MECHANICAL ENGINEERING
SENIOR DESIGN

2016-2017

"It's simply amazing to witness such innovative minds collaborating to better the world we live in," said ME Department Head, Susan James who has watched E-days grow and evolve over the last 22 years.

On April 14, 2017, yet another successful Senior Design Showcase went on display in the Lory Student Center ballrooms. Hundreds of spectators from all over the state were inspired by the sea of science-fair style projects and eager students filling the room.

This year, Mechanical Engineering boasted 24 innovative projects – a mix of industry-sponsored, faculty- sponsored, and competition-bound projects. ME senior design professors, Drs. John Petro, Chris Weinberger and Bret Windom humbly floated around the room – hats off to them for another fruitful senior design semester in the books.

Engineering students explain their senior design projects at the 2017 E-Day Senior Showcase. *Photo by John Eisle*

Guests included the Mechanical Engineering Advisory Board, comprised of individuals from industry and the private sector. MEAB judges the projects as part of their spring meeting. Each MEAB award-winning team was presented with a cash prize at the awards banquet. "Judging Senior Design projects is one of the highlights of my year. Everything from the students who get there at the crack of dawn getting the last minute adjustments ready, to those you can tell have completed their projects and are working on their presentations. The dedication and excitement from the students throughout the day as you see judges, friends, and family viewing the various projects is evident in everyone who attends. It is humbling for me to see how far the depth and range of senior projects have come since 1985," said MEAB member, Jim Dietvorst.

E-Days has been enriching the undergraduate engineering curriculum since the university was established in 1870. "The legend is that E-Days began as a combined activity between the then-College of Forestry and College of Engineering as a friendly competition between colleges," said Dr. Fredrick Smith, emeritus mechanical engineering professor who was heavily involved in the College from 1965 to 2005.

"Circa 1975, I had a freshman engineering class that was assigned to conduct a "fuel economy rally." Six teams designed and built cars from bicycle parts that had to carry two people each. Each team was equipped with the same Briggs & Stratton 3 horsepower engine, and each team had 5 minutes to install the engine in their car and prepare to drive. The course was laid out in the engineering parking lot and the winning cars went the furthest and got the highest gas mileage. The project gathered a huge crowd of spectators during E-days and it was great fun for all!" Dr. Smith reminisced.

Nowadays, the week-long celebration includes a variety of activities in addition to the Senior Design Showcase. The week kicks off with a barbeque with live music and a mechanical bull. Other activities include an ASME social, and an awards banquet following the showcase. Each new class builds upon traditions from year's past. Festivities conclude with an engineering savvy carnival, and a job well done to all participants who put months of hard work into a capstone project that made an everlasting impact on their educational careers.

Some students will pass the torch onto the incoming senior class, building upon previous projects, but all will leave behind memories, teammates who became friends, all-nighters in the lab, and most importantly, a part of the senior design legacy that continues to inspire, year after year.

2017 SENIOR DESIGN RECAP

Sponsored Projects:

1. The **Indirect Cylinder Pressure Measurement Team**, sponsored by Pioneer Engineering, was tasked with creating a method to non-invasively measure engine cylinder pressure in industrial engines, which are notorious for releasing harmful emissions into the atmosphere. Shockingly, 90% of these engines are not equipped with cylinder pressure monitoring systems, which greatly improve engine health and efficiency. The high usage of these engines in the natural resources, electricity, and transportation industries, make it impossible to phase out; so, this team set out to measure engine health without the need to shut down the system.

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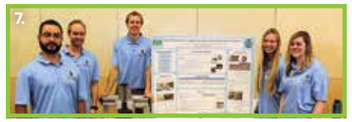

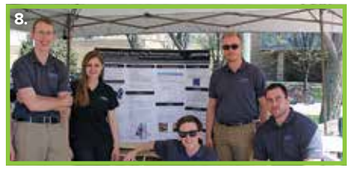

2. The **Absorption Chiller Team**, sponsored by Wave Solar Technologies, was tasked with designing and building a 1.5 kW ammonia/water absorption chiller to be utilized in a solar, co-generation home air conditioning system. They also created testing procedures and devices to collect and analyze cooling performance data. With the data collected, they discovered that a prototype absorption chiller could provide up to two tons of continuous cooling from utilization of a hot water heat source.

