University-Industry Partnership to Enhance Senior Capstone Design

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Mechanical Engineering Capstone Design

The mechanical engineering senior capstone design course at North Carolina A&T State University (NC A&T) is a two-course sequence. The change from a one-semester course four years ago allows students sufficient time to design projects from concept through prototype construction, testing, and evaluation. The class has approximately forty students each year and is divided into four to five sections, each with a different project. Projects include professional society sponsored design competitions and industry sponsored projects. Design competitions include Society of Automotive Engineers (SAE) Aero Design Competition, Formula SAE, and Mini Baja, and American Society of Mechanical Engineers (ASME) Design Competition. Industry sponsored projects include those from Boeing, Caterpillar, Kimberly Clark, Gillette, and Michelin.

Industry sponsored projects allow students to work on actual, meaningful engineering design projects that relate theory with practical applications. These industry leaders provide opportunities for students to gain experience with realistic applications along with funding to support the project objectives. Unfortunately, NC A&T is not geographically located near major industrial regions, and the distance between the University and sponsoring companies tend to limit effective implementation of projects. Scheduling plant tours for students to view project assignments is difficult or impossible, and similar problems exist with building relationships with liaison engineers. An effective liaison engineer must dedicate a fair amount of time to address student questions, review designs, and help find supporting data and information. In the current climate of corporate downsizing, few engineers are in a position to volunteer their time to serve as liaisons.

Another barrier to industry sponsored projects is a lack of strong mentoring by faculty members who are experienced within the selected subject area. Each capstone design course at NC A&T is taught by a single faculty member who has the responsibility to coordinate all sections of project activities, including design reviews. The remaining faculty members within the department are assigned on a rotating basis as advisors to individual project sections. The frequency of rotation for a faculty member to serve as an advisor is approximately four years. Unfortunately, rotating faculty advisors does not help develop expertise specific to subject areas, as most faculty have little or no industrial experience.

The limitations of faculty mentoring and the significant challenges of industry support leave the capstone design course with significant opportunities for improvement. Strong, focused, and comprehensive industry support with a long-term commitment is required.

The Gillette – NC A&T Partnership

The Gillette Company has made a long-term commitment to NC A&T, funding student scholarships with internships, faculty fellowships, and the establishment of a Project Center. The Gillette Project Center was created to provide students with an opportunity to gain project related experience of technologies used for the design of Gillette product and manufacturing equipment. The Gillette Faculty Fellowship, similar to the Boeing Faculty Fellowship [1], encourages faculty to be more engaged in engineering practice by allowing professors to spend an extended period of time at Gillette to learn of their business and technological requirements. The fellowship enables faculty to gain in-depth knowledge from Gillette personnel, which helps minimize the level of industrial liaison support. The fellowship also provides an opportunity for the advisor to identify suitable project activities, ensuring a good match of project work to student capabilities.

The Gillette Project Center

The current two-semester Gillette project is titled Cam Dynamic Testing Machine. The overall project objective is to build an apparatus that provides for the learning and testing of mechanical cams. The test stand will make use of two cams, one double-dwell cam and one four-dwell cam. The double-dwell cam will control a slide in the vertical direction and the four-dwell cam will control the slide in the horizontal direction.

During the first semester, the students will research motors, drives, and sensors that will be required for the project. This effort will guide the appropriate selection of power systems, controllers, and sensor components to operate the test stand. In addition, they are expected to build the core mechanical platform which houses the shafts, slides, and associated cams. The development of the test stand will build student confidence from several disciplines and ensure that sufficient power is calculated to operate the test stand. Different views of the test stand are shown in figures 1-4 when driven by an electric power drill to verify power and speed requirements.

During the second semester, the students will power the test stand with a DC motor and speed controller. Motion sensors (position, velocity, and acceleration) will be added and an output device will be added underneath the slider to make the machine interesting. A force sensor will be required to measure the force generated by the slide. The students will mount the test stand to a mobile cart outfitted with a control panel. The control panel will include a speed control dial, test points to gain access to the various sensors, and an emergency stop switch to ensure safety. The testing machine will remain on the NC A&T campus and will be utilized as a part of

Mechanical Engineering Laboratory to illustrate mechanical cams, motion control, and sensor technology.

