AC 2009-14: A PACKAGING FOCUSED MECHATRONICS ENGINEERING TECHNOLOGY PROGRAM

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A Packaging Focused

Mechatronics Engineering Technology Program

Abstract

The consumer packaged goods industry consisting of food, beverage, and consumer products accounted for more than $2.1 trillion of the United States economy in 2004. The packaging industry itself represented about a $165 billion market in the U.S. Automation plays an important part in U.S. packaging representing about $6 billion yearly sales in machinery alone. Several factors work together to increase this dollar amount each year. As more and more goods are packaged, new equipment must be purchased to package the goods. As energy and material costs increase, more development effort must be spent to minimize cost in these areas. These factors have caused the packaging industry to transform into a high technology, information critical, high speed industry. As these developments have occurred, educational institutions have been slow to provide graduates that can work in this intense industry. As it turns out, engineering technology programs are in an ideal position to support the packaging industry. This paper describes the first Mechatronics Engineering Technology bachelor program specifically designed to serve the packaging industry. The paper describes the program's development process, the finalized curriculum, industry partners, and laboratory development efforts.

I. Introduction

With global economy, consumer, industrial and commercial goods need to be packaged and shipped to different locations. The package must protect the content, deliver proper information about the content and in certain applications be appealing to customers. Packaging industries are under continuous challenges as the cost of energy and material increases. More efficient packages with less material are needed to reduce the cost of packaging. Machines performing these packages are getting more complicated with faster speed and better accuracy. The new packaging machinery utilizes high speed controllers, imaging techniques, wireless technology, and a high degree of intelligence for operation and diagnostics. The packaged goods consisting of a vast variety of items such as food, beverage, and consumer products in 2004 constituted more than $2.1 trillion of United States economy.[1] The packaging industry itself allocated about $165 billion market in U.S.[2] The U.S. packaging machinery has an annual sales exceeding 6 billion dollars[3]. The packaging industry and packaging machinery are expanding rapidly and requiring engineers and technicians to design, to modify and operate the equipment. In the past automotive industry employed a large number of engineers and technicians. The collapse of the automotive industry in 2008 had many ramifications worldwide. From an Engineering Technology perspective, it limits job opportunities for interns, co-ops, and graduates, but it also creates a perception issue. For years, the automotive industry was held in high esteem by many college students, and many graduating seniors sent resumes off in hopes of an interview and a steady career. The automotive industry's use of technology created and reinforced the perception of desirable, highly respected careers. The recent economic downturn has changed that perception, and most technology students are now looking elsewhere for stable careers.

Oddly enough, the packaging industry has similar high technology careers, but students, faculty, and institutions are generally unaware of the opportunities available in this $6 billion per year industry. The industry has a trade association, the Packaging Machinery Manufacturer's Institute

(PMMI). PMMI is a trade association with more than 550 member companies that manufacture packaging and packaging-related converting machinery, commercially-available packaging machinery components, containers and materials in the United States and Canada. The equipment built by PMMI members often uses the latest automation and robotic techniques for high speed packaging machines. The new packaging machines can deliver packages more than 1000 times per minute. Such high speed equipment demands the most strenuous design and automation capabilities. As the packaging industry continues to automate, its specialized needs become more apparent, and engineering technology programs, at the associate degree level at least, started to become aware of the opportunity they have to serve those needs.

PMMI has a history of partnering with education, and there are currently 40 affiliated institutions[4]. PMMI provides access to scholarship funds, travel opportunities, and marketing via the annual PackExpo conference[5]. With 40 affiliated institutions, one might question how the industry has been ignored by higher education. A review of the affiliated programs shows a diverse group of technical schools, community colleges, and universities. The associate level technology programs affiliated with PMMI, usually using the word Mechatronics in their description, seem to concentrate on training packaging machinery operators, mechanics, and support personnel. Mechatronics is a well established field of study in Europe and Canada. The university programs often titled Packaging Science, concentrate on package and container design including packaging material properties, printing, graphics, and their effect on marketing product. However, packaging machinery design and manufacture, the subject of this paper, have not been the focus of U.S. engineering and technology programs although mechanical or electrical graduates do the engineering and manage the industry.