3. The **Seedling Transport System Team** sponsored by the Colorado State Forest Service Nursery focused on designing and building an improved system to move hundreds of thousands of seedlings through 18,000 square feet of greenhouses. The old system was an inefficient, 50-year-old conveyor belt that kept breaking. This team not only delivered, but also exceeded expectations by installing their newly designed overhead monorail system, allowing the nursery to increase their productivity for a fraction of the cost to repair or replace the old system. This new monorail system will help the forest service improve and restore our forests, investing in the future of our state and surrounding states for generations to come. More information can be found here: http://source.colostate.edu/forest-service-nursery-gets-upgrade-courtesy-engineering-students/

4. The **Tier 3 Team** sponsored by John Deere was tasked with improving the Crankcase Ventilation System in their 4.5L engine. The current system involves drilling a hole at the top of the crankcase to release pressure; however, doing that released unfiltered oil into the atmosphere, which greatly concerned the Environmental Protection Agency. There became a need for improvement, so this senior design team stepped up to the challenge. This new and improved ventilation system removes oil particulate from the blow-by gas emitted from a John Deere 4.5L diesel engine without disrupting the engine's efficiency. They also designed a testing apparatus to characterize the composition and flow rate of the blow-by gas for future research in the area.

5. The **Exhaust Gas Recirculation Condensation Test Stand Development Group**, sponsored by Cummins, developed a test stand to simulate Cummins exhaust system conditions with the purpose of mitigating the presence of condensation in the combustion chamber causing engine overheating. This issue is causing their systems to work inefficiently, and is also releasing greenhouse gases into the atmosphere – so, Cummins enlisted the help of our senior design students. In the end result, the team found conditions that optimize performance and control capabilities of the system, eliminating condensation build up.

6. The **Onboard Refueling and Vapor Recovery Team** sponsored by Honda was given the responsibility of developing a computer-aided engineering system to improve on Honda's current ORVR design system. An ORVR system prevents gas from evaporating into the atmosphere. This initiative emerged when the Environmental Protection Agency recognized the prevalence of this evaporated fuel in the environment. An updated automated system was needed to streamline the design and development process of ORVR systems, as the current process is too complex, wasting money, time, and resources.

7. The **High Temperature Composite Team**, sponsored by the CSU Composite Materials Manufacturing and Structures Lab, manually produced baseline Geopolymer Matrix Composites for the purpose of redesigning its manufacturing process. The current manufacturing process if flawed, as there is too much variability in the final product, and the repeatability is poor.

8. The **Slotted Fiber Reinforced Facesheet/Sandwich Panel Team** sponsored by Boeing produced a proof of concept device with the purpose of reducing engine noise. The panel, resembling the shape of a honeycomb, was created with the help of the 3-D Printed Attenuator Team. Design details include a quasi-isotropic laminate with slots comprising 20% of the area of the panel.

9. The **Inverted Roller Screw Actuator Team**, sponsored by Woodward, was tasked with designing, building, and testing an innovative and compact electric linear actuator. The actuator is comprised of an inverted roller screw to be used in power generation applications by controlling the stator vanes of small industrial gas turbines to improve the efficiency. With this in mind, the team built an actuator around an inverted roller screw that allowed for higher position accuracy, making the generator run more efficiently while having all the force and speed capabilities of the existing actuators.

2nd PLACE

10. The **High-Temp Flow Team** sponsored by Woodward was tasked with utilizing CFD technology to augment operational testing to attempt a reduction in non-recurring engineering costs and testing requirements. Currently, air that flows through a jet engine gets extremely compressed, pressurized, and hot; this adverse air makes it hard for Woodward, and other companies, to operationally test components that go into aircraft engines. This team's innovative model has the potential to replace operational testing for Woodward's air valves, saving time and money, ensuring their customer gets the best quality product in the shortest possible lead-time.

Faculty-Sponsored Projects

11. The **Air Quality Monitoring Team** built and tested a field-deployable, ozone sensor to accurately reflect ambient ozone levels. The sensor is precise, inexpensive, portable, weather resistant, and battery- powered. The ozone levels in Fort Collins are the 10th worst in the nation; this is due to UV radiation breaking down the air. Implementing these sensors, which can be spread over an entire region, can capture where the highs and lows are occurring, producing significant data about the health of the atmosphere.

