CCEFP RESEARCH

EXCAVATOR OUTREACH

By Micah Olson, 2010 REU Student, Purdue University

IN YEAR 5, THE CCEFP E&O PROGRAM was awarded an additional $10,000 to support the TRIBES-E (Teaching Relevant Inquiry-Based Environmental Science and Engineering) program in the northern Minnesota town of Bemidji. The conference was made up of 25 teachers of Native American students from around Bemidji. Dwight Gourneau, who was born on a reservation and is a retired electrical engineer from Rochester, Minn., has been running this conference annually since 2004, when it got its start. He and Diana Dalbotten pulled off another great weeklong conference in Bemidji.

The CCEFP sent me up to the conference to present one of the Portable Fluid Power Demonstrators, the Micro-Excavator. I am an undergraduate mechanical engineer at the University of Minnesota and spent my summer as a CCEFP REU at Purdue University working on developing the Micro-Excavator. When Alyssa Burger asked me to travel to Bemidji for the conference, I was more than happy to go to beautiful northern Minnesota and present the Micro-Excavator and the curriculum for it, written by RET's at Purdue University, Brian Bettag and Gary Werner.

The Micro-Excavator is an excavator arm scaled down to about 3 feet in length and powered with water with a 70-psi pump and controlled by four valves and cylinders. It is mounted on a 17-gallon tank, which is used as its reservoir. While the first ones used manual

valves, we have since moved on to electronic valves with joystick controls, and our most recent generation is operated by a microcontroller. The main purpose of the excavator is to be used in high school curricula to teach the basics of fluid power, and with the recent additions, electronics and robotics as well.

The first day of teaching in Bemidji, I began with the fluid power basics, beginning with Pascal's Law and moving on to schematic drawings to show a basic fluid power system: pump, valve, cylinder, and reservoir. I let the teachers experiment with different size cylinders, different pressures, and different amounts of flow to see how they affected speed and force. Next I had them put back together three of the first- and second-generation excavators from the University of Minnesota that I had taken all the cylinders off of and disconnected all the hoses. This activity really helped them to grasp the whole of the system and let them think about how they could use these in their own classrooms.

The second day, I introduced a generation 4 excavator, which was operated by the Vex Robotics microcontroller. I taught them some programming using EacyC, the language used for the Vex Robotics. They were able to grasp the basics in the little amount of time we had and even programmed a sequence into the excavator to make it do a specified task. The teachers learned the basics of Boolean statements and digital outputs in order to program the sequence.

The teachers were very excited about the opportunities to use the excavators, and they were enthusiastic about learning basic fluid power concepts. Most of them had little to no understanding of fluid power going into it, so I am convinced that they learned a lot. They know that they can borrow the excavators from the University of Minnesota, but it would be best if they could have their own up north with them that they could share between their classrooms. Hopefully a number of the teachers will incorporate the excavators into their science curriculum.

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FLUID POWER CAN BE NOISY

By Nick Earnhart, Graduate Student, Georgia Institute of Technology

WHILE CURRENT NOISE LEVELS in industrial applications are often tolerable, if fluid power systems are to be used in homes, hospitals, or in devices worn on the body, this noise must be greatly reduced. Noise has been specifically identified by the Center for Compact and Efficient Fluid Power as a major technical barrier to both broadening the use of fluid power in traditional applications and to using fluid power in more noise-sensitive environments. Whether it is hydraulics or pneumatics, the high forces involved in transmitting power using fluids induces vibration and noise. This is often attributed to the source of the power, say, an engine, but techniques for reducing noise in these systems are well known; reduction of the noise produced by fluid power pumps and actuators has not received as much attention. The question of reducing noise in fluid power systems is the focus of work currently in progress in Project 3B.1: Passive Noise Control in Fluid Power.