II. Development Process

Current needs of the packaging industry, especially the machinery manufacturers, call for a combination of electrical and mechanical skills. Some schools such as Penn State and RIT have instituted BS degree programs in Electro-Mechanical or Electrical-Mechanical ET and a number of two year programs in Integrated Systems Technology have sprung up with help from workforce development funding. These programs are generally aimed at manufacturing. Analogous interdisciplinary engineering programs tend to concentrate on designing mobile mechanical systems with embedded micro controllers. The packaging industry is in a unique position to shape or influence these programs, as we'll discuss here.

Morrison Container Handling Solutions and Purdue University Calumet share the same geographic area on the southern end of the Chicago metropolitan region. Long known for its expertise in timing screws, Morrison also manufactures change parts and kits along with building custom packaging machinery. Purdue University Calumet was started during World War II to train supervisors in the steel industry. Mechanical Engineering Technology and Electrical Engineering Technology programs were added shortly after the war. As an autonomous partner in the Purdue system, Purdue University Calumet has the flexibility to tailor programs to the local area while drawing on the strengths of the Purdue system.

Morrison hired their first Purdue University Calumet graduate more than 20 years ago, and Purdue Calumet mechanical or electrical alumni make up more than 50% of Morrison's current engineering staff. With so many graduates, it was inevitable that Morrison would turn to Purdue

University Calumet for technical assistance and student projects. Beginning in the spring of 2006, faculty at the University completed several projects in the areas of solid modeling, automated manufacturing, and training at Morrison. Technology students must complete an in-depth senior project as a graduation requirement, so student projects in several areas followed. Students benefit from adding a real project on their resume.

Chicago is home to more than 30 manufacturers of packaging machinery. Nick Wilson, president of Morrison, suggested further interaction with the local packaging industry at the same time the University was considering developing a Mechatronics Engineering Technology program. PMMI offered to make Purdue University Calumet an affiliated school at this time, and then found resources for two faculty members to attend the 2007 PackExpo conference and trade show in Las Vegas[5].

PMMI, exhibitors, and other affiliated schools provided tremendous support during Pack Expo. During the conference, the faculty attending roughed out a mechatronics program refined later by eight Purdue Calumet faculty and many PMMI members.

III. Curriculum

The faculty members designed a prototype curriculum based on general ABET engineering technology criteria, and then meet with packaging industry professionals at all levels for assistance in refining the curriculum to meet industry needs. The packaging industry partners generally looked at course outcomes for the courses proposed, making suggestions based on their experience. In some cases, the faculty decided to modify existing mechanical, electrical, or other courses from the School of Technology, in two instances new courses will be developed that integrate areas in the curriculum. As part of this process, the following partners provided plant tours and curriculum review:

- Morrison Container Handling Solutions
- Dorner Conveyor Manufacturing
- PMMI
- Goodman Packaging Equipment
- Schneider Electric and ELAU Inc.
- B&R Automation
- Triangle Package Machinery
- Shuttleworth, Inc.
- Rockwell Automation

At the conclusion of many meetings, the bachelor degree curriculum shown in Table 1 was approved by the faculty and the Indiana Commission for Higher Education. Students were first admitted in the fall, 2008 semester. The number of students attending the program is 7 and will be increased next semester. We are anticipating this number will reach to 150 students in next five years.

The development of the curriculum utilized a balance between the mechanical and electrical disciplines. For a two year associate program, student must satisfactorily finish 64 credit hours. This process, for a full time student usually takes 4 semesters or two years. For a bachelor

degree in the Mechatronic engineering technology a students must have a minimum of 127 credit hours. Students can earn their two year associate degree and enter the job market and continue their education later on. The normal time for a full time student to finish a bachelorette degree in Mechatronic engineering technology is 8 semesters or 4 years.

The Associate Science (AS) goal is to specify in maintenance, installation, sales, test, operation or documentation of engineering management (EM). The Bachelor of Science (BS) goal is to specify on analysis, design, development, integration, implementation or oversight of EM systems. Both AS and BS students must complete the ABET requirements for English composition, natural science, mathematics and statistics, humanities, social science, speech communication, computer utilization, wellness education and technology and experiential learning. The students in BS program take a minimum of 39 credit hours from Electrical and Computer Engineering Technology (ECET) courses, while they take 37 credit hours from Mechanical Engineering Technology (MET) courses and a 3 credit hours course from Industrial Engineering Technology (IET). Students in BS program must also take a minimum of 48 credit hours non-tech courses including experiential learning and freshman experience courses. The total minimum requirement credit hours for a BS graduate in Mechatronic engineering technology is 127 hours.

