AC 2008-2243: AUTOMOTIVE ENGINEERING TECHNOLOGY: A COUNTER-INTUITIVE PATH TO GREATER ENGINEERING TECHNOLOGY ENROLLMENT

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Automotive Engineering Technology: A Counter-Intuitive Path to Greater Engineering Technology Enrollment

Abstract

At Arizona State University, the Mechanical and Manufacturing Engineering Technology Department has implemented an automotive concentration within its Mechanical Engineering Technology program. This concentration, consisting of 18 credits, was added in part due to continued student interest, both among prospective students and those already enrolled in the program.

The paper briefly describes the path of the program's conception and development. Benchmarks such as the initial curriculum design by the faculty, the dramatic overhaul of the curriculum based on the comments of the then President of the Society of Automotive Engineers (SAE) and related design process involving industry representatives are discussed. The current state of the courses and overall curriculum structure is discussed.

Of importance to engineering technology educators is the impact of this concentration on the enrollment within the Mechanical and Manufacturing Engineering Technology (MMET) Department. In spite of gloomy national news about the automotive industry and Arizona State University's geographical remoteness from the Michigan and upper Midwest heart of the US-based automotive industry, the automotive concentration has experienced explosive enrollment growth (of both in-state and non-resident students). These data are shared in the paper.

Introduction

Automotive technology refers to all aspects of vehicles, including, but not limited to, design, analysis of automotive power-plants and power-trains, vehicle dynamics, automotive electronics and electrical systems, human comfort and system integration¹. A classical automotive engineering curriculum has an analytical bias and sometimes lacks exposure to important practical aspects. A strong automotive engineering technology curriculum not only deals with the analytical and mathematical concepts that are the backbone of any engineering program but also the 'hands-on' practical engineering that gives students confidence in solving typical engineering problems. A close association with industry is important for a successful program. Current automotive technology is very complex. A typical vehicle power-train, traditionally comprised primarily of an engine and transmission, now includes an increasingly complex array of electronic components such as microprocessors, digital signal processors, miniaturized accelerometers, relays, and solenoids. It is important that students are exposed to the fundamental subsystems that make up today's automobile. A new engineer entering the automotive industry must relate well to current technology and be able to adapt to future trends². The practice of automotive engineering today is interdisciplinary, and requires team members with expertise in mechanical, electrical, electronics, computer science, industrial design and systems engineering, all working toward a common goal³. Thus, to meet the evolving needs of

industry and support student interest in the ‘practical’ aspects of engineering, Arizona State University’s Mechanical and Manufacturing Engineering Technology Department has developed an innovative automotive concentration of its Mechanical Engineering Technology degree program.

Curriculum Structure

The Mechanical Engineering Technology program at Arizona State University uses a “concentration” model for its curriculum. Thus, within the 128 semester credit degree program, there is a core of 110 credits that all students must take. Each student must then select an 18 credit concentration to complete the 128 hour degree. Typically, all the concentration courses are 300 and 400 level courses (junior and senior courses). This means that students have had typical engineering science courses as well as manufacturing processes. One of the available concentrations is the “basic” mechanical concentration. It is available for students that do not desire to take one of the specialty concentrations. At the time of the automotive concentration development, there were two existing specialty concentrations—aeronautical engineering technology and automation engineering technology. The new automotive engineering technology concentration became the third specialty concentrations.

In a traditional automotive curriculum, the courses follow a system-subsystem model. Thus, courses are based on automotive subsystems such as internal combustion engines or the suspension. In the more non-traditional model presented here, the curriculum is organized in a manner similar to that of an automobile company, with emphasis on system integration. This approach was suggested by Ted Robertson, then President of the Society of Automotive Engineers (SAE), in late 2005. In this approach, the courses reflect the different divisions within a large automobile manufacturing company, such as General Motors. In the early stages of development of the automotive concentration, a team composed of program faculty, practicing engineers from the automobile industry and automotive-related industrial advisory board members had an afternoon curriculum design meeting. After discussion, the six industry representatives validated the idea suggested by Mr. Robertson. In addition, as a part of an engineering design process, they voted on various structures, content areas, and credit arrangements of the courses. Eight general topical areas were suggested and rated on a qualitative importance scale of high (H), medium (M), or low (L). Credits were assigned after the importance rankings were made. As mentioned earlier, due to the existing curriculum structure, that the automotive concentration would be 18 credits.