Project 3B.1 is focused on using passive techniques, such as engineered materials, to make fluid power systems quieter. A prototype hydraulic silencer has been developed to reduce the amount of noise that is allowed to propagate down a hydraulic circuit. The silencer uses a specially designed polymer lining that both reflects fluid-borne noise back toward the pump and dissipates sound energy before it gets to the rest of the system. This design showed improved performance against a benchmark commercial off-the-shelf silencer in a non-optimized design of the same size. A theoretical model of the silencer performance was developed to allow engineers to design this type of silencer for a specific application. More advanced integration could include the use of this material directly in a pump or accumulator so a separate device is not needed.

There is another aspect to this research question; that is, how do noise control techniques need to change when the device to be treated is very small? When the size of a device becomes small relative to the wavelength of radiated sound, classical noise control techniques do not work well. In addition, as fluid power systems become used in more noise-sensitive environments, the fraction of energy that may be allowed to generate sound gets much smaller. These two factors pose significant challenges, hence the focus within the Center to address noise concerns.

There are two projects within the Center that will be specifically addressed for noise treatment. First is the Ankle Orthosis in Test Bed 6, which aims to use a small, internal combustion engine as a power source. Project 3B.1 will evaluate the potential of engineered lattice materials to provide a lightweight, multifunctional structure to attenuate noise and control structural vibration in the orthosis. The second project is the High-Speed On/Off Valve under development in the Center; a combination of predictive modeling and experimental analysis should yield understanding of the noise-generating mechanisms of the device, and permit reduction of its noise signature.

The future is bright for fluid power, with noise reduction a necessary solution to adoption of more compact devices and expanded use of the technology.

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WHAT'S THE DEAL WITH EV'S AND PHEV'S?

BY PERRY LI, CO-DEPUTY DIRECTOR AND HHPV TEST-BED LEADER

THE PAST FEW MONTHS saw the launch of two electric vehicles on the market with much fanfare—the Nissan Leaf and the GM Chevy Volt. The former is an all-electric vehicle whereas the latter is marketed as an electric vehicle with a gasoline engine for extended range. What got the public excited is the seemingly high fuel economics when these vehicles are operated in pure electric mode. The Leaf is listed as having a 99-MPG-e and the Volt having a 93 MPG-e. The "e" after "MPG" stands for "equivalent" and is the EPA's attempt to equate the electricity usage with fuel usage. Are electric vehicles really that much more efficient than engine-powered vehicles? Are they then the solution to our fuel dependence or do they significantly reduce emission of greenhouse gases?

To answer these questions, we need to understand EPA's definition of MPG-e, which turns out to be quite misleading. EPA defines MPG-e by equating 1 gallon of gasoline to 33.7 kWhr of electricity—this value is the heating capacity of the gasoline and does not consider the efficiency of the electricity generation process. In the U.S., the majority of our electricity is derived from fossil fuel and the average efficiency of a fossil fuel plant is only about 33% (according to DOE). Thus, in a true well-to-wheel comparison, the Leaf and the Volt would get: 0.33*99=33MPG and 0.33*93=31MPG respectively! These are not stellar fuel economies and are significantly lower than those achievable by a well-designed hybrid vehicle such as the Prius (~50MPG). Thus, unless the electricity used to power the Leaf or the Volt is derived predominantly by nuclear or renewable sources, they would actually use more fuel than a hybrid vehicle. While our nation is moving forward to incorporating more and more renewable sources, this will take time.

The analysis and results above are consistent with a study that the CCEFP hydraulic hybrid passenger vehicle test bed (TB 3 – HHPV) research team undertook last year to compare the efficiencies of Hybrid Electric Vehicles (HEV's) and Plug-In Hybrid Electric Vehicles (PHEV's). Fuel and electricity usage data from a fleet of HEV's and PHEV's from Google (www.google.com/recharge) driving standard cycles are used. The PHEV's are converted from the Toyota Prius and Ford Escape HEV's so that the same basic vehicles can be compared. For the HEV, only gasoline is used and in PHEV, both gasoline and electricity are used. In the study, we ask the question: If all the electricity used by the PHEV is derived from gasoline, what efficiency does this conversation have to be in order to have the same fuel economy as the equivalent HEV? For the Prius, the required conversion efficiency is 41%; for the Ford Escape, it is 37%. The average power plant efficiency in the U.S. is quite a bit lower than these values so that using the onboard gasoline engine can sometimes be "greener" than running on electricity. Details of the study can be found at www.me.mnu.edu/~pli/google_plugin_study.pdf.

