

## **Environmental Engineering Technology As an Area of Emphasis In Manufacturing**

**Dr. Charles U. Okonkwo  
Arizona State University**

### **ABSTRACT**

Industry practices impacted the environment in such a way that it has become imperative to train engineering and technology professionals who can create, refine, and apply technological advances that minimize deleterious impact on the environment. These professionals are ultimately responsible for making decisions about process and material selection for manufactured products. We had little or no success in finding a model curriculum that incorporates an environmental program into a predominantly metal working based manufacturing curriculum. Many universities offer separate environmental curricula and manufacturing curricula, but do not incorporate the two. Our proposed program will bring the two together.

Our long term goal is to create an undergraduate environmental engineering technology program. This paper describes the addition of emphasis area consisting of six new environmental engineering technology courses to an existing manufacturing engineering technology curriculum. These courses incorporate the philosophy that engineers and engineering technologists must focus on improvements in total waste reduction by designing waste reducing and energy efficient processes, and manage manufacturing in ways that increase the quality of life and reduce negative impact on the environment. In the spring of 1997 the department will teach one of these courses, Waste Minimization and Prevention. This paper serves two purposes: 1) describe what we are doing to create an emphasis area in environmental engineering technology and hope that it may be useful to others thinking about similar programs and 2) stimulate discussions and ideas that will improve our efforts toward curriculum development in this area.

### **Introduction**

Manufacturing is one of several departments at Arizona State University's School of Technology. Currently, there are no course offerings in environmental engineering technology at a time when increasing governmental regulations dictate that businesses must adopt environmentally responsible practices. Employers require engineering and technology professionals who are knowledgeable in the applications of environmentally safe design and manufacturing processes. Authors such as McCright and Bergmiller(1), Wells(2), believe there is a need for manufacturing engineers trained in product quality, environmental protection and conservation. Wells (3) shares the opinion that environmentally safe manufacturing is cost effective in the long run. We have designed the following six courses to prepare students to work in industries including, but not limited to semiconductor, aerospace, automotive air-bag, environmental consulting firms,

small metal manufacturers, large mechanical based manufacturers, small machining process industries, printing and publishing industries, and water treatment plants. Students from this program will be more attractive to employers seeking prospects of reduced liability and compliance problems, and reduced manufacturing costs due to waste elimination and reduced raw material costs.

**Current Course Offerings in Manufacturing**

The total semester credit hours required for graduation in the school of technology are 128. Manufacturing engineering technology requirement consists of 51 credit hours in the major and 12 credit hours in an emphasis area. The major course requirement is shown below followed by the six newly designed courses.

**Manufacturing Engineering Technology Major (51)**

<i>Courses</i>	<i>Hours</i>
EET 406 Control System Technology	4
MET 231 Manufacturing Processes	3
MET 300 Applied Material Science	4
MET 302 Welding Survey	3
MET 313 Applied Engineering Mechanics: Materials	4
MET 331 Design for Manufacturing I	3
MET 341 Manufacturing Analysis	3
MET 344 Casting & forming Processes	3
MET 345 Advanced Manufacturing Processes	3
MET 346 Numerical Control Point to Point & Continuing Path Programming	3
MET 401 Statistical Process Control	3
MET 416 Applied Computer Integrated Manufacturing	3
MET 444 Production Tooling	3
MET 451 Introduction to Robotics	3
MET 460 Manufacturing Capstone Project	3
MET 461 Manufacturing Capstone Project II	3

**Current Emphasis Area Requirements (12)**

Computer Integrated Manufacturing Engineering Technology

<i>Courses</i>	<i>Hours</i>
MET 448 Expert Systems in Manufacturing	3
MET 452 Implementation of Robots in Manufacturing	3
+ 6 hours Technology Electives	

Manufacturing Engineering Technology

MET 442 Specialized Production Process	3
MET 438 Design for Manufacturing	4
+ 5 hours Technical Electives	

Welding Engineering Technology

MET 321	Engineering Evaluation of Welding Process	3
MET 420	Welding Metallurgy I	4
MET 421	Welding Metallurgy II	3

Mechanical Engineering Technology

AET 415	Gasdynamics & Propulsion	3
MET 434	Applied Fluid Mechanics	3
MET 438	Design for Manufacturing	4
	+2 hours Technical Electives	

Rob/Automation Engineering Technology

MET 448	Expert Systems in Manufacturing	3
MET 452	Implementation of Robots in in Manufacturing	3
	+6hrs Tech Electives	

**Six Proposed Courses for Environmental Emphasis Option**

Environmental Engineering Technology

<i>Courses</i>		<i>Hours</i>
MET 4XX	Manufacturing and the Environment	3
MET 494G/598D	Waste Minimization and Prevention	3
MET 4XX	Material and Energy Balan in Manufacturing Processes	3
MET 4XX	Energy	3
MET 4XX	Environmental Ethics and Regulations	3
MET 4XX	Environmental Site Planning for Industries	3

Students with environmental emphasis option would substitute Manufacturing and the Environment course (MET 4XX) and Waste minimization and Prevention (MET 494G/598D) for MET 344 and MET 346 respectively. In order to maintain the total 128 semester credit hours, they would use the remaining four of the proposed courses as their emphasis area. We recommend that the students begin with the course, Manufacturing and the Environment to learn basic principles of manufacturing processes and their environmental impact. Knowledge gained from this course will be valuable in the Waste Minimization and Prevention course. The Material and Energy Balance in Manufacturing Processes course will benefit from the previous two in terms of application to environmental systems. Ethics and Regulations course will be better appreciated after environmental principles have been laid down in the first three courses. The fifth course, Energy, would incorporate the principle of ethics and regulations into equipment and process design. Environmental Site Planning for industries would come as the last course.

