LOAD FLOW ANALYSIS OF POWER SYSTEMS USING POWERWORLD AND POWERTOOLS

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ABSTRACT

Hoosier Energy requested us to implement and analyze two power flow test cases in the PowerWorld and PowerTools software packages, which we have used to create an addendum to an existing user's manual. The addendum to the "PowerWorld and Cyme Iterative User's Manual" will be utilized by Hoosier Energy engineer trainees, giving trainees the ability to practice their newly acquired skills with larger power flow test cases. This addendum includes instructions, one-line diagrams and load flow analysis results for the IEEE 57 and 118-bus power flow test cases in the PowerWorld software package. Data for the power flow test cases are on the University of Washington College of Engineering website (http://www.ee.washington.edu/research/pstca/).

The team has been structured with Raymond Wise as the Team Lead, Chad Steider as the Webmaster and Jonathan Meyer and Eric Fenelon sharing the Recorder responsibilities. Project responsibilities have been divided up among group members with a joint effort to create the user's manual addendum. Ray and Chad are responsible for implementation and load flow analysis of the IEEE 57-bus power flow test case and Jon and Eric are responsible for the IEEE 118-bus power flow test case.

We used the "PowerWorld and Cyme Iterative Users Manual" to learn the PowerWorld software package. We used a lab tutorial, from a Power Systems I course, on the implementation of a 5-bus power flow test case to learn the PowerTools software package. Each sub-group implemented and ran load flow analysis for their test case and compared their results to what is on the University of Washington website. With the results the team created the addendum to the user's manual, following the format and language that the previous teams used.

CONCLUSION

The main deliverable of the project is the addendum to the "PowerWorld and Cyme Iterative Users Manual," which Hoosier Energy trainees will benefit from using. A secondary benefit will be the availability of the one-line diagrams and load flow analysis files on the University of Washington website. This is important because load flow analysis was last conducted on the IEEE 57 and 118-bus power flow test cases in FORTRAN, a software package little known to young engineers.

LAS VEGAS AIRPORT TERMINAL

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INTRODUCTION

Our client, Walter P. Moore and Associates is a large well-respected design firm based in Austin, Texas. They have worked on many large projects which include stadiums, convention centers, and dormitories. The company is designing a terminal addition to Las Vegas Airport, Terminal X, and has asked that we provide an in-depth scheme for nearly the entire structure. The most important part of this project to our client is our conceptual roof designs. The most important part of this project to us is the chance to work with people in the industry and to put the skills we have learned in school to use.

ENGINEERING WE HAVE PERFORMED

A lot of work has gone into the design of this terminal. Walter P. Moore and Associates requested that we provide a geo-tech report, gravity system, lateral system, foundation system and roof designs. The deliverables for our client include AutoCAD drawings of various aspects of the structure (column and beam layout, typical beam cross-sections, roof concepts, etc.) and over 250 pages of hand calculations and computer generated reports. We used many by-hand methods used in class as well as many covered in various text books and code books that aided our design. We've included in the report our recommendations and also more information regarding Leadership in Energy and Environmental Design (LEED) certification.

FINDINGS

As a result of our analysis we determined the best structural system for the terminal is a steel frame with a combination lateral system. The foundations have been designed as shallow footings. We explored three roof systems: membrane, truss, and suspension; and feel the membrane style, because of its innovative and aesthetic design in conjunction with its environmental friendliness, is most appealing.

Low Impact Development of Country Estates

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Overview

Paragon Construction, of New Palestine, Indiana, has proposed the development of Country Estates south of Greenfield, Indiana. The 66 acre residential development is to incorporate Low Impact Development guidelines and to be designed to the specifications of the Hancock County Area Plan Commission. It was our responsibility to design the neighborhood to meet these requirements. Our three main focuses consisted of designing the layout of the neighborhood to have a low environmental impact during and after construction, developing an on-site wastewater treatment system, and developing a way to treat stormwater and non-point source pollution before it is released into local streams.

Low Impact Design

We chose a clustered home layout for the neighborhood in order to minimize the impact on the environment. All of the lots were designed along the east side of the development with a designated space for community use. The layout design incorporated the natural lay of the land to reduce cut and fill sections along the roadway. In addition, we have developed an erosion control plan to reduce the amount of sediment that contaminates local streams during construction.

