory test fixture which allows for each of the pouch cells of a lithium battery stack (< 60V for safety) to be programmed to maintain its own unique and automatically controlled temperature.

As a battery module in a vehicle pack (similar to the one shown here) reaches steady state in cold weather, the outermost cells at the ends of the cell stack are colder than those in the middle. This asymmetrical temperature across the battery module makes it more complicated to predict what its overall power capabilities. In addition, the warmer cells over time age faster than the colder ones and adds to the performance variability. This fixture will allow the user to tailor the temperature profile across the stack of pouch cells and collect data.

Specifications:

- Be able to accommodate pouch cell sizes up to 320 mm square (not including the tabs) and 20 mm thick.
- Handle pouch types in which the module has either has cells with all tabs on the same side or all with tabs on the opposite sides of the pouch (see below).
- Be scalable to handle as few as two cells and up to 14 cells maximum (< 60V) in a stack.
- Bus bars to accommodate current flows up to 150A continuously and 350 A pulses for 2 seconds.
- A mechanism to apply a uniform compression of the cell stack adjustable up to 5 psi and be automatically self-adjusting as the cell thickness expands and contracts up to 10%.

- Be able to maintain a temperature difference of up to 40°C across the stack at any one time.
- Receive temperature data from sensors attached to each cell to be processed and adjustments automatically made in the heat/cooling system to maintain the preset temperature.
- Heating/cooling applied to both sides of each cell simultaneously.
- The heating/cooling and thermal reservoirs can use Peltier devices, air flow from a Venturi device, glycol from a PolyScience bath circulator, or any combination of these or other technologies.

- Allow for manual temperature setting on each cell within a range of -20°C to 60°C.
- For a quick visual check by the user, a green light for every cell temperature that is within 1°C of the manual setting, a yellow light for it is more than 1°C but less than 2°C and a red light for temperature differences greater than 2°C.
- Hardware mounted on a base or low-profile box with a footprint so that it can be placed on a large, wheeled cart for easy transport. Components and hoses/wires may be mounted/routed within the box.
- Handle heat generation of up to 300W per cell under worst case conditions.
- Provide a single pair of positive and negative posts for attachment to an external battery cycler with assurances that posts cannot be accidently short-circuited.
- An emergency manual disconnect switch/button to the battery cycler that the user must easily and purposefully (i.e. not accidentally) activate.
- Electronics operating on standard 120V AC outlet. Compressed air (if needed) is 100 psi at the source. If compressed air is continuously exhausted, some means of routing away the exhaust or muffling the noise must be used.
- Any bus bars and/or cabling protected against accidental shorting.
- Insulation incorporated in strategic places to minimize heat transfer to/from plumbing/hoses.
- Easy to use manual valves/switches to deactivate thermal action to idle cell holders.
- Cells may be either in a vertical or horizontal position when placed in the fixture.
- An audible warning and flashing light when the temperature of any cell reaches a user-defined upper temperature setting (typically 80°C) on any cell.
- IMPORTANT: There cannot be any scenario where the stack cells can be inadvertently

shorted during setup, operation, or teardown.

Optional:

- Automatic disconnect of power from the battery cycler by the control system with siren/light activation when the upper temp is reached on any cell.

This design should strive to be as reliable, elegantly simple, inexpensive, and ergonomic as possible so that only one person is needed to safely set it up. All design choices must be preceded by a Pugh matrix to justify the direction chosen.

As a lab instrument, it should be esthetically pleasing with plumbing and wiring routed to avoid clutter. As engineers, you should also be thinking what other features and functionality can be added to make this fixture more useful and user friendly.

Given a full semester on this project, it is expected that this design be completed and documented to such a degree that any student group can use it as a complete detailed guide in fabrication, purchasing the components, assembling it, and making a working prototype.

Any specially fabricated components (brackets, linkages, etc.) must be fully drawn and dimensioned in a print. Purchased components must be identified by model number, supplier's website, and cost. Complete and fully detailed wiring diagrams are part of this package as well.