10th Annual School of Science, Engineering, and Health Symposium

Engineering IPC Presentations

Frey 110 – May 3, 2013

9:05 a.m. ***Solar Power Demonstration Cart***

Ethan Crane, Luke Hostetter, Carl Erikson*

This semester our IPC group has designed and manufactured a new solar demonstration cart. The previous solar cart that the solar project group made and used now belongs to the Oakes Museum. The new solar cart is lighter and easily movable with the objective of showing how solar energy can power diverse applications.

9:25 ***Pressed Oil Processing***

Seth Fickett, Tyler Newswanger, Carl Erikson*

In the summer of 2011, five acres of sunflowers were grown on the Messiah College campus in an effort to implement a sustainable solution to obtaining quality cooking oil and biodiesel. The goal was to harvest the five acres of sunflower seeds, mechanically press these seeds to obtain oil, deliver the pressed oil to Dining Services to be used for cooking oil, and produce biodiesel from the oil once it was no longer usable for cooking. The processing of the pressed oil is an important part of this process if we are to provide clean cooking oil for dining services use. The objective of the filter project is to obtain an efficient, reliable, and safe way to remove the sediment from the oil using a press filter, to optimize the filter parameters so that the highest quality oil yield is obtained. After use as cooking oil, the oil quality is in a state which once again needs filtering.

9:45 ***Thermoelectric Generator Ventilation Hood***

Lee Drummond, Abhishek Jacob, Carl Erikson*

The TEG project was started after discovering that open cook fires take the lives of nearly 1.5 million people a year as a result of respiratory infection from the biomass and harmful particulates that are emitted from cook fuels. Because of the increased need for a proper ventilation system, we have used a thermoelectric generator to convert waste heat from the cook stove to electricity that powers a fan used to draw smoke away from the fire and out of the indoor environment. We have designed and built a hood that is as unobtrusive as possible and is adjustable to fit a wide range of cookstoves.

10:05 ***Oxygen Concentrator Filter Re-design and Testing***

Steven Bandstra, Emily Lewis, Barbara Ressler*

Oxygen concentrators provide respiratory support for patients in hospitals around the world. However, oxygen concentrators used in rural hospitals in Africa tend to fail much sooner than their expected lifetime; this high failure rate is most likely due to contamination by dust and humidity. Intake filters on the concentrators are adequate to handle the intake of dust as long as they are properly maintained, but they are not designed to reduce humidity. This year we researched, designed, and prototyped a new filter to combat not only the dust component of failure but also the humidity factor. We did this by adding a quantity of silica gel to our filter to absorb water from the air. After constructing several prototypes we tested the filters to determine how long they would last and how effective they would be. Results showed that our filters are capable of reducing the relative humidity by up to 30%, but maintaining this reduction would require almost daily replacement of the silica gel. Even if the silica gel were changed biweekly, our new filters could increase the concentrator lifetime by a factor of four. This summer our design will be brought to Macha Mission Hospital to be tested in actual conditions.

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10:25 ***Flight Tracking and Messaging Systems (FTMS)***

Ben Clouser, Joel Love, Harold Underwood*

Once outside radar range, small planes flying in remote locations must be tracked by alternative means. Organizations focused on emergency relief, humanitarian development and missionary support need to follow such flights, for reasons of safety and more. The Automatic Flight Following System (AFFS) owned by JAARS has been safety tested and used extensively for this purpose, but its central microcontroller (a small single board computer / SBC) has become obsolete, since it is no longer marketed or supported by the manufacturer. Thus, FTMS at Messiah College has agreed with JAARS to upgrade AFFS 1.0, so additional units could be fabricated. Replacing the existing Rabbit SBC in AFFS 1.0 with the Rabbit 2610 involves both hardware software challenges, since the Physical footprint and pinout of each don't match and the newer micro uses an enhanced programming language known as "Dynamic C". Thus, thousands of lines of code had to be ported (translated) from the old micro to the new one. This porting process has now been completed so the new code can be compiled (loaded) on the AFFS 2.0 prototype. Current work involves interfacing essential devices to the new SBC, with additional code modification as necessary, for a test-configuration that insures AFFS 2.0 functionally emulates AFFS 1.0. Vision for future work includes developing AFFS 2.0 interoperability with other modes including satellite communication, so as to make it a more flexible system useful for a variety of organizations.