We investigated three options for wastewater treatment. Those options were a conventional septic system, the Enviro-Septic Treatment System, and wetlands treatment. Each of these options were evaluated based on environmental impact, cost, feasibility, and creativity. The environmental impact rating was based on the quality of the effluent and the potential for untreated discharge. The feasibility rating was based on how well each system would function in the available space, and creativity was rated on the ability to market the neighborhood as progressively treating wastewater.

The stormwater treatment design maintains present runoff conditions. Water modeling was completed to find the current runoff conditions and to evaluate the proposed runoff conditions. Roadside swales were incorporated to allow for overland flow to the wetlands rather than traditional curb and gutter systems. An onsite wetlands area was proposed to allow for the treatment of the first inch of stormwater runoff from the site, as it tends to be the most polluted.

Conclusion

After evaluation of the wastewater treatment options, we determined that the Enviro-Septic Treatment System is optimum for the site. The Enviro-Septic Treatment System treats the effluent on site in half the area of a conventional septic system, and is more feasible than a wetlands treatment system due to the freezing temperatures in Indiana. Our design for stormwater treatment will increase the quality of water by treating it on-site, without chemicals, before releasing it into the local water system. The peak release time will also be reduced by the low density of development on the site which will reduce the potential for downstream flooding.

Multilane Portable Traffic Monitoring System

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Introduction

As part of Rose-Hulman Institute of Technology's Senior Design curriculum, our team was assigned the task of producing a *mobile* unit that can simplify data collection for State traffic flow studies. Current implementations of traffic collection systems are expensive and require semi-permanent installation. Our client believes that the Indiana Department of Transportation (INDOT) can save taxpayer money by using a mobile device for conducting traffic studies. Such a system would only require a few minutes of configuration before being left unattended for up to four days.

System Overview

The traffic monitoring system can be divided into three major subsystems – sensing, data acquisition, and data extraction. Two pairs of optical through-beam sensors generate events when a vehicle passes the monitoring system. A data acquisition subsystem places a timestamp on each event and stores them onto flash card in 10-byte segments. Users can extract the stored events by connecting a USB cable to the system's logging unit. An executable file on the user's PC analyzes the collected data and outputs consolidated traffic flow information in the form of a Microsoft Excel spreadsheet.

The system is enclosed in two weatherproof cases that are placed on opposite sides of the roadway. Each case is equipped with a power management subsystem that is capable of providing sufficient power to operate continuously for four days.

Results

Our team has analyzed the requirements for our system and followed a detailed design process that has resulted in a manufacturable and cost-effective prototype unit. We are in the process of testing to determine the performance limits of the system. Specifications call for an accuracy of ±1mph and 95% accuracy on the count of passing vehicles. We believe that after verification we will exceed these requirements. The prototype works successfully on a two-lane roadway and is able to determine the direction of passing traffic.

Demonstration

We are prepared to bring the prototype unit to supplement our poster. The prototype can be configured to output data in real-time which will be used in an interactive demonstration. Visitors can compete to see who can come closest to guessing their walking speed.

Electrotactile Refreshable Braille Display

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Abstract

A refreshable Braille display is used to convey text to the blind. Once connected to a computer it allows text on the screen to be translated into Braille characters which the blind community can "read" using their fingertips. Current refreshable Braille technologies use solenoids to create a movable array of raised dots; our project aims to instead use electrical stimulation to simulate the feel of such an array. This approach would eventually lead to lower construction costs for Braille displays (which currently cost thousands). Our senior project will involve proving the electrically stimulated Braille concept on a small scale.

Team Structure

Our team was created last year during the Junior level engineering practice sequence at Rose-Hulman. After being asked to conceive of products for the blind, we noted the extreme expense of refreshable Braille displays for computer users and wished to find a way to decrease the cost. After creating our group we divided the project into four parts; each team member being responsible for one part: Jeremy Fox was to be responsible for creating the proper signal, Micah Houtz was to be responsible for power conversion, Michael Mosley was to be responsible for limiting current to the user's skin and Patrick Cunningham was to be responsible for creating the display's surface.

Design of Electrotactile Display

Our display is based on a design created by Dr. Kurt Kaczmarek on a grant from the National Eye Institute. The signal sent to the user's fingertips consists of a series of low current pulses at a high DC voltage. This current travels from the center of a coaxial electrode through the user's dermis to stimulate nerves near the surface of the fingertip and travels back to the device through the ground path. The device has multiple mechanisms by which current is limited, making it safe to use in all situations. As of this moment we have not tested our device with a human subject though we plan to have it completed and tested before the end of this academic year.