While there was significant debate about the number of credits in each course, Table 1 below records the conclusion of the voting and discussion. Points were assigned to each priority vote, with a ‘L’ earning one point, a ‘M’ earning two points and a ‘H’ earning three points. The rating reflects the importance of an automotive concentration topic treatment in the minds of the industry representatives (all engineers). It is observed that Power-train, electrical and control system topics are regarded as the highest priority followed closely by chassis, thermal design, system integration and vehicle testing. Courses related to the vehicle body are ranked lowest. The industry representatives explained this as a result of belief that there are specialized engineering branches dealing with industrial design, ergonomics and aesthetics. It can be observed that this approach is different than a standard academic focus/curriculum design paradigm and the courses reflect the functional organization of the automotive company.

Table 1: Course Development Matrix

1 credit	1. Vehicle Body: Exterior	2. Vehicle Body: Interior	1 credit
7 points	LLLLL M	LLLLL M	7 points
3 credits	3. Chassis	4. Thermal Design & Climate Control	2 credits
15 points	HHH MMM	HHH MMM	15 points
3 credits	5. Powertrain	6. Electrical Systems, Computer & Control Systems	3 credits
18 points	HHH HHM	HHH HHH	18 points
3 credits	7. System Integration	8. Vehicle Testing	2 credits
15 points	HHH MMM	HHH MMM	15 points
Plus a 6-credit Capstone Design sequence (easily could be an integrative project)			

The following short descriptions reflect the discussion of the design group regarding what the content should be within concentration courses. These descriptions are broad but provide some sense of the extent of coverage with each course. As can be seen, while the suggested courses followed the design shown in Table 1, areas were combined, leading to only six courses.

Body Design (Interior/Exterior) – 2 credits: Design of interior and exterior components of automotive bodies. Manufacture and assembly of body components. Ergonomics, seating, styling, customer preferences. *Prerequisites:* Mechanics of Materials, Introduction to Manufacturing Processes

Power-train – 3 credits: Spark ignition and compression ignition engines, mechanical power transmissions, intake and exhaust systems, accessory systems. *Prerequisites:* Thermodynamics, Fluid Mechanics, Machine Design I.

Chassis Design – 3 credits: Design and Manufacture of Automotive Chassis, Automotive Structures, Steering and Braking Systems and Components, Wheels and Tires, Suspension Systems. *Prerequisites:* Mechanics of Materials, Dynamics, Machine Design I.

Control Systems – 3 credits: Automotive electrical systems, computer control and analog control systems. *Prerequisites:* Automotive Powertrains and Automotive Chassis Design.

Thermal Design & Climate Control – 2 credits: Heat management in automobile systems, including thermal design of engine and transmission cooling systems, cabin heating and air conditioning. *Prerequisites:* Heat Transfer, Thermodynamics II, Automobile Powertrains.

System Integration and Testing – 5 credits: Systems engineering principles. Design of the interfaces between automobile subsystems. Testing of integrated systems.

The preliminary course structure shown above was then subject of some additional faculty efforts towards course design and matching with textbooks. This led to another reconfiguring of the courses. These changes were taken back to the industrial group for additional discussion. The current design is shown in Figure 1. The arrows give an indication of the desired sequence that students would take the courses. Additional elective courses can also be offered based on student interest and available resources.

Figure 1: Automotive course offerings

From the existing mechanical engineering technology course structure, a junior student will have background in basic mechanics—statics, dynamics, and strength of materials—and be taking two semesters of thermo-fluids, material science, machine component design, manufacturing processes, engineering economics and instrumentation and testing. The Automotive concentration will build on this background.

It is important to understand that current vehicles are essentially mechanical systems benefiting from increasingly sophisticated electronic sensing and control subsystems. However, as the primary nature of vehicles is mechanical in nature, this fundamental aspect of the vehicle is emphasized in the course work. Within these courses, important aspects pertaining to electronic control systems and computer technology are addressed within the framework of their interaction with the primary mechanical system under study. For instance, when addressing internal combustion engines, engine control units (ECUs) will be covered. But an ECU is an embedded

computing system and will be addressed at a higher, user, level than at a detailed electronic design level that might be appropriate for electrical engineering technology students.

