AC 2007-2652: CIM LAB TO SUPPORT MANUFACTURING DESIGN IMPLEMENTATION

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CIM Lab to Support Manufacturing Design Implementation Course in Manufacturing Engineering

Abstract:

Integration of information technology in manufacturing industry in recent years has dramatically affected the delivery of instruction in manufacturing engineering programs. Inclusion of the state of art techniques and technology in a manufacturing education, particularly in the engineering field, is a key factor in the advancement of this discipline. CIM laboratory strongly supports manufacturing engineering curriculum to fulfill some of the ABET requirements for criteria: (b) an ability to design and conduct experiments, as well as to analyze and interpret data, (c) an ability to design a system, component, or process to meet desired needs, (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. Some key components of CIM and hierarchy of operation in a manufacturing facility are studied and correlated. They include CAD-CAM link, numerical control, automation, production and manufacturing control, control through proper communication and computer supervisory control, robotics control, process planning. A short summary of planning, implementation, and managing of a CIM environment will also be covered. The students will conduct experiments on creating a CIM environment using computer supervisory control. By conducting a hands-on CIM lab project, students have access to the relatively new technologies associated with computer integrated manufacturing, which enable them to participate in tomorrow's rapidly changing technologies and become creative problem-solvers and designers. In this project, students design a product that starts with raw materials and continue with fabricating parts, inspecting, assembling, and storing. This paper emphasizes on the technical contents as well as educational values of the projects.

Introduction:

At our Engineering and Technology Learning Center (ETLC) we provide our students with access to a CIM lab, a CAD/CAM lab and a Robotics lab to support our Manufacturing Engineering program. These labs have significantly enhanced this program by providing excellent teaching aids and hands-on experience to educate our students. Our curriculum is designed to have Engineering Graphics, CAD/CAM, Manufacturing Automation, Quality Engineering, Production Planning and Inventory Control, Materials Engineering and related labs to provide our students with quality hands-on experiences. Through these courses the students can receive the appropriate training using different software including Solidworks, Mastercam, MS Project, Labview, Matlab and other manufacturing simulation software.

As a result, our graduates will be more marketable due to their acquired soft and hard skills through our Manufacturing Engineering program. They will be able to satisfy the growing need of robotics and real-time programming expertise in industries.

Although there have been many papers published on automation, robotics, and the applications of CIM in manufacturing[1, 2, 3, 4], few of them have used an approach to build such projects over several different courses. In this paper, we emphasize on defining a final project using the CIM Lab having prepared the students in other classes as well. The same project is being worked on in other courses but focusing on different aspects and perspectives. For example, this project was conducted in courses MANE 410 Production Planning and Inventory Control, and MANE 415 Project Engineering and Management. In MANE 410 students focus on the production planning aspect of the project, and in MANE 415 a different group of students focus on the project management.

In this paper we want to focus on the course MANE 450, Manufacturing Design Implementation. This is one of the courses that have been offered in the past two years in our program. MANE 450 is a capstone course that manufacturing engineering students take in their senior year. The course is team project-based, which focuses on design and implementation of a simple product utilizing CIM lab equipment.

This course has the main objectives that follow:

- apply technical knowledge to solving engineering problems
- enhance decision making skills
- enhance teamwork
- perform engineering analysis
- demonstrate synthesis
- enhance communication skills through documentation and presentation
- enhance project management skills

CIM Laboratory Facilities:

The Computer Integrated Manufacturing (CIM) Laboratory includes the following equipments: CNC mill and lathe, Industrial robots, Automated Storage/Retrieval System (AS/RS), Computer-controlled conveyor system, and Vision System. A pictorial view of some CIM laboratory facilities is shown in Figure (1).