Significance of the Design

Once our hardware is complete we look forward to getting feedback from the blind community about the usability and significance of the device. We hope that the design of our display will eventually allow the blind greater access to technology by decreasing the cost of digital displays which they can read.

BACK-IN-TIME CAMERA

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PROJECT OVERVIEW

The Back-in-Time Camera is a product that allows its users to capture those moments in life that are extremely memorable, yet unexpected, into a "video scrapbook". This is a collection of saved audio/video files that is available for the user to view in order to relive past memories. It has a video camera with built-in audio that is continuously and wirelessly buffered by a computer. At any given time, the circular buffer contains one minute of video and audio. To keep that minute, the user can wirelessly signal the system with an RF remote to record it along with the next minute of video and audio. This video and audio is then stored on the computer where it can be viewed and edited by the user for future use.

EXPLANATION OF TEAM STRUCTURE

This project is sponsored and inspired by Steve Mannheimer of IUPUI. The team is led by Jacob Phillips who is a senior computer engineer. He has taken a major part in writing the software for the project and is responsible for all external communication for the team. Paul Benjamin is a senior computer engineering major who has worked on the camera software with an emphasis on the connectivity with the camera. Brian Phelps, a senior electrical engineering major, is involved with the project documentation and is responsible for the software and user testing for the project. Ryan Rakestraw, a senior electrical engineering major, is working with the camera software, particularly the user interface and preferences.

RESULTS

We have successfully connected to the D-Link DCS-950G Wireless G internet camera using a custom Visual Basic program and are able to capture audio and video. Visual Basic has also allowed us to create a graphical user interface that permits the user to view the current audio/video stream and also the current program status. The interface also allows us to add user settings and preferences to the program. This program is signaled by a programmable RF remote. This is used to change the program settings, as well as inform the software when to start and stop saving video and audio.

WEIGHT-BEARING DETECTION DEVICE

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OVERVIEW

The Rehabilitation Hospital of Indiana (RHI) is a medical clinic in Indianapolis that approached Rose-Hulman to help develop a device to be used in the physical therapy of impaired patients. The therapists at RHI have asked us to design a compact, mobile system to measure the amount of weight placed on a single foot as a patient walks. The device also maintains a threshold weight, set by the therapist, and alerts the therapist if patients exert too much pressure on that foot as they walk. The purpose of this device is to make sure patients are not overexerting themselves during therapy.

We've drawn up plans and begun construction on a prototype that meets RHI's specifications. The device features three pressure sensors on plastic strips that attach to the patient's sock with Velcro. The measurements are performed by a small box that the patients wear on their hip as they walk. The current and threshold weights are displayed on an easy-to-read LCD on the device along with a warning light that flashes when the patient exerts a pressure higher than the threshold. When the patient applies too much weight on his foot, the visual alert as well as an audible warning is triggered. The threshold weight maintained by the device is set by a pair of buttons that raise and lower the threshold in five pound increments. In accordance with our client's specifications, the sensors are configured to measure a range of weights between 10 and 200 pounds.

The device's novelty is in its simple design that makes it easy to use. With only two buttons and a straightforward setup, the device is designed to be used by anyone. The sensors are the only real point of contact with the patient and are sealed in plastic. The plastic is resistant to gentle cleansers so the sensors can be used repeatedly and the device has no disposable parts. The sensors themselves are as thin as paper and if properly applied will not affect the patient's gait.

PROGRESS

We are currently in the testing and packaging phase of our project's development. The prototype has been constructed on a series of breadboards but we have not made it portable yet. It also performs all of its primary functions and we have just begun testing the prototype to see if it operates within specifications. We hope to have the system tested and ready for demonstration by the end of March.

DESIGN OF A MODULAR AVIONICS TELEMETRY SYSTEM

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Abstract

As the pace of the world moves faster and faster, an increasingly important feature of any moving vehicle is the ability to measure its dynamics. With the precision of modern Micro-Electro-Mechanical System (MEMS) and Global Positioning System (GPS) technology, data collected from a vehicle can be critical to improving its design. The more data that is gathered during real-world use of the vehicle, the better the chances of reducing costly and potentially catastrophic failures in the future. The goal of this project is to construct a generic and self-sustaining telemetry system to provide real-time flight dynamics for a rocket capable of reaching space.

Spearheaded by members of the Indiana Institute of Technology student branch of the IEEE, the team consists of largely electrical and computer engineering majors. Yet, the project is not exclusive to IEEE members or any specific discipline. A number of mechanical engineers are also involved with the job of designing the physical package for mounting the electronics system in a rocket body. The task of designing the power system and electronics is the main responsibility of the electrical and computer engineers. Also, industry advisors were brought in to offer expertise for the RF components of the project. One thing that every team member has in common is the fact that all are volunteers.