Learning Modules for Capstone Design

Many students experience difficulties in a project-based design course because most students lack prior hands-on experience with electrical and mechanical systems. Unlike students from past generations, engineering students today typically have little or no experience repairing cars, appliances, or toys. Additionally, student's lack shop know-how since this requirement has been removed from many engineering curricula. Often students are not prepared to tackle the real-world projects that are the basis of a capstone design course. The Gillette Project Center helps develop these skills through training on hardware and software learning modules.

These learning modules provide students with design and build challenges of small electromechanical systems. They are designed specifically to introduce various mechanisms and electromechanical components to the students. These mini-projects serve two purposes. First, students gain hands-on experience in building relatively simple systems from standard components. Second, these modules help students learn critical mechanical and electrical functions within a hands-on, exploratory setting, very similar to science museum exhibits.

From a mechanical perspective, these modules provide exposure to gears, chains, pulleys, cams, linkages, shafts, keys, bearings, couplings, and clutches. Electrically, the modules will afford an introduction to motors (DC motors, stepper motors, and servomotors), switches, solenoids, and sensors (motion and force sensors). Integration of electrical and mechanical components is paramount to a solid comprehension of machine design fundamentals.

The capstone design includes Learning Software in the form of multimedia courseware, augmenting information, which is available from textbooks and other sources. Many textbooks cover project management and design processes, but unfortunately not all application specific data is readily available. Although numerous catalogues and design guidelines [2, 3, 4] are available on-line, it is difficult for students to retrieve all relevant information. The multimedia courseware fills the information gap relative to specific principles of major mechanical and electrical systems.

For example, to help visualize the cam in motion, like the one shown in Figure 3, computer simulation using Working Model 2D [5] was developed, as shown in Figure 5. Another simulation, as shown in Figure 6, was also developed for the 4-dwell cam as shown in Figure 2. Courseware on motors and sensors are also being developed. This type of learning modules is necessary as kinematics is an elective course in the Mechanical Engineering curriculum, and not all students have exposures of cams and linkages.

Discussion

This paper reports on the benefits to the capstone design courses as an outcome of the Gillette / North Carolina A&T State University partnership. Within the framework of this partnership, The Gillette Company has established a long-term commitment to support university and student development in several ways. Gillette is providing summer intern opportunities for students, financial support for project activities along with engineering liaisons, and faculty fellowships for academic advisors. Student and faculty gain exposure to Gillette through project work, summer internships, and faculty fellowships which is critical to help overcome the geographic barriers discussed earlier. Through these actions, students and faculty network with Gillette's engineering staff to gain knowledge of Gillette products, manufacturing processes, and equipment design.

North Carolina A&T is recognized as one of the nation's leading institutions of higher learning, graduating more African American engineers and technologists than any other university in the country. The Gillette Company, headquartered in Boston, MA, is the world leader of grooming products – blades, razors and shaving preparations. The Gillette / North Carolina A&T State University partnership is building strong relationships, which is beneficial to both the university and Gillette. Gillette will identify and recruit the best and brightest minority graduates and North Carolina A&T University will gain additional resources to enhance the capstone design course to better prepare their students for industry.

Acknowledgements

Mr. Edwin Ryan, Vice President for Gillette Engineering Implementation Group in Grooming Products, is the champion behind this Project Center. He provided the leadership and resources to make the Center a reality. The authors also want to thank Mr. Royall Mack, Vice President for Gillette Civil Affair, who spearheaded the Gillette – NC A&T Partnership.

Reference:

1. Boeing - A. D. Welliver Faculty Summer Fellowship
   http://www.boeing.com/companyoffices/pwu/fellowship/objective.html
2. MIT Open Courseware URL: http://ocw.mit.edu/OcwWeb/
3. MIT ME 2.007 on Power source, battery, motors URL:
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4. MIT ME 2.670 Machine Shop URL:
   http://web.mit.edu/2.670/www/Tutorials/Machining/Description.html
5. MSC.Software, URL: http://www.workingModel.com/.

Biographical Information

Shih-Liang (Sid) Wang is Professor and Director of Mechanical Engineering in the Department Mechanical and Chemical Engineering at North Carolina A&T State University. Dr. Wang received his Ph.D. in mechanical engineering at Ohio State University in 1986. His research interests include computer-aided design, machine and mechanism design, motion simulation of mechanical systems, design theory and methodology, and robotics.