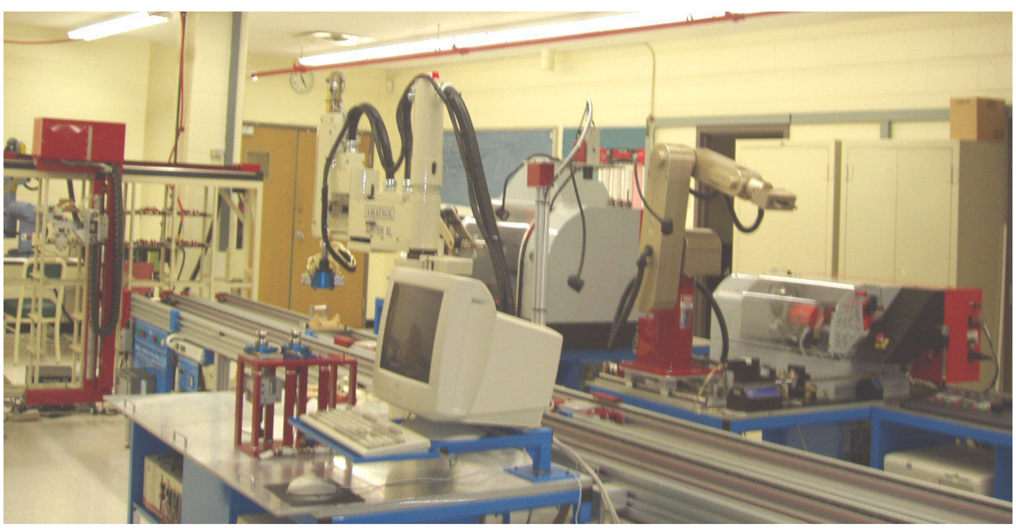

Fig. 1- Pictorial view of CIM facilities.

Learning Objectives for MANE 450

By the end of the course each student should be able to develop several skills.

Design Skills

Through working on their project, the students enhance this skill by going through the complete product development process, and by developing and meeting a schedule and budget constraints. Students are required to develop a complete set of functional specifications that the design solution must meet. They are also required to select the most promising design concept using structured methodologies. Then they are expected to develop the design models and/or drawings for the prototype and the final design components. After coming up with the complete design plan, students go on to produce, fabricate and assemble the final design hardware. Once they have come up with the final product, they are to run some tests and evaluate and analyze their prototype and the final design components and systems to identify any further modifications and improvements to be made on the design. If necessary modifications are made to better the quality and also increase the production rate of the system.

Team Skills

Students are to work on their project in a team. This allows them to enhance their team-working skills. By putting their different strengths on the table as a team, they learn to work harmoniously and effectively to complete their manufacturing design and implementation project.

Communication Skills

Finally, after the completion of their project, the students are required to write a final high-quality design report and give a clear and informative oral presentation elaborating on the works they have done throughout the semester. They are also required to demonstrate the operation of their production line.

Project Components

After specifying the target product through brainstorming by team members, considering all constraints (time, budget, availability of tools and equipment), the activities follow the three project phases of definition, planning, and implementation.

The project has the following two main components (refer to figure 2) [5]:

a) Defining and solving design problems, which includes the following steps:
   - Designing products and process plans
   - Component decomposition diagram of product
   - Component decomposition diagram of process

b) Implementation and solving manufacturing problems, which includes:
- Robotics programming
- CNC programming
- Tools and fixture
- Material handling
- Production planning
- Manufacturing scheduling