12. The **Engine Dynamometer Redesign Team** focused on improving the usability of the Thermalsciences Lab by redesigning the dynamometer test stand. They strayed from the previous industrial motor, and instead integrated a 2.4L Chevy Malibu engine to allow for easier operation for students and teaching assistants alike. The team also equipped the dynamometer with computer capabilities to fully automate functions.

13. The **Engine Dyno Emissions Team** designed and built a new and updated engine test stand for the Me Thermal Sciences Lab. The system is capable of monitoring emissions of a modern gasoline engine focusing on the temperature of the catalytic converter, controlling the temperature with an air-to-air heat exchanger, observing the correlation between emissions and the catalyst temperature, and analyzing NOx emissions.

14. The **CSU Material Tester Redesign Team's** goal was to improve the material testers in the Mech 231 lab. The current material testers, which need to be manually operated, produced inconsistent data, and therefore, hindered students' learning abilities. This team created a computer-automated material tester that will eliminate user error and increase precision. The new tester will also test a wider range of samples and interpret data in real time for instantaneous results. The group hopes their redesigned tester will serve as a prototype to pave the way for the development of more automated machines, benefiting students in the long run.

3rd PLACE

15. The **3-D Printed Attenuator Team** focused on reducing sound on an aircraft by designing and constructing a device to reduce pressure. Reducing noise is critical for commercial jetliners due to strict and increasing regulations around noise pollution. The attenuator lines the inlet of the engine and consists of two pieces, a composite face sheet with slots for airflow, and a honeycomb structure to provide support to the composite face and to absorb a range of frequencies. The attenuator is constructed of polyether ether ketone, using 3-D printing, a cost-efficient manufacturing method.

Competition Teams:

16. The **EcoCAR 3 Controls Team** was responsible for strategizing and programming a 2016 Chevy Camaro's supervisory controls system. They created and ran software simulations that modeled the vehicle to outline their strategy. Along with programming the vehicle, the team also upheld drivability features by improving driver safety, and integrating intuitive driver input controls for a user-friendly operation. The final result was a low-emitting, hybrid electric vehicle, retaining exceptional power and performance.

17. The **EcoCAR 3 Innovation Team** ambitiously decided to increase the engine coolant temperatures from 90 degrees to 120 degrees to boost the performance of the 2016 Chevy Camaro. This innovative technique allowed for a smaller radiator and frontal area of the vehicle for better efficiency. The excess heat from the coolant has the potential to enhance the waste heat recovery systems. The team will monitor the vehicle closely, as operating the engine at a higher temperature may degrade the materials at a faster rate.

18. The **EcoCAR 3 Keysight Team** designed and built a compact stand to test the efficiency of a Remy HVH250 electric motor, which was integrated into the 2016 Chevy Camaro. Stand features allow all components to be easily relocated for future use, accurately measure torque and speed, monitor the cooling system for efficiency, utilize user-friendly software for controllability, and provide fellow EcoCAR teams with data to improve the overall performance of the electric motor.

19. The **EcoCAR 3 Composites Team** explored the benefits of, and applied innovative use of composite materials in the 2016 Chevy Camaro. The team focused on designing, manufacturing, and testing composite materials used in the muffler and anti-roll bar. They also modified other parts to accommodate for their new and improved parts. To adhere to the budget, this team fabricated their parts in-house out of aluminum and 3-D printed components.

20. The **EcoCAR 3 Mechanical Team** was responsible for integrating fellow EcoCar teams' components into the 2016 Chevy Camaro. The mechanical team was also responsible for converting the stock Camaro into a hybrid electric vehicle, improving fuel economy and reducing tailpipe emissions – while simultaneously upholding performance, utility, and safety standards. The team also redesigned the oil pan, improved the inverter, and will bring the car into completion for final execution at the competition.

The EcoCAR 3 competition will be held May 20-21 in Milford, MI and Washington D.C.

21. This year's **Ram Racing Formula SAE Team** is pushing the envelope in a variety of ways. Firstly, the team, which has been competing since 1996, is comprised of more students than prior years: 14 seniors! On June 21-24, in Lincoln, NE, CSU's Ram Racing team will complete in the FSAE Design Competition with a quarter-sized, formula-style, electric racecar, that they designed and built. The team has pushed innovative boundaries this year by incorporating active arrow dynamics and regenerative braking – two ventures Ram Racing has never explored before.