The dynamics measured by on-board sensors will include three-axis acceleration and the spin rate of the rocket, while a GPS receiver will provide the latitude, longitude, and altitude. This data will be transmitted real-time via an RF downlink consisting of a 1-watt (adjustable) OEM modem and a custom antenna designed to work at a range upwards of 70 miles. For redundancy purposes, the data will also be stored on a flash memory card encased in a water-tight compartment with other more expensive electronic components. Assuming a window can be installed in the outer casing of the rocket, a digital camera will be installed to provide pictures from the rocket. All of this will be mounted in a 4.5” diameter by 24” tall cylinder package that must withstand at least 20 vertical g’s, spin rates up to 25 Hz, and weigh less than seven pounds.

On April 8th, 2006 this system will undergo its first real test. The launch will not subject the system to the originally expected g-forces or spin rates, but will test all critical systems and software. The in-circuit programmable microcontroller has led to a process whereby each subsystem can be individually built and tested before total system integration. This has also led to a parallel development process between physical package and the software. All in all, the project has presented a magnificent learning experience for students and advisors alike, and should lead to an exciting conclusion on April 8th.

GAS SNIFFING MOBILE ROBOT

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INTRODUCTION

In the United States, natural gas is used to heat most homes. When natural gas does not burn properly, carbon monoxide and other harmful gases can build up and cause sickness or even death. Carbon monoxide is odorless, colorless, tasteless, and difficult to identify. Gas leaks can happen any time, and if not detected, in time it can become dangerous to the property and lives. In order to detect gases in any of these cases a gas sniffing mobile robot has been designed and is currently under development as a senior design project (part of our undergraduate program). To operate this robot, all the user has to do is simply turn it on and set it into a room or area where there is a possibility of harmful gases. The robot will move around the area and will zero-in on the source of a leak or the location of highest gas concentration. The location identifier fitted to the mobile robot will allow the operator to know the source/location of the problem.

THE GROUP AND WORK PLAN

A group of Northern Illinois students will design and fabricate this mobile robot with a budget of approximately two hundred dollars. This project will take one academic year to design and build. The first semester will allow team members to gather information, design, and order parts for the robot. During the second semester, tasks will involve circuit assembly, programming, development of mechanical structure and locomotion, system integration, and testing. The team is comprised of two Electrical Engineering Technology students (Jesso and Evenson) and a Mechanical Engineering Technology student (Patterson). All three students were responsible for the planning, design, development, and project management; while Dustin is the project manager. Jesso and Evenson (EETs) will be responsible for electronics design, involving controller, sensing systems, and programming. Patterson (MET) will be responsible for building the mechanical structure, drive system, and enclosure for the robot.

THE SYSTEM

The mechanical structure of the mobile robot will be as light as possible. This is to reduce the operating power consumption. Locomotion system will be on three wheels; two of them will be active, while the third one will be passive. This will allow the robot to make sharp turns. A microcontroller (68HC11) will be used as the central controller. There will be two gas sensors and one infrared obstacle sensors. The gas sensors are to detect differential gas concentration and will help to drive the mobile robot towards the gas source, while the infrared sensors will be fitted around the front of the robot to avoid obstacles when moving around a space.

CURRENT STATUS

The group has spent the first semester (Fall 2005) completing the design part of the project. During the current semester (Spring 2006), the team has acquired all the components and parts and has started the building process. We are anticipating that the system will be built and tested before the ASEE IL/IN conference and will be ready for demonstration.

DESIGN AND CONSTRUCTION OF AN AUTONOMOUS WALL-FOLLOWING SUBMARINE

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INTRODUCTION AND DESIGN PROJECT OVERVIEW

We established a goal of building an autonomous, robotic submarine. The submarine would submerge to a specified depth and travel parallel to a swimming pool wall until it reached a corner. Once the corner was detected, the submarine would turn 90° and follow the adjacent wall. After reaching a second corner it would emerge, surfacing itself. All of this was to be done with only a push of a start button upon entering the pool.

Organizationally, each member of our group took turns as the team leader. We set deadlines based on a Gantt chart that we developed early in the semester. Working as team had its own challenges. Not only were there schedule conflicts, but our members did not always work well together. However as the year progressed, we were able to work out differences, contribute to a larger team effort, and appreciate the importance of planning and individual contributions to the team. Our instructor guided us and kept us on task. He acted as a mentor, coach, referee, baby-sitter, and occasionally warden. But mostly he allowed us to run our own project.