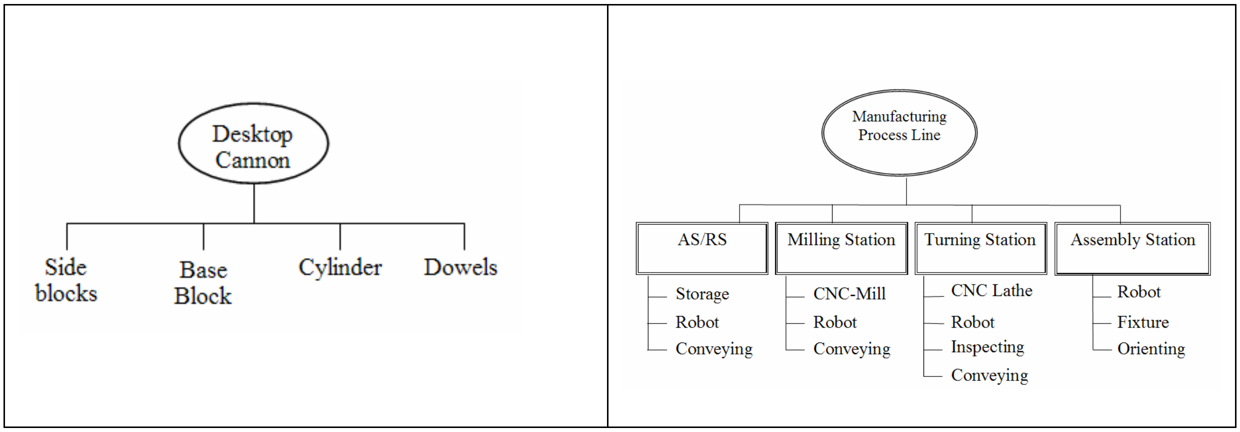

Fig. 2- Component Decomposition Diagrams of Product and Process

Last year's Project:

Last year a team of four students worked on designing and manufacturing a desktop business card holder. The idea was selected by students after brainstorming based on availability of resources and geometric constraints of CIM lab equipments such as robot griper maximum opening, milling machine travel size, and other issues. See Figure (3) for the arrangement of parts and assembly on fixture mounted on a palette developed in design process by solid modeling software. In this project the CIM line was composed of ASRS, Automated Conveyor, Milling Station (mill - Flexible Manufacturing Cell), and Assembly Station.

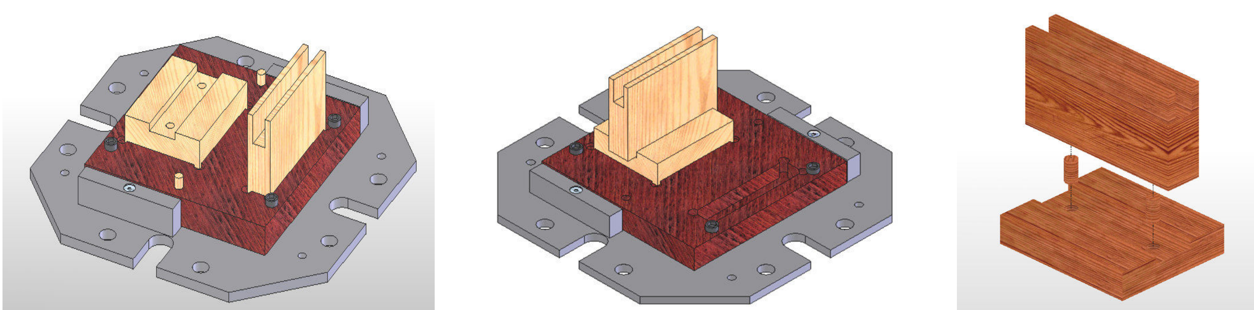

Fig. 3- Business Card Holder parts before and after assembly

Although the project was completed and demonstrated on the time frame, there were many issues in which the students were interested to work on but they were unable to due to shortage of time. In a conducted exit survey and interview with the four graduating students that participated in the project, one of the students stated, "MANE 450 was the best course among the others and I learnt the most". Another student commented to add more hands-on machining lab in the earlier years of the students in the curriculum.

This year's Project:

This year a team of five students worked on the design and manufacturing of a desktop cannon. See Figures (4 and 5) for arrangement of parts and assembly on the fixture. In this project the CIM line was composed of ASRS, Automated Conveyor, Milling Station Turning Station, and Assembly Station. Seeking for simplicity, the project is designed for only holes operation of the base part at the Mill – FMC, a linear turning of the bar at the Lathe – FMC, and all other parts were pre-manufactured.