The program is designed such a way that both mechanical and electrical courses provide the basic understanding of machine design and operation. The lab experiments incorporate mechanical and electrical principles to give a practical understanding of real world system. For instance in one experiment the students are required to find the gear ratio to reduce or increase a conveyor belt speed using an ac electric motor. The current, voltage and power for such motor will be calculated and compared with measured values. In another experiment, a controller will be programmed to move a bottle on a conveyor belt and fill with a pre specified amount of liquid. The experiments will be developed in consultation with packaging industry to address the relevant topics.

Each BS student must complete an internship program during his/her course of study. The internships in the sophomore and junior years are a key element of the curriculum. All the industrial partners expressed a desire to assist with the internship process to develop the students' abilities before graduation. To that end, companies local to the Northwest Indiana/Chicago area have committed to approximately 70 internships over the next three years. Students during the internship apply the gained knowledge from course and laboratory works in real machine design. A supervisor oversees the progress of the attending student and provides a written report to the student's advisor at Purdue University Calumet.

Table 2 shows concentration course areas that could be selected to accommodate special interests or transfer students.

IV. Laboratory Development Efforts

As part of the curriculum development process, it became clear that the laboratories at Purdue University Calumet needed renovation to support the Mechatronics Engineering Technology program. To that end, the PMMI member companies generously donated modern automated equipment as follows:

- 5 conveyors from Dorner
- Electrical sensors from Balluff
- Material and timing screws from Morrison
- High speed digital camera from Fastec Imaging
- Box labeler from Fox IV Technologies
- Controllers and servo motors from Elau
- Advanced HMI, safety, and remote I/O equipment from Schneider Electric

Purdue University Calumet renovated room 113 in the Potter Building as a new Packaging Laboratory. The room houses all the equipment listed above along with networked computers to serve all the automation. Figure 1 and 2 show the lab as it is under development.

V. Conclusion

Packaging industries have been expanding in recent years and demanding complicated machinery. The machines designers require both mechanical and electrical expertise for design, development and operation. Most of packaging machinery manufacturers hired electrical or mechanical engineering technology graduates in the past. The engineering technology students enter the packaging industry with no specific training. Most do very well after a short familiarization period. The packaging machinery industry requires engineers with multi skills which combines both mechanical and electrical skills. The Mechatronics Engineering Technology program at Purdue University Calumet brings together the multiple skills a technologist needs to succeed in this industry. This Mechatronics program is the first in the nation with emphasis on packaging machine design, development and operation. The curriculum is developed in consultation with packaging industry. The students are required to have internship in relevant industries. A commitment for 70 internships from the local industries during the next three years gives the opportunity to currently attending and the new students to gain experiential learning and hands on training. The program started in fall 2008 with 7 students, which will be increasing in coming semesters. We are predicting the number of students to increase in next five years to more than 150 students.

The university has recently articulated the program with the Mechatronics associate degree program at the Reading Area Community College in Reading, Pa. The program faculty will apply for TAC of ABET accreditation after the first students graduate. Since most of the courses in the program are taken from TAC of ABET accredited MET or ECET programs, course assessment is well established. The program faculty will be working with ASME and PMMI in hopes that program criteria for Mechatronics Engineering Technology can be established, although the program can be accredited under the general criteria until then.

Bibliography

1. Package Printing website, http://www.packageprinting.com/article/41000-41999/41602.html, December 1, 2006
2. Brad Kelly, "Keeping a Lid on Costs: Container industry seeks efficiency amid rising energy, supply prices," Investor's Business Daily, March 10, 2008 Monday National Edition

3. Reilly, S. “Pick 6, US Packaging Shipments Rise for the Sixth Straight Year, Breaking the $6.2 Billion Mark,” *Packaging Machinery Technology,* Volume 5, Number 4, November/December 2008, pages 20-21.
4. PMMI educational website, http://www.pmmi.org/ms/connection/partners.asp
5. PMMI website, http://www.pmmi.org/a/article.asp?id=1359&navitemid=275

MECHATRONICS ENGINEERING TECHNOLOGY PLAN OF STUDY (MTET Degree)