## **Description of Proposed Courses for Environmental Emphasis Area**

### Manufacturing and the Environment MET 4XX

Principles of mechanical and chemical manufacturing processes with emphasis on hazardous and non-hazardous waste minimization and prevention. Prerequisite: ETC 340, MET 231

#### Background Course Description:

Analyzing manufacturing processes with intent to point out areas of adverse environmental impact and how this impact could be minimized or prevented. Alternate processes incorporating these environmentally based improvements. These improvements take advantage of recycling, substitution of environmentally favorable materials and redesign of processes. Construction of devices to implement these features.

### Waste Minimization and Prevention MET 494G/598D

Industrial waste minimization and waste prevention methodology. Life cycle analysis and selection of environmentally compatible materials. Economics of waste prevention. Prerequisite: ETC 340.

#### Background Course Description:

This course addresses waste minimization and waste prevention techniques. Life cycle analysis. Design of metal and nonmetal waste minimization equipment operation. Analysis of manufacturing process flow sheets and environmental impact of processes and their alternatives. Economics of waste minimization and prevention. An overview of environmental regulations and agencies regulating waste generation. Importance of chemistry concepts in hazardous waste regulation. Guide to effective waste minimization program and waste minimization as the responsibility of all employees. Identifying and prioritizing pollutants in manufacturing processes.

### Material and Energy Balances in Manufacturing Process. MET 4XX

Material and energy balances for quantifying waste generation. Principles of pollution abatement devices. Plasma, water, and metal working based environmental issues. Prerequisite: ETC 340\*.

#### Background Course Description:

This course teaches how to compute waste generation, fugitive, and toxic emissions. Student will learn environmental issues associated with water pollution and how pollution devices such as strippers and absorbers work. It teaches environmental issues involving water treatment; plasma based, metal working based and chemical based manufacturing.

### Energy Course MET 4XX

Efficient energy usage and utilization in manufacturing processes. Design of heat transfer equipment and manufacturing processes with emphasis on efficient utilization of energy. Principle of heat transfer applications. Prerequisite: MET 231

#### Background Course Description:

This course focuses on making manufacturing processes and heat transfer equipment design more energy efficient, incorporating energy efficient medium and construction materials. It teaches environmental impact of thermal failure in manufacturing processes, and how to avoid it. This course investigates ways to improve efficiency of current systems and investigates the energy efficiency and environmental impact of alternative forms of energy.

### Environmental Ethics and Regulation MET 4XX

Use of prototypical examples of manufacturing processes to illustrate how environmental rules and regulations would be interpreted at each step of the manufacturing process. Prerequisite: Senior Standing.

#### Background Course Description:

Discusses the use of chemicals involved in manufacturing processes to illustrate the applications of environmental ethics and regulations. The chemicals include products, raw materials and byproducts.

### Environmental Site Planning for Industries MET 4XX

Factors associated with site planning of environmentally safe manufacturing plants. Prerequisites: Senior Standing.

#### Background Course Description:

This course illustrates factors that must be considered in locating a manufacturing plant site, giving an intimate knowledge of the manufacturing process. For example, it examines the ramifications involved before putting a semiconductor plant on a hill overlooking the city's main drinking reservoir.

\* ETC 340 is a 3 credit hour engineering thermodynamics course required of all engineering technology students.

We recognize the need for incorporating an environmental program into our manufacturing curriculum. We have created six courses as a first step toward that goal. By introducing these courses as an emphasis area rather than as a full program, we can evaluate student and employer demand that will lead us to develop a full program responsive to industry needs. Our interaction with employers indicate that they welcome the addition of these courses. They stand to gain by recruiting prospective employees capable of reducing liabilities, manufacturing costs, and waste. We hope that others who

face similar challenge can derive some benefit from our efforts and that we can stimulate discussion and ideas to build and improve our program.

### **References**

- (1) McCright, P.R. , and Bergmiller , G.E. 1995. Teaching Engineers to Consider Environmental Issues in Design. ASEE 2: 2646-2650.
- (2) Wells, W.E., 1996. Environmental Education For All Engineers. ASEE: Session 3151.
- (3) Wells, W.E., 1996. Modelling the Economics of Environmentally Responsible Manufacturing. ASEE: Session 3251.

### **Charles U. Okonkwo**

Dr. Charles U. Okonkwo graduated with bachelors and master's degrees in chemical engineering from Iowa State University, and a Ph.D. in chemical engineering from the University of Florida. He has worked as a process engineer for both the chemical and semiconductor industries. Since joining the College of Technology and Applied Sciences at Arizona State University as a lecturer, he has taught graduate courses in hazardous waste management and undergraduate courses in the Department of Manufacturing Engineering Technology. Before joining the College of Technology and Applied Sciences, he taught for several years in the Department of Mathematics, at Arizona State University.