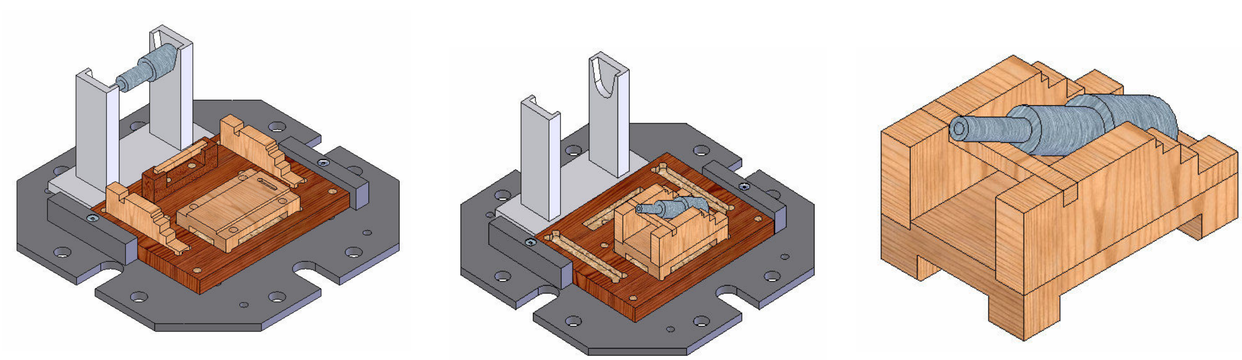

Fig. 4- Cannon parts before and after assembly

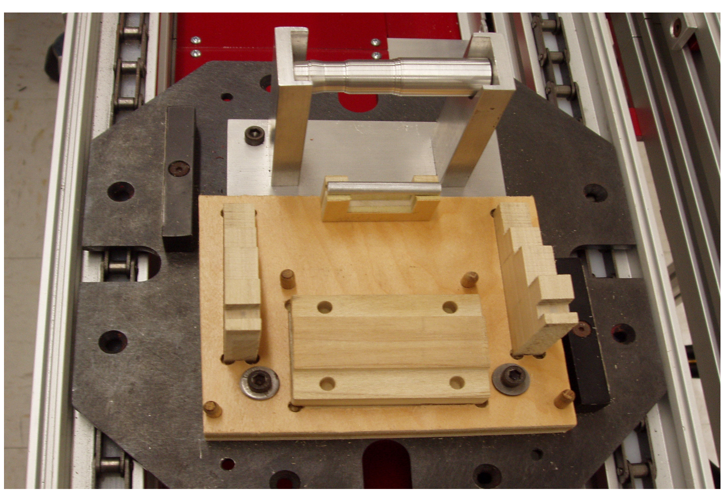

Fig. 5- Cannon Parts

Working on this project, each member brought ideas to the table. After coming up with the idea of the building a desktop cannon, students developed their Responsibility Assignment Matrix (RAM) and Work Breakdown Structure (WBS). Then, they created a Gantt chart to plan out the different steps and components of the project. After planning, they proceeded to the design activities composed of creating solid model of parts and assembly considering the machines and robots dimensional specifications. Students then conducted the manufacturing process and finally did a final review and evaluation of their project.

c) Responsibility description and team organization
   - *Student 1(M)/ Project Manager + Assembly process*
   - *Student 2 (Q)/Product Design Coordinator +*
   - *Student 3 (D)/ Manufacturing Process Design Coordinator/ Milling FMC Coordinator*
   - *Student 4 (C)/ Manufacturing Support Coordinator + Fixture design and fabrication*
   - *Student 5 (A)/ Turning FMC Coordinator + Secretary*

Team Organization:

The members of the project team divided-up the primary responsibility for coordinating the three areas listed below.

Product Design Coordination:
The coordinator is responsible for coordinating all issues concerning the design of the system including development of design specifications, including manufacturing documentation, coordinating product design activities between project team members, and preparing the final design process report and presentation.

Manufacturing Process Design Coordination:
The coordinator is responsible for coordinating all issues concerning the implementation of the design including feedback concerning the implementation of the preliminary design, writing the production report and presentation for design review, coordinating manufacturing process activities between project team members, and preparing the final manufacturing process report and presentation.