Department of Engineering Technology
School of Technology, Purdue University Calumet
Andrey A. Potter Building
2200 169th Street
Hammond, IN 46323
ET Department: (219) 989-2471
MET Advisor: (219) 989-3125 ECET Advisor: (219) 989-2484

Name
Student PUID
Advisor
Date entered

Revised Plan of Study approved 5/7/2008

ASSOCIATE OF SCIENCE DEGREE **MECHATRONICS ENGINEERING TECHNOLOGY**

SEM	GR	CR	SEMESTER 1	SEM	GR	CR	SEMESTER 2	SEM	GR	CR	SEMESTER 3	SEM	GR	CR	SEMESTER 4
		3	ENGL 104 English Composition			3	ENGL 220 Technical Report Writing			1	ET 151 Internship			3	Social Science Elective
		3	MA 147 Algebra & Trigonometry for Tech.			3	MA 148 Algebra & Trigonometry II			4	MA 219 Calculus I			4	PHYS 220 Physics I
		1	ET 100 Freshman Experience			3	COM 114 Fund of Speech Communication			4	MET 211 Strength of Materials			4	ECET 212 Electric Power & Machinery
		2	ECET 110 Computer Architecture			4	ECET 102 Electrical Circuits I			3	ECET 109 Digital Fundamentals			4	ECET 217 Introduction to Process Control
		3	MET 100 Prod. Drawing & CAD			3	MET 118 Statics			4	ECET 152 Electrical Circuits II			3	MET 214 Machine Elements
		3	MET 242 Manufacturing Processes												
		15				16				16				17	64
															Total Credits for AS

BACHELOR OF SCIENCE DEGREE **MECHATRONICS ENGINEERING TECHNOLOGY**

SEM	GR	CR	SEMESTER 5	SEM	GR	CR	SEMESTER 6	SEM	GR	CR	SEMESTER 7	SEM	GR	CR	SEMESTER 8
		3	MA 222 Calculus II			3	Humanities Elective			1	ET 252 Internship			3	Humanities or Social Science Elective
		4	ECET 262 Programmable Logic Controllers			3	MET 141 Materials I			3	OLS 474 Conference Leadership			3	OLS 331 Occupational Safety & Health
		4	ECET 330 Industrial Prog. & Networking			3	ECET 312 Power Electronics			1	ET 495 Senior Project Survey			3	ET 497 Senior Project
		3	MET 213 Dynamics			4	ECET 362 Process Control			3	Concentration Selective			3	Concentration Selective
		3	MET 230 Fluid Power			3	Concentration Selective			3	IET 308 Project Management			3	MET 420 Machine Design
										4	ECET 462 Advanced Process Control				
		17				16				15				15	127
															Total Credits for BS

Table 1 – Mechatronics Engineering Technology

Mechatronics Packaging Machinery Selectives

MET	315	Mechanism Kinematics	3
MET	102	Prod. Design & Specs	3
MET	461	Comp. Integ. Design & Mfg.	3

HVAC / Control Concentration Selectives

MET	313	Fluid Mechanics	3
MET	329	Heat Transfer	3
MET	421	HVAC	3

Manufacturing / Mechatronics Selectives

MET	285	CNC	3
IET	204	Quality Techniques	3
MET	461	Comp. Integ. Design & Mfg.	3

Microcontroller Concentration Selectives

ECET	456	Computer Hardware Design	4
ECET	209	Intro to Mictocontrollers	3
ECET	210	Struct. C++ for EM Syst.	3

Manufacturing Maintenance Concentration Selectives

A fifth concentration which is to be customized with three Maintenance related courses approved by the department head / coordinator can accommodate transfer courses from a two year Integrated Systems Technology, Mecomtronics, Electromechanical, or other appropriate program.

Humanities electives includes courses from: A & D Art & Design, COM Communication, ENGL English, FR French, GER German, HIST History, JPNS Japanese, MUS Music, PHIL Philosophy, SPAN Spanish, OLS 163 Fundamentals of Self Leadership and OLS 350 Creativity In Business And Industry

Social Science electives include courses from: ANTH Anthropology, ECON Economics, ETHN Ethnic Studies, GEOG Geography, POL Political Science, PSY Psychology, SOC Sociology, WOST Womens Studies

AS Degree Goal -- Specification, Maintenance, Installation, Sales, Fabrication, Test, Operation, or Documentation of EM systems
BS Goal -- Analysis, Design, Development, Integration, Implementation, or Oversight of EM systems