10:45 ***Multimodal Tutor: A Substitute Teacher***

Andrew Dowling, Randall Fish*, Harold Underwood*

The Multi Modal Tutor (MMT) is a Gameboy-style device developed to help students in Burkina Faso learn basic math and reading skills. Where the student-to-teacher ratio in the Burkinabe schools is not optimal for student learning, the MMT can allow students to get more individualized attention by practicing math and reading skills. Students can choose from a French story about Finbo the Whale or a simple math game that involves counting. The MMT has an LCD screen that displays graphics and text. The user interface provides two buttons-- one to advance the book or math game and one to select the correct answer in the math game. Future improvements to the MMT will include some basic audio capabilities that allow the device to be used by blind students.

11:05 ***WERCware: Remote Assistive Care Through Android and Arduino***

Chad Clemens, Josiah Merola, Harold Underwood*

Wireless Enabled Remote Co-presence (WERC) is a project being pursued in partnership with SymBionyx that focuses on dispensing coaching services via a remote connection. Currently those with cognitive disabilities and traumatic brain injuries often have a lifecoach or attendant-care provider who helps them learn or re-learn daily tasks. However, this approach can foster dependency and is not always the best long term practical solution for coaching or attendant-care agencies. WERCware aims to revolutionize this industry, by allowing one attendant to provide services to multiple participants from a remote location, while creating the opportunity for more independent development by the participant. The current prototype (WERCware 3.0) initiates and maintains contact between attendant and participant via a Skype call over an Android smartphone. The participant wears the smartphone pendant-style in an adjustable holster, customized to the individual. The holster is positioned for the attendant to observe along the same line of sight as the participant sees, providing the best viewpoint for helping a participant resolve problems in the immediate environment. WERCware also helps a coach teach new tasks, by playing instructional videos via Skype that walk the participant through the process step-by-step, using a faded approach to facilitate learning. The coach can still oversee during the learning process to assist if necessary. WERCware records essential session data, including task-times and prompts using an innovative WERCtymer

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application. A habilitation study completed in the Fall 2012 assessed the current WERCware prototype and identified some issues to address, including the reliability of the internet connection during peak usage, etc. This presentation reports on results of the habilitation study and current efforts to use the Arduino microcontroller as an interface with the smartphone. The vision for future work involves developing biometric sensors interfaced through the Arduino to monitor the participant, implementing an automatic privacy shutoff function, and developing a wireless connection monitor.

1:20 p.m. ***Garden Water Access Project***

Lindsey Adomat, Marcus Upton, David Wilson, Tony Beers*, Joseph Longenecker*, Timothy Whitmoyer*

The Collaboratory Water group is partnering with Serving in Missions (SIM) and Open Door Development in Burkina Faso to design low cost well drilling and water lifting technologies to complement their Survival Garden program. In January of this year we went on a site trip to Burkina Faso to meet with our client. This year we have also begun fabrication of our well drilling equipment. Our goal is to provide Burkinabe well drillers with reliable equipment that will allow them to work more efficiently while improving safety in comparison to their current tooling.

1:40 ***Village Water Ozonation System (VWOS)***

Amy Heindel, Eric Kauffman, Amanda Schneider, Tim Yoder, David Vader, Timothy Whitmoyer*

The Village Water Ozonation System (VWOS) is a village-scale water purification system designed to produce potable water for communities who lack access to clean water. Our system uses a combination of ozone disinfectant and standard filters to purify water from an existing source. Although VWOS has undergone several design iterations and implemented a prototype in Honduras, the project team lacked a suitable test bench to support design optimization. This year, we have designed and constructed a test bench to isolate and test independent design variables on a significantly shorter time scale. The project team will scout locations for installation of a VWOS system in Managua, Nicaragua with client Forward Edge International during the summer.

2:00 ***Hollow Fiber Membrane Water Filtration System***

Daniel Earl, Jonathan Hepner, Darin Horst, Rebecca Ports, David Vader*, Timothy Whitmoyer*

The goal of the Hollow Fiber Membrane (HFM) project is to provide under-served communities around the world with a locally sustainable water filtration technology. Our design implements HFM technology provided by Sawyer Products® in a configuration that requires no electricity and is suitable for village-scale water treatment or a small water bottling business. In 2013, two prototype systems were designed and installed in Burkina Faso, West Africa. The project team produced professional operating instructions and assembly instructions to enable our clients to independently construct, use and maintain the system. These instructions include full parts lists and detailed diagrams with every part labeled to guide construction. The project team also designed a new prototype that lowers cost by implementing several smaller HFM filters in parallel. The smaller Hollow Fiber filters offer flexible sizing for system installations and allow more efficient testing by our team.