Design and Manufacturing Support Coordination:
The coordinator is responsible for coordinating all issues for supporting the project both in design and manufacturing phases. These responsibilities include the design and fabrication of required fixtures and tooling attachments, preparing raw material, standard and prefabricated parts required for project, and also preparing the related final report and presentation.

Student Evaluations:

Our student evaluations were based on four elements: (1) final report, (2) final presentation, (3) faculty evaluations, and (4) peer evaluations. The final presentation was evaluated by faculty and also by a member of the Industry Advisory Committee. The peer evaluations were made based on the following criteria: attitude, meeting attendance, cooperation, quantity and quality of work, meeting deadlines, leadership, creativity and overall understanding of the project.

The course outcomes are in line with our Manufacturing Engineering program outcomes numbered 2, 3, 4, 7, and 11, which are:

Outcome 2: Ability to perform engineering analysis by designing and conducting appropriate experiments and analyzing and interpreting results.
Outcome 3: Ability to design products, equipments, tooling and environment for manufacturing systems.
Outcome 4: Ability to function effectively in team or group setting.
Outcome 7: Ability to communicate effectively.
Outcome 11: Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The results of outcomes assessment conducted by faculty are shown in figure (6).

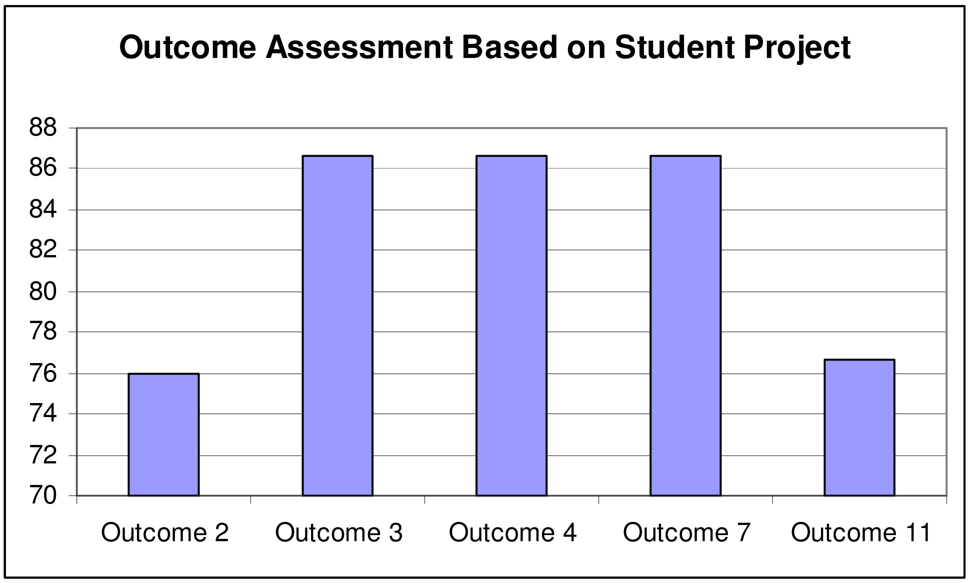

Figure 6 – Results of faculty and peer evaluation of the course.

Conclusion:

Through the experiences gained from teaching this course for the past two years, we have come into several realizations. It was noted that shortage of time was a common problem in both years. The MANE 450 course was designed to be completed in one semester. However, the course objectives have proven to be too many to be completed within one semester. It is being considered to decompose this course into two semesters, one focusing on product design and the other focusing on process design.

Our students have found this course to be very interesting and challenging. There were a few difficulties that the team faced. This year's team, for example, had the problem of one member being idle and not participating. This act put the whole team through a lot of stress and put their project into jeopardy. The problem seemed even more significant due to the diversity of activities that different members were held responsible for and also the shortage of time issue.

Another conclusion that we drew was that the experience and technical skills that our students entered the project with were bellow what is required in order to successfully finish the project. This is due to the lack of experiences obtained in the lab during the earlier years of their college career. Therefore, it is now being suggested that students gain more hands-on training in labs prior to their senior year.

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