Our submarine consists of six sub-systems. Our main hull is constructed using 6” PVC pipe. The microcontroller is interfaced to and used to control every aspect of operation of the submarine, guided by programs written in a variant of C. The ballast tank is 3” PVC pipe and utilizes solenoid valves to control the vertical motion of the submarine. One valve allows water to enter the tank to decrease buoyancy and another releases compressed air into the tank to increase buoyancy. Weights were included to counteract the buoyancy from the hull. A pressure sensor is used to maintain the desired depth, independent of the distance to the pool bottom. To propel and steer our submarine two thrusters are used. The thrusters are constructed using DC motors, 2” PVC pipe and fittings, propellers, and stuffing boxes. Ultrasonic sonar sensors detect the pool wall that our vessel follows and handle corners. A digital compass aids in our positioning as well by measuring the degree of rotation during the turning phase.

SUMMARY

In May of this year the six of us will be receiving our B.S. degrees in Electromechanical Engineering from Loras College. This project has been an excellent opportunity for us to put our engineering education to practical use and we are now more prepared and confident as we enter into our careers.

MODELING AND TESTING A COLD PLATE

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Faculty Advisors: Professors Donald W. Mueller and Hosni Abu-Mulaweh

During operation, electronic devices dissipate energy in the form of heat which must be removed for reliable performance. Because the physical dimensions of these electronic devices are constantly being reduced, increased demand is placed on their cooling systems as the dissipated energy must be removed from smaller and smaller spaces. Cold plates have come into favor due to their ability to effectively remove a large amount of heat from a small area. The two main features of a cold plate are a heat sink to conduct heat from the electronic device and a fluid passage that allows a circulating fluid to transport the heat to an external reservoir or heat exchanger. These features allow the cold plate to operate effectively in areas where the local environmental conditions are not conducive for convective or radiative heat transfer to ambient. Cold plates of this description are often used to cool arrays of power electronics that drive devices such as computers or electric motors.

The objectives of this work were to build and test a liquid-cooled cold plate similar to that shown in Figure 1, and then to develop a numerical model to describe the thermal characteristics of the cold plate. An important parameter of interest was the total thermal resistance of the cold plate which is defined as the maximum temperature difference divided by the net heat flow rate.

A cold plate was constructed by machining nine parallel, rectangular channels into an aluminum base (1.65 cm x 7.6 cm x 40 cm) upon which an aluminum cover plate was then welded. Twelve thermocouples were used to measure the temperature of the plate (surface and fin tip) and the circulating fluid at the inlet, outlet, and mid-plane. The working fluid was a 50/50 ethylene glycol-water mixture. Three heater blocks were mounted to the cold plate, and the assembly was insulated so that heat loss to the surroundings was minimized. Four runs were performed with flow rates ranging from 56 g/s to 95 g/s, and after steady-state conditions were reached the temperatures were recorded. Using these temperature measurements, the total thermal resistance was calculated and the results are shown in Figure 2. The thermal resistance of the cold plate was also calculated using a one-dimensional numerical model; agreement between the experimental measurements and model predictions is good. The results of this work are useful to applied thermal engineers.

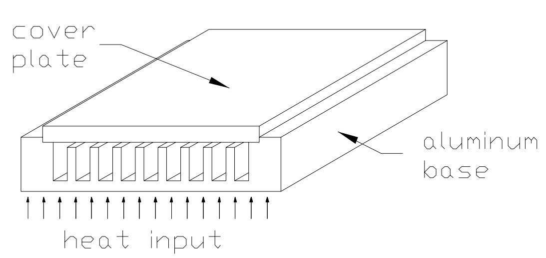

Fig. 1. Schematic of the cold plate with parallel channels for liquid flow and heat input from the bottom.

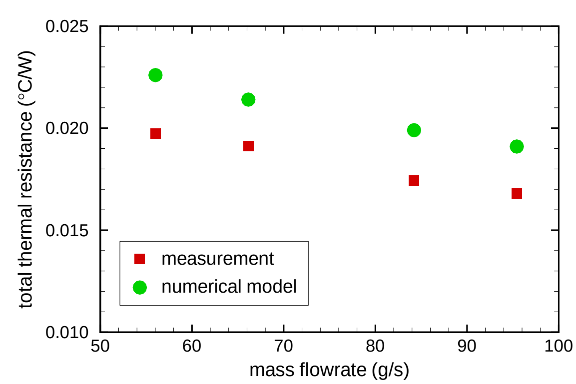

Fig. 2. Effect of flowrate on thermal resistance – comparison of measurement and numerical model.