Developmental Status and Impact

As mentioned above, the concentrations in the Mechanical Engineering Technology program are junior and senior courses. When the automotive concentration was approved in the early spring of 2006, the MMET Department decided to allow only new freshmen to enroll in the concentration. This created a two year development window before the concentration courses had to be offered to the students. It also allowed interest levels to be judged before committing major resources to the program.

Thus, the first students were admitted in to the automotive concentration in the Fall of 2006. With minimal advertising or recruitment efforts, 11 new students enrolled, which was about 25% of the Departmental freshmen class of that year. It should be noted that if existing MMET students would have been allowed to transfer into the program, the number of students would have been much larger. In the fall of 2007, a total of 40 students were enrolled in the program. As of the time of writing, the fall 2008 admission statistics point to continued growth. Currently, 45 new freshman have applied (up 74% from this point in the previous year) and 25 have been admitted to the concentration. (Not all of that difference of 20 students are rejected for admission since the applications could still be progress at the time these data are captured.) Thus, the automotive concentration is having a significant impact on the MMET Department enrollment.

The concentration curriculum model mentioned above also protects the student in terms of their employment status. Since their earned degree is an ABET-accredited B.S. in Mechanical Engineering Technology, the student has access to all the normal types of employment opportunities for such graduates. But, since the concentration name also is indicated on the student's transcript, they can claim the automotive specialty as well.

It is anticipated that a student or graduate of this program will be able to fit in an automotive world broadly classified as follows.

1. Car and truck volume manufacture and testing
2. After market car and truck manufacture and testing
3. Specialized manufacture (sand rails, tractors, buses, military, etc)
4. Support systems - dealerships, repair, etc
5. Entertainment and hobbyists (restorations to racing)

An automotive concentration student can choose courses that will help her acquire the skills required by a particular industry segment. For an example, a student interested in quality and reliability in the auto industry or materials science may fill their two technical elective course slots (included in the core Mechanical Engineering Technology credits) with two specialized courses in quality systems or engineering materials. A student interested in manufacturing of automobiles can take additional manufacturing or CNC machining courses. A student interested

in research and development can be introduced to emerging concepts in hybrid cars or fuel cells through courses focused on those technologies.

Currently, specific courses as shown in Table 2 (below) are in development. Several of these have been taught to students not in the automotive concentration as technical electives. These courses cover the topics and subtopics discussed earlier. The courses are offered in hierarchical manner so that these courses not only cover the topics that are significant from industry point of view but also builds knowledge base in a sequential fashion (as shown in Figure 1).

Table 2: Course developmental status

Course	Developmental Status	Instruction Method
MET 321 – Introduction to Automotive Engineering	High	Lecture
MET 421 – Vehicle Powertrains	High	Lecture and Lab
MET 423 – Vehicle Chassis Design	High	Lecture and Lab
MET 424 – Vehicle Electrical & Control Systems	Low	Lecture and Lab
MET 426 – Vehicle Thermal Design	Medium	Lecture and Lab
MET 427 – Vehicle System Integration and Testing	Low	Lecture

Conclusions

In this paper, the Arizona State University Mechanical Engineering Technology automotive concentration's conception and development was discussed. The program curriculum development involved industry representatives in an engineering design process. The program reflects an automotive company's engineering organizational structure and includes an emphasis on integration of various functions. This concentration is well received by student and is contributing significantly to the Mechanical and Manufacturing Engineering Technology Department's growth.

The topics and associated courses in the concentration are Introduction to Automotive Engineering, Vehicle Power-trains, Vehicle Chassis Design, Vehicle Electrical & Control Systems, Vehicle Thermal Design and Vehicle System Integration and Testing. The curriculum is designed to be flexible and meet current industry needs and expectations. It is anticipated that

this automotive concentration will help a mechanical technology student acquire skills to work in variety of automotive industry segments.

Bibliography

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