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2:20 ***India Mark II Sustainability Study***

Zachary Sizemore, Tony Beers*, Timothy Whitmoyer*

The India Mark II pump is one of the most widely used village level water pump systems in the world. Developed in the 1970s, the basic design remains unchanged except for a few modifications. Despite the pump's long history and rugged design, World Vision's installations experienced an unacceptably high failure rate. Our project studied the pump's function and analyzed the most common failures. With this information, we redesigned the problematic aspects to reduce down time, to return existing pumps to working order, and to increase the mean time between failures of future pump installations.

2:40 ***Light Sport Aircraft Wing Folding Design***

Dane Johannessen, Anne Trapp, Donald Pratt*

The Wing Folding design team is in charge of the mechanism which will allow the LSA's wings to fold for easy storage and transportation. The team has chosen a three joint system at the connections of the fuselage, strut and wing. The motion is described by a forward rotation followed by a backwards bend leaving the wings parallel to the side of the fuselage. The requirements of the LSA specify that the aircraft must be able to withstand 4Gs of force during flight. The wing folding joints have been designed to withstand the force in simple tension. In previous years, the design, construction, and testing of the Universal Fuselage Connection Joint has been completed. The main focus of this year's work revolved around the design and fabrication of the Wing Strut Joint. The group completed stress analysis to determine design specifications and the material for this joint. These results led to the decision of a Wing Strut Joint consisting of a small U-bracket made of 7075 T-6 aluminum and two high strength pins. Join the Wing Folding team for a discussion on the progressing wing folding mechanism, specifically targeting design considerations, stress analysis, and manufacturing process of the Wing Strut Joint.

3:00 ***Light Sport Aircraft Engine Integration***

Aaron Black, Andrew Breighner, Jacob Francis, Donald Pratt*

Several years ago the Engine Integration team found a replacement engine for the original rotary engine for the light sport aircraft. The team has been preparing this new engine for use on the airplane. The fall of 2012 was spent testing the recently purchased HKS engine for thrust and fuel efficiency characteristics at different propeller pitches. This testing was done on campus with the use of a custom built test stand. The spring of 2013 was spent preparing the engine mounts for the aircraft, the exhaust system, and other auxiliary systems. Design work was required for adapting the original mount designs to fit with the new engine type - a four-stroke engine. Also required was the use of an oil cooler which was different from the water cooled rotary engine. Therefore, the auxiliary systems for the new engine also needed to be redesigned for use on the airplane.

3:20 ***An Alternative Way to Commute: 90 Volt Electric Motorcycle***

Matthew Bergey, William Jones, Zachariah Steeves, Donald Pratt*

The Alternative Commuter Vehicle project is in the form of a battery-powered electric motorcycle. Transportation Group students and their advisor, Dr. Don Pratt, have built the bike from two salvaged Kawasaki Ninja motorcycles, components from the famous Messiah solar racing cars, and more than two hundred donated lithium batteries. The project is currently in its final stages. All drive-train components are installed, a test drive was performed, and final bugs are being worked out of the motor. This presentation will cover the battery pack completion, motor diagnosis and repair, throttle construction, power management circuit, and progress on the battery-balancing system. We hope you will join us as we share about our experiences exploring the world of alternatively powered vehicles.

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3:40 ***Light Sport Aircraft Suspension and Landing System***

Benjamin Jarvis, Benjamin Richter, Donald Pratt*

The Light Sport Aircraft (LSA) Main Gear Suspension Team is working to develop an innovative suspension system that is simple, robust, and economically viable for use in the mission field. During the 2011 academic year at Messiah College, the team established initial designs for the main gear suspension system and proceeded to fabricate prototypes. Testing began in 2012, during which the initial design failed to meet required specifications. The team is currently in the process of redesigning the suspension system for the LSA and has succeeded in establishing correlations between theoretical calculations and experimental data. These correlations will be used to more accurately determine the system response for different loading conditions and, thereby, assist the team in finalizing the design to meet specifications for the LSA main gear suspension.