DESIGN OF A MODULAR AVIONICS TELEMETRY SYSTEM

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BUSTING HEIGHT OF AN EGG

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Faculty Advisor: Dr. James Spreen

OVERVIEW

This project was originally done for the course Probability and Statistics for Engineers, and completed by a group consisting of one mechanical, one computer, and two electrical engineering students. The purpose of this experiment was to find the height that an egg dropped on the floor would bust. In order to do this a sensitivity test was conducted using the Bruceton test method.

In this method of testing each specimen is exposed to a given level of stress. For this test the specimen and stress are the egg and the height that it is dropped from; with the initial height being four inches from the ground. Once the egg is dropped, the test can go one of two ways. If the egg busts, then the height from which the next egg is dropped from is decreased by a predetermined increment. The increment for this test was one half of an inch. If the egg does not bust then the height from which it is dropped is increased by the predetermined increment.

Since the outcome of the test relied on whether or not the egg busted, the definition of busted was established to be any spillage of the yolk through the shell. If the shell of the egg was simply cracked, with no spillage, it was not considered busted. In order to insure all eggs were subjected to equal conditions, many precautions were taken also. All of the eggs used were size medium, purchased from the same store at the same time, and stored at the same temperature until the time of the test. A test fixture was also built to insure that all of the eggs were dropped from the correct height. For this a piece of foam core board was used. It was affixed to a wall, over a level area of floor, with the bottom of the board resting on the ground. On the board a scale was made with markings every half of an inch to insure that each sample was dropped from the right height. To insure that the surface of impact was the same for all trials, the surface was cleaned after each trial.

For this test sixty trials were completed. From there sixty trials the most correlated section of forty were chosen to analyze. This was done because the starting height of the test had no backing to support it as a proper starting height, so in order to allow for the results to reach the region closest to the mean value, extra trials were allowed. Once the forty trials were chosen the data was analyzed using the equations for the Bruceton test to find the mean bust height and standard deviation of the data.

CONCLUSIONS

From the use of the Bruceton test the expected height that an egg dropped on the floor will bust was found to be 6.63 inches with a standard deviation of 0.87 inches. Though the standard deviation was high for the height found, the educational value of learning how to design and conduct a Bruceton test outweighed our slightly unsatisfactory results.

Human Resources Buzzer Project

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Purpose and Design Process

A buzzer project team was organized from the student branch of IEEE students at Indiana Institute of Technology to support an intercollegiate competition. In December, Professor of Business Administration Dr. Jeff Walls asked if engineering students could build a push-button game for an upcoming Society for Human Resource Management (SHRM) intercollegiate competition in April, to be held at Indiana Tech. During this event, two teams representing colleges will be asked a question by a judge, followed by the students providing a correct response. We were asked to build a buzzer system to insure that the game is fair. The system would allow a team to hit a button that would light up the team's LED's and set off a buzzer. After a team has hit its button first, the other team is blocked from lighting up its LED. A cross-discipline (Electrical Engineering, Computer Engineering, and Mechanical Engineering) and multi-level (Sophomore – Senior) project team was formed to provide 24 buzzer systems to support his SHRM event.

The students have taken over the process of the build all the way from written proposals to soldering the hardware. Ryan Camp, Senior CPE, is in charge of building the TTL logic that will drive the center console LED's and buzzer in response to the push-button input. Zach Stauffer, Senior EE, and George Matocha, double major in EE and ME, are in charge of supplying the appropriate power needed. Janelle Freeland and John Welsh, Junior EE students, have worked hard on coming up with the design of the button design that the SHRM teams will use. Clinton Gulley, Stefan Hollis and Lindberg Williams, all CPE students, are in charge of documentation standards which made sure every part used in this project was documented properly for further use. Justina Horner, Sophomore EE, is going to head up the soldering and overall box assembly for the build. Chris Cress, Senior CPE, has taken over as project leader. His main role is to keep the build on task and settle decisions that could lead to higher or lower costs.

The project team has had several internal design reviews, as well as presenting progress reports to Dr. Walls. These reviews have resulted in several design changes, including reducing box size for easier manipulation and selecting LED's for larger viewing angle.