Total AS Credits =	64	39	=Credits Electrical & Computer Technology (ECET)
Total 3rd & 4th year Credits =	63	37	=Credits Mechanical Engineering Technology (MET) for packaging option
Total BS Credits =	127	3	=Credits Industrial Engineering Technology (IET)
Need 1/3 of Total BS non tech =	42	48	=Non tech incl Exper. Learning & Fresh. Exper. (ET)
		127	=Total

General Education Requirements for all Purdue University Calumet Students (satisfied within the curriculum):

English Composition-6 Credit Hours: 3 credit hours in Composition and an additional 3 credit hour course which is writing intensive.
Natural Science-3 Credit Hours: 3 credit hours chosen from natural science laboratory courses in physics, biology, chemistry, geoscience or appropriate interdisciplinary natural science laboratory courses.
Mathematics or Statistics-3 Credit Hours: 3 credit hours in collegiate level mathematics or statistics courses.
Humanities-3 Credit Hours: 3 credit hours chosen from the humanities: literature, history, philosophy, foreign languages, art, music, theater, or appropriate interdisciplinary humanities courses.
Social Sciences-3 Credit Hours: 3 credit hours chosen from the social sciences: anthropology, psychology, sociology, political science, economics, or appropriate interdisciplinary social science courses.
Speech Communication-3 Credit Hours: 3 credit hours in speech communication.
Computer Utilization: Departments shall identify appropriate course(s) to enable their students to develop computer utilization skills relevant to their major.
Wellness Education & Technology: Recognizing the importance of wellness education and of technology's impact on society, the University, as part of the general education experience, shall offer students: A) The resources and information necessary to facilitate wellness. B) The opportunity to develop an understanding of the interface between technology and society.
Freshman Experience Course: 1-3 credits required of all entering freshmen and transfer students with less than 60 credits.
This course would include utilization of campus resources, goal setting, values exploration, relationship of academic planning and life goals, discipline specific career exploration and critical thinking.
Students who change majors will not be required to take a second freshman experience course.
Experiential Learning: Two courses with an experiential learning component.