4:00 ***Applied Research and Design of Brake Systems for the Mobility Electric Tricycle***

Jeffrey Herwig, Nathan Richards, John Meyer*, Tim Van Dyke*

The Mobility Project's tricycles utilizes modified bicycle caliper brakes for supplying the braking force, but the weight of the electric tricycle necessitated doubling the width of the wheels, which rendered the brakes ineffective and unsuitable for the tricycle. The modified caliper brakes were difficult to adjust and did not provide sufficient braking force. The poor quality of the components available in Burkina Faso made them unacceptable for our clients there. Our objective was to create an alternative design that would address the issues of adjustability and braking force while still being simple to implement, appropriate for the limited mobility and strength of the tricycle users and be cost effective by using locally available parts and materials. To meet our objective we researched commonly used brake systems such as wheelchair brakes, bicycle brakes and friction band brakes to look for potential designs or modifications that we could make. A band brake design was chosen because of the simplicity of the design, the ability to modify and reuse existing tricycle components and the ease of use for users with limited mobility and strength. The last portion of our project was devoted to fabricating a prototype system using the friction band concept. That prototype has given promising results from preliminary testing on the electric tricycle, both in its effectiveness and ease of use. Further work is planned to refine the design and complete research and testing on different friction band materials to optimize performance.

4:20 ***Electric Mobility Tricycle: Rear Axle Redesign***

Seth Betteridge, Judah Mendez, Jean Esther Zipagan, John Meyer*, Tim Van Dyke*

In 2009, the tricycle frame was redesigned to include advancements in ergonomics, strength, and manufacturability. This frame supports the rear axles on only one side as in traditional wheel chairs; our previous frame designs supported the axles on both sides, similar to how standard bicycle axles are supported. Data collected from Burkina Faso and from extensive testing here demonstrated that the axles used on the new frame design fail prematurely in the electric version of the tricycle. The goal of this project is to increase the life of the axles while delivering a sustainable solution that utilizes locally available materials and manufacturing processes. Our team tested and evaluated different axle designs developed by previous teams. After evaluating several variations of single sided axle supports, our team ultimately decided to revert to a double-sided axle support design. This configuration is easy to manufacture, uses local materials, and is expected to provide improved part life. Our team refined this solution, analyzed it for possible failures, and constructed a prototype for experimental testing. It is currently being evaluated through long-term testing to verify that the axle wear problem has been sufficiently diminished prior to implementation in Burkina Faso. Initial results are promising.

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4:40 ***Electric Tricycle Speed Reducer Assembly Redesign***

Moses Keener, Jared Landis, Eric Love, John Meyer*, Tim Van Dyke*

The drive train of the Disability Resources electric tricycle contains a planetary gear set in order to reduce the speed from the output of the motor. This planetary gear set has a splined socket output that connects to a splined shaft which is contained within a housing and supported by a bearing. Field testing has indicated that there were several flaws in the initial design of this assembly. These flaws lead to premature wear in the bearing and in the splines of the planetary gear set. Through several different tests and discussions with the manufacturer of the planetary gear sets, it was determined that the failures arose from the fact that the output shaft was only supported by one bearing which was not sufficiently stiff to resist the forces applied on the end of the shaft. Two design revisions were developed and tested through field testing on the tricycle and through an accelerated testing method to compare wear, especially in the splines of the planetary gear set. Initial results on these redesigns look promising although additional testing will be needed to determine the appropriate long term solution.

5:00 ***Mobility Tricycle Front-End Redesign***

Jeff Dwier, John Nordstrom, Sumin Seong, John Meyer*, Tim Van Dyke*

The Mobility Tricycle Project designs electric and hand-powered tricycles for physically disabled people in Burkina Faso, West Africa. While much of the tricycle design has been carefully considered and optimized, one area in particular, the front-end of the tricycle, still can benefit from a systematic redesign. The first aspect of our project looks at changes in the geometry of this front-end which can improve the handling and steering ability of the tricycle, particularly in the electric tricycle. With the current tricycle design, the rider must constantly exert a force on the steering handle in order to maintain a straight path. This is undesirable and troublesome for many, such as those with limited upper-body strength. Moreover, as the tricycle reaches higher speeds, the steering begins to wobble left and right. To develop a more stable and comfortable riding experience, we developed an accurate 3-D model of the tricycle and performed an analysis of the motion in SolidWorks, a computer aided design program. This allows us to simulate various front-end configurations in motion, in order to lead us to a design with potentially better handling and greater stability. The second aspect of our project involved redesigning the head-tube interface, or the part of the front-end where the steering fork attaches to the frame of the tricycle, to simplify its construction and implementation. We successfully developed a new design that contains fewer parts, less welding, and is easier to assemble and install. Currently we are developing a testing simulator to verify that this new head tube interface will have the appropriate long-term endurance.

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