Status and Summary

The buzzer project has been run with efficiency and teamwork. The team works well together and is learning much about project planning and coordination. The circuit design has been verified in simulation and on a prototype board. Costing for purchases for initial package fabrication, build and testing are in process.

Coffee System Design Project Abstract

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1. Background

GVSU formed a relationship with a group of farming communities (Mirraflor) outside of Estelli, Nicaragua after Hurricane Mitch struck them in 1998 to assist in rebuilding their community. GVSU has continued this mutually beneficial relationship and recently identified a promising opportunity. A coffee system is to be designed and sold with a monthly subscription of green beans from the Mirraflor farming community to increase local welfare and to build relationships through a monthly subscriber newsletter.

2. The Challenge

A group of six GVSU engineering students currently enrolled in Advanced Product Design are to design, build, and test a coffee system that roasts green coffee beans, grinds the roasted beans, and brews coffee. The purpose and significance of this project is to provide consumers with the best coffee possible using a home coffee system. The specifications for the project were determined by practical limitations and customer needs. Concepts were generated by brainstorming, refined using the Pugh selection method, and the final selected design was optimized using DFA.

3. Technical Challenges

Ferris Nut, a local commercial coffee roaster, was consulted to familiarize ourselves with roasting and grinding processes. It was discovered that roasting green coffee beans is a controlled process in which the byproducts of smoke, smell, and chaff must be contained. During the roasting process the beans must be under constant agitation to provide an even roast. Combining the functions of removing smoke, removing smell, removing chaff and bean agitation in one roasting apparatus is the most significant technical challenge.

4. Work Groups

The project was carried out by three different teams. The coffee machine processes were broken into three sets of related functions. A function structure diagram enabled logical grouping of the coffee system critical sub-functions. The functions were assigned to minimize the interfaces between the different groups. The three teams, consisting of two students each, were responsible for designing, testing, programming and building prototypes of their functions.

5. Important Findings

Several different concepts of each critical sub-function was researched and tested before finalizing the design. The critical sub-functions include metering, roasting, removing smoke and smell, grinding, brewing and controls. Optimal solutions were chosen to carry out each critical function. The final prototype of the entire system is to be completed by April 20, 2006.

VERIFYING AND VALIDATING THE ROCSTAR MULTI-PHYSICS SIMULATION PROGRAM WITH A SUPERSEISMIC SHOCK PROBLEM

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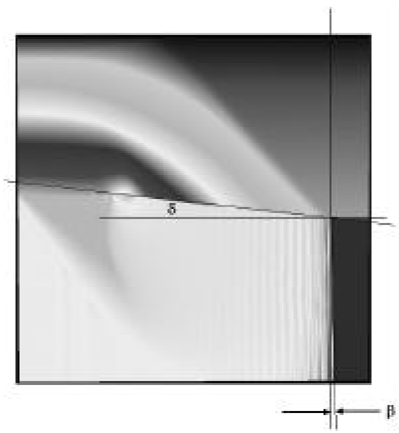
BACKGROUND

The Rocstar Computer Program is a three-dimensional, multi-physics code that has been developed at the Center for Simulation of Advanced Rockets (CSAR) program at the University of Illinois at Champaign-Urbana. Rocstar contains multiple solid mechanics, fluid dynamics, and combustion modules that provide flexibility in modeling coupled physics problems. The interactions between these codes cause complexity when verifying and validating the program. In order to verify and validate the results of the program, various problem sets are simulated and their results compared to the analytical, mechanical, or experimental solutions.

INTRODUCTION



One simulation used by CSAR is a fluid-solid interaction problem that models a super sonic shock wave traveling through a fluid domain along its solid domain boundary. The speed of the shock wave becomes super-seismic in the solid—causing a predictable angle of deformation in the solid-fluid interface boundary, d. Also, the speed of the shock wave in the fluid is slightly slower at the deforming boundary at the top than the speed at the non-deforming boundary at the bottom, which creates an angled shock front, ß. It is this angle of the shock with the surface that has not yet been reached by the shock wave that can be calculated. The results from the Rocstar Simulation are used to calculate the angle ß and that result is compared to the analytical results.