22. The **Baja SAE Team** competed in the Baja Collegiate Design Series in Los Angeles, Calif. in late April with a single-seat, all-terrain vehicle. The vehicle was built by 10 students separated into 3 groups – the chassis, powertrain, and drive train. CSU has not competed since 1993 – so, this group's biggest challenge was to start from the ground up. The team fabricated many of their own parts in the EMEC lab and implemented a hydroregion system which has never been done successfully in a Baja competition. A hydroregion system allows the driver to charge the system by holding the brake down, which then allows the driver to utilize a temporary 4-wheel-drive capability.

23. The **Intercollegiate Rocket Engineering Competition Team** will compete June 20-24, 2017, in Las Cruces, NM, launching a rocket carrying an 8.8-pound payload reaching an altitude of 10,000 feet, and returning safely to the ground. This year, the team is using a tribrid rocket motor that uses three different propellants. They also implemented an active guiding system to control the rocket in flight. The payload will serve as a fuel-sloshing experiment to test different fluids under different acceleration loads to understand and limit the movement of liquid propellant.

1st PLACE

24. The **Human Powered Vehicle Team** designed and built a recumbent bicycle that competed in the ASME Human Powered Vehicle Competition in April 2017 held in Cookesville, TN. This year's design was a tadpole design with two wheels in the front and a larger wheel in the back, putting the driver in a recumbent position with a full-shell aerodynamic faring. The team opted to use ZOTEK foam instead of carbon fiber, as it is a lighter alternative that produced a better drag coefficient. The design details included an innovative snow conversion kit, adding skis to the front wheels and a track to the rear wheel that eliminates the need for wheels to be replaced. The team also implemented a braking system that allows the driver to actively brake, as opposed to other snow vehicles that have a passive brake system.

MECHANICAL ENGINEERING
COLORADO STATE UNIVERSITY

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SENIOR – ACADEMIC EXCELLENCE AWARD
ERIC A. WENDT

This award is given to a senior MECH student with an outstanding academic record who demonstrates potential for future success in mechanical engineering.

JUNIOR – ACADEMIC EXCELLENCE AWARD
MARCO F. PEYFUSS

This award is given to a junior MECH student with an outstanding academic record who demonstrates potential for future success in mechanical engineering.

OUTSTANDING SENIOR RESEARCHER
JEFFREY T. MOHR

This award is given to a senior MECH student who demonstrates strong potential for research.

OUTSTANDING JUNIOR RESEARCHER
ANDERS J. BOOTH

This award is given to a junior MECH student who demonstrates strong potential for research.

OUTSTANDING STUDENT LEADER AWARD
BENJAMIN G. LORDEN

This award is given to a junior or senior MECH student with a strong record of leadership and service, combined with academic success.

MECHANICAL ENGINEERING ADVISORY BOARD AWARDS

These awards are judged by the Mechanical Engineering Advisory Board and are given to the top three teams based on overall scoring by the panel of judges. The teams are scored on:

- Creativity and Quality of their Engineering Solution
- Level of Completion
- Quality and Professional of Display and Explanations

1ST PLACE

1st PLACE

The **Intercollegiate Rocket Engineering Competition Team** (Christian Chavez, Heidi Potton, Jennifer Rochau.)

2ND PLACE

2nd PLACE

The **Inverted Roller Screw Actuator Team** sponsored by Woodward (Jared Collins, Lydia Fahrenkrug, Annie Lelek, Meghan Reimann, Ryan Russell, Tyler Sloboth)

3RD PLACE

3rd PLACE

The **CSU Material Tester Redesign Team** (Marina D'Ambrosio, Jesse Jacobson, Eric Kaliamos, Jill Mellecker, Katie Pearson, Colter Spearing)

HONORABLE MENTION

The **Onboard Refueling and Vapor Recovery Team** sponsored by Honda (Faculty: Dr. Bret Windom; Students: Ethan Cochran, Joseph Fitz William, Tamara Haynes, Tarik Jamel, Daniel Kloepfer, Andrew Spencer)

FACULTY AWARD
DR. BEN GADOMSKI

"Best Dressed Professor"
"Golden Bowtie Award"