Paul Burt is the manager of the Electrical Controls Systems department at The Gillette Company, headquartered in Boston, MA. He has 25+ years of automation experience with a broad field of industrial applications Paul is also developing the Gillette / North Carolina A&T State University technical partnership along with Professor Wang and helps manage the recruitment of all engineering disciplines within the Engineering and Implementation Group.

Figure 1 Test Stand – Side View

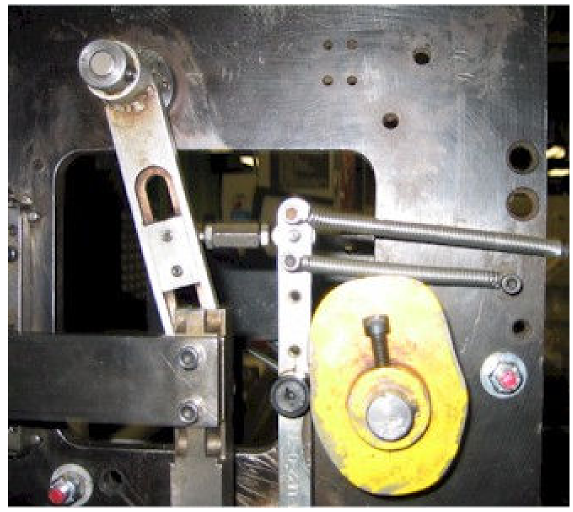

Figure 2 Test Stand – End View

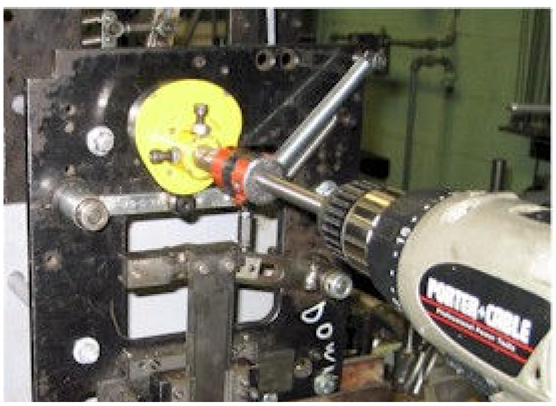

Figure 3 Test Stand – Front View

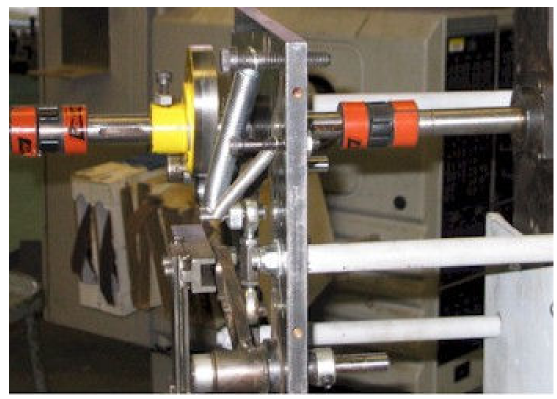

Figure 4 Test Stand – Back View

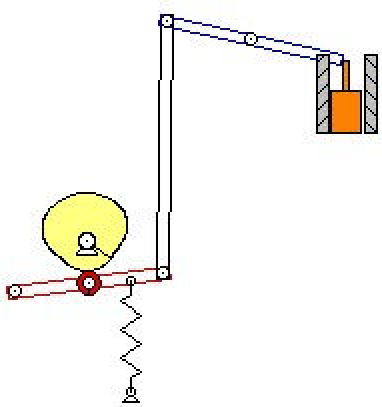

Figure 5 Simulation – Double Dwell Cam

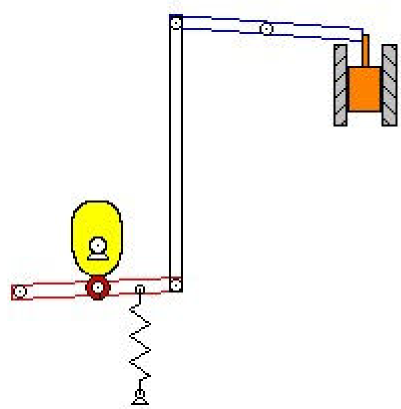

Figure 6 Simulation – 4- Dwell Cam