How about hydraulic hybrid vehicles? Because of the limited energy density in hydraulic accumulators, plug-in hydraulic hybrids are not a reasonable option. Compared to hybrid electric vehicles, hydraulic hybrid passenger vehicles offer both fuel economy without sacrificing performance, thanks to the superior power density advantage of hydraulics. Moreover, it does not require exotic materials as in batteries or electric motors, making them environmentally friendlier to manufacture and to recycle. They are also more affordable and therefore more appealing to a larger market segment. CCEFP is excited to be engaged in research that makes hydraulic hybrid passenger vehicles a reality.

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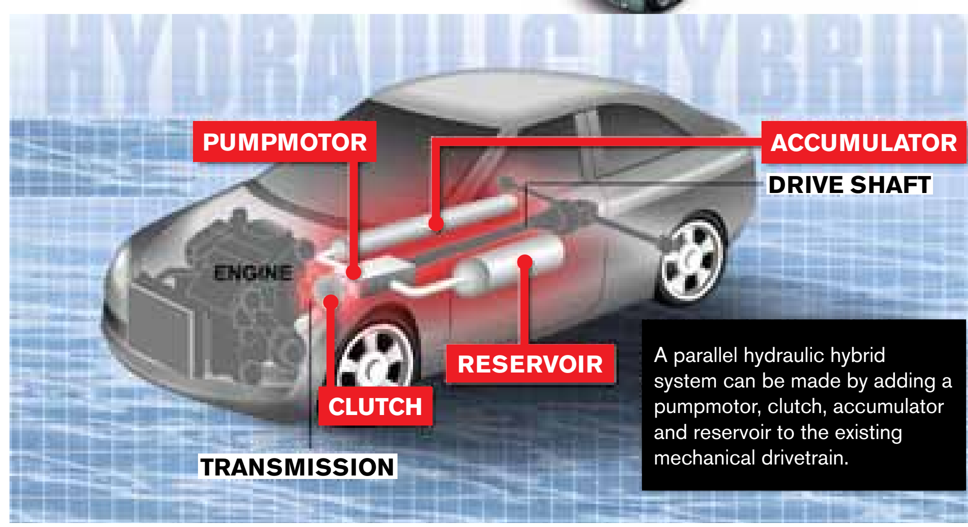

CCEFP RESPONDS TO DOE OFF-SHORE WIND ENERGY REQUEST FOR INFORMATION

ON JULY 14, the CCEFP submitted a project proposal titled "Development and Demonstration of a Variable Speed Wind Turbine with a Hydrostatic Drivetrain" to a request for information from the U.S. Department of Energy (DOE) titled "DOE Offshore Wind Program—Input Requested for Demonstration Projects." The response proposed a 3-part project targeted at developing and demonstrating a hydrostatic drivetrain in a wind turbine. The drivetrain would replace the mechanical gearbox in the wind turbine and potentially eliminate the need for power electronics to condition the power before it is sent to the grid. In Phase 1, a lab scale drivetrain (under 100 kW) would be built and tested. This work would focus on control algorithm development and technology proof of concept. Phase 2 would focus on scaling the drivetrain to approximately 500 kW with development and testing being done in both the lab and in real-world use. In Phase 3, the system would be scaled to off-shore turbine size (5 kW+) and brought to commercialization.

Of particular interest in the proposed project is the exploration of the trade-off between the mechanical efficiency of a variable speed drivetrain and the aerodynamic efficiency of the wind turbine. Research has been done on wind turbines that take advantage of this trade-off. However, the variable speed wind turbines in development or production are generally 1-3 orders of magnitude lower in power output than what is typically used in off-shore wind turbine applications. The CCEFP proposal aims to take advantage of the inherent reliability, scalability, and power density of hydraulics to create a new generation of very high output wind turbines.

For more information, contact Brad Bohlmann, CCEFP Sustainability Director: bohlmann@me.umn.edu or 612-626-1795.