RESULTS

Mach	**ß Theory**	**ß Simulation**
2.5	-1.7982	-1.708 ± 0.04
3.0	-2.1214	-2.120 ± 0.02
3.5	-2.3041	-2.282 ± 0.06

These are results that I obtained after running the code with smaller time steps than had initially been run. The new results had smaller standard deviations that were closer to the theoretical calculations. This led to a grid resolution study designed to identify what causes this variability in precision of the grids. The code is run with several different grids with different levels of resolution, and results compared to investigate the relationship between the accuracy of the simulation and the resolution of the grids. Another part of verifying this code will be to run the same grids in different modules, to show that the same results are obtained. So far, the modules that have been used for this problem are *Rocflo* (a structured fluid dynamic solver that uses only hexahedral elements) and *Rocfrac* (an explicit unstructured solid mechanics module). The other two available modules are *Rocflu* (an unstructured fluid module that can use a variety of element types) and *Rocsolid* (an implicit unstructured solid mechanics module). *Rocflu* and *Rocsolid* are not yet able to run this problem, although researchers are currently working towards that capability.

High-performance visible AlGaInP semiconductor diode lasers

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Abstract

With the recent advancements in heterojunction, multiple quantum well based light emitters, there is a wide variety of demand for Gallium Arsenide based lasers with output in the 630-670 nm (red) spectral emitter. Our new high-index contrast fabrication techniques promise higher device performance, including lower threshold currents and higher quantum efficiency. These benefits result from a deep etch-defined mesa and sidewall oxidation technique that allows for enhanced current and light confinement in the active areas. These high-index-contrast structures also give rise to their potential use in photonic integrated circuits (PICs) due to the superior waveguiding ability and electrical isolation provided by the native oxide grown on the device. To our knowledge, oxidation of the quaternary alloy AlGaInP used in this work has not previously been reported, making this work a unique contribution to this field.

Using the Engineering Design Process to Provide Scientific Demonstration Kits for the Study of X-ray Diffraction for High School Students

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ABSTRACT

Students enrolled in a first-year Introduction to Engineering class in Fall 2005 worked in groups to make working prototypes of a demonstration kit for a local high school science teacher. The demonstration kit was designed to teach x-ray diffraction of single crystals (without using harmful x-rays) and to allow the high school teacher to demonstrate the mathematical concepts of 2-, 3-, and 4-fold rotational symmetry. In completing these designs, ENGR 1010 students closely followed and applied the engineering design process. They first researched the physics of x-ray diffraction of single crystals and rotational symmetry. Following consultation with the science teacher and the ENGR 1010 instructor to make a list of design specifications, the students brainstormed ideas and selected a final design based on the design specifications. They performed vendor research for components of the demonstration kit and assembled a working prototype. Now, in the Spring 2006 semester, two groups of students are re-designing, improving, and manufacturing their prototypes from the previous semester. They continue to work with the science teacher and incorporate his feedback to create a demonstration kit that best suits his students' needs. Prototype development will be followed by classroom user testing in March and final recommendations. Through this project, these students are involved in genuine service learning while successfully using the engineering design process to solve a real-world problem.

Title: Student-designed Materials for K-12 Classroom Demonstrations of Science, Technology, Engineering, and Mathematics (STEM) Concepts

Abstract: Students enrolled in a multidisciplinary service learning engineering design course work in groups to make working prototypes of hands-on experiments in STEM (**S**cience, **T**echnology, **E**ngineering, and **M**athematics) areas for K-12 teachers. The module to be discussed addresses the topic of "simple machines," geared for a 3rd-grade classroom but adaptable to other age groups. The experiments illustrate mathematical relationships in mechanical engineering through interactive play that engages students and stimulates interest in engineering as an everyday part of life. The student-designed materials involve plastic gears and small pulleys used on separate platforms designed to allow the young students to place and move components in specified or experimental locations. Changing the positions and relationships of the components results in a variety of outcomes for students to manipulate, observe, and respond to. As a starting point, two to five different configurations would be used by the 3rd-graders to become familiar with how the various machine components work. A separate, more heavy-duty apparatus will be created for and used by the classroom instructor for initial, follow-up, or brief demonstrations to the class.

Classroom instructional materials will also be provided for the teacher and for students to use and respond to. After the hands-on experiments, students in the class would be asked for oral and written responses to observational questions like, "Why does one gear rotate in one direction while another spins in the opposite direction?," "When a big gear turns a small gear, what happens?," and "Where are gears used in everyday life?" The teacher will receive mathematical calculations covering the mechanical and physical relationships of pairing different sizes and orientations of gears and pulleys, and simpler, age-appropriate versions will be supplied for the young students to work through.

The college students in the multidisciplinary university course benefit from this project by seeing a real-world outcome and use of their engineering design and fabrication. The college students will user-test their modules in real classrooms, will analyze and evaluate the testing results, will modify their materials as appropriate, and will then provide the tested and improved materials to the teacher.

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