Table 2 – Mechatronics Concentration Selective Courses

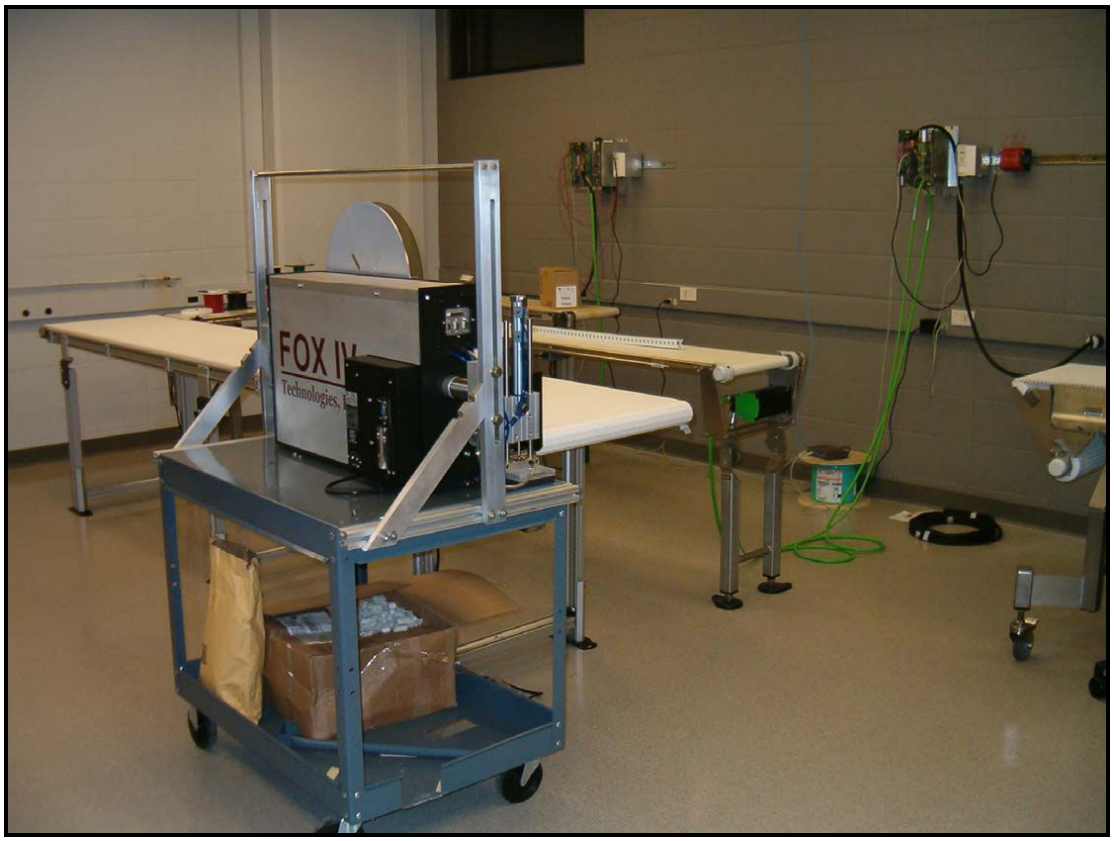

Figure 1 – The Potter 113 Packaging Laboratory

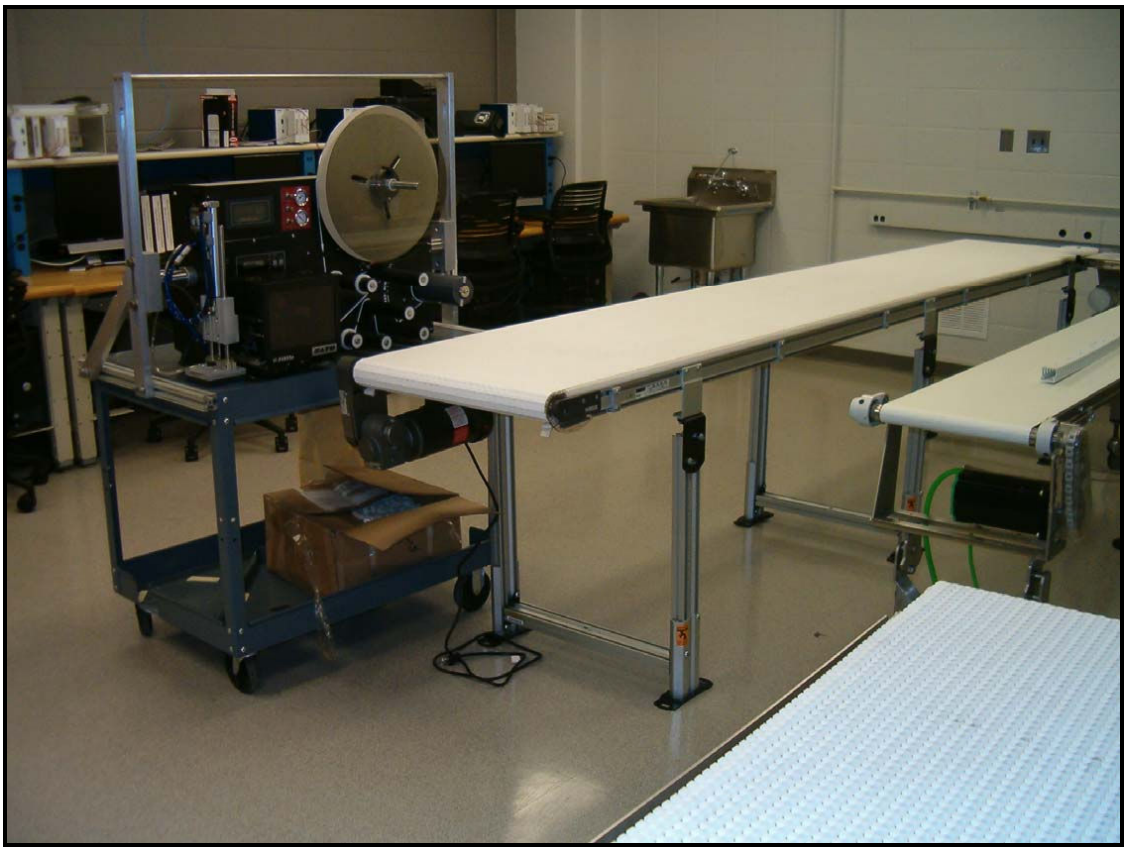

Figure 2 – Another View of the Packaging Laboratory