
Environmental Manufacturing: Existing Types

Unit: Emerging Technologies

Problem Area: Environmental Manufacturing

Lesson: Environmental Manufacturing: Existing Types

- **Student Learning Objective.** Instruction in this lesson should result in students achieving the following objective:

Identify types of environmental manufacturing.

- **Resources.** The following resources may be useful in teaching this lesson:

“Environmental Manufacturing,” *Environmental Manufacturing*. Accessed Dec. 5, 2010. <<http://www.environmentalmanufacturing.com/>>.

Madu, Christian N. *Handbook of Environmentally Conscious Manufacturing*. Kluwer Academic, 2001.

Myer, Kutz. *Environmentally Conscious Manufacturing*. Wiley, 2007.

National Research Council of National Academies. *Retooling Manufacturing: Bridging Design, Materials, and Production*. The National Academies Press, 2004.



■ **Equipment, Tools, Supplies, and Facilities**

- ✓ Overhead or PowerPoint projector
- ✓ Visuals from accompanying masters
- ✓ Copies of sample test, lab sheet, and/or other items designed for duplication
- ✓ Materials listed on duplicated items
- ✓ Computers with printers and Internet access
- ✓ Classroom resource and reference materials

■ **Key Terms.** The following terms are presented in this lesson (shown in bold italics):

- ▶ environmentally benign manufacturing (EBM)
- ▶ environmental officers
- ▶ environmental protocols
- ▶ systems approach

■ **Interest Approach.** Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations.

Explain to the students the relationship between old manufacturing techniques and their negative effects on the environment as well as how important it is for manufacturing companies to update their processes and to follow new codes and regulations.

CONTENT SUMMARY AND TEACHING STRATEGIES

Objective 1: Identify types of environmental manufacturing.

Anticipated Problem: What are different types of environmental manufacturing?

- I. Environmental manufacturing
 - A. Environmental manufacturing can cover every aspect of manufacturing, from product design to its final delivery to consumers.
 1. Companies addressing environmental manufacturing take different steps to create more environmental friendly products and processes. These vary depending on the products being developed and the availability or possibility to utilize different techniques.
 2. Some of the steps are relatively simple, but others require long-term research and analyses.

- B. Sustainable and life cycle manufacturing addresses the product and how it is manufactured. It is focused on limiting the negative impact on the environment that can be caused over the full life cycle of the product.
1. It focuses on the need to develop innovative technologies for manufacturing. These technologies reverse global resource shortages and remove heavy environmental loads.
 - a. One type of sustainable manufacturing uses the concept of product take-back and recycling. It is an example of the **systems approach** (to manufacturing operations), which uses inter-connected relationships between all aspects of product design, manufacturing, and distribution to coordinate recycling and the life cycle cost of products. Two aspects are to reduce landfill contributions and to reduce the need for new material resources. Concerned parties in this process include governments, manufacturers, consumers, communities, and the recycling business.
 - b. The Hitachi Corporation is developing systems of design that allow for disassembly and recycling of their products.
 - c. Sustainable and life cycle manufacturing improves efficiency, reduces the carbon footprint, and develops reuse strategies in manufacturing.
 - d. The development of information exchange loops are being used to improve the management of a product's life cycle.
 2. Many other companies are developing a systems approach that considers manufacturing in terms of a product's full life cycle.
 - a. The approach includes specific design tools in which the product's end life is taken into account.
 - b. These tools are used to create modular component designs.
 - c. Reverse logistics models are used to analyze how products or manufacturing processes can become more sustainable. They can be used to address end-of-life issues for the products.
 - d. System analyses (or simulation models) are being used to study the overall product life (long versus short) and the costs involved.
 3. Engineering laboratories are involved in defining processes for sustainability related to energy resource management, hazardous materials, and carbon footprints.
 - a. The process includes the development of computer software that can determine the carbon footprint of any product.
 - b. Data can be used to determine the best material and manufacturing techniques to use.
 - c. They can give numeric scores that allow manufacturers to see if a reusable or disposable material is more appropriate.

- C. The development of standards and regulations for performance in environmental manufacturing is an ongoing local and international process.
1. Many standards are currently under development by national and international organizations. The ISO is one of the organizations addressing energy use, material resources, and pollution.
 - a. Some of the standards establish methods of evaluation for environmental and energy efficiency in manufacturing, such as ISO 20140.
 - b. The standards can be used to evaluate a system and to make process improvements for a machine line facility. They can help reconfigure the system for improvements to the products.
 - c. The ISO 20140 has five parts that focus on various aspects of manufacturing and the environment.
 - (1) Part one consists of general principles and an overview.
 - (2) Part two includes guidelines for environmental evaluation procedures.
 - (3) Part three is an environmental evaluation index model.
 - (4) Part four is for an evaluation data model.
 - (5) Part five focuses on the facility life cycle impact and the indirect impact through specific models or processes.
 - d. Other standards evaluate the impact on the environment caused by machine tools. This includes the ISO 14955 series. These guide manufacturers in designing machine tools to meet efficiency goals. They also can be used to test and determine how well machines perform.
 - (1) Part one of this standard addresses eco-design methodology for machine tools.
 - (2) Part two gives methods of testing the energy consumption of machine tools and functional modules.
 - (3) Part three focuses on test pieces, test procedures, and parameters for energy consumption on metal cutting machine tools.
 - (4) Part four focuses on test pieces, test procedures, and parameters for energy consumption on metal forming machine tools.
 - e. Regulatory mandates are being developed that control emissions standards for air, water, and solid waste; work exposure standards; product take-back requirements (or recycling); and the use of banned materials.
- D. Alternative product and production plans are an important part of environmental manufacturing.
1. Some manufacturing techniques and products have the possibility to use a range of materials, designs, and systems.
 - a. In a systematic approach to manufacturing, one that addresses its environmental impact, research into material and process selection are part of the initial design process.
 - b. In the case of existing products and facilities, it becomes necessary to modify manufacturing systems. The product and its production are re-

evaluated in terms of their global impact (e.g., resource usage and waste streams).

- c. Many of these companies are reconsidering options in their processing methods (e.g., the sequencing or ordering of techniques for product assembly). They will improve the energy efficiency of the existing methods and assembly systems.
 - d. Some specific ways in which companies create environmental manufacturing solutions with production plans are reducing waste, water consumption, and energy. The reduction of energy through lighting is achieved by using more efficient bulbs as well as better lighting plans/layouts. In this case, factory activity is studied in terms of human traffic and required lighting. Fixtures are placed only where and when they are needed.
 - e. Energy meters are being installed that track and locate where and how much energy each element of operation requires.
2. Some companies have (and may be required in the future) to hire or give authority to **environmental officers**—employed authorities who give advice on and enforce environmental standards. Their concern is the end profit for the business and the environmental effects.
- E. **Environmentally benign manufacturing (EBM)** is a process concerned with limiting the impact or negative effects of manufacturing on the environment. It can have a range of influence on products and procedures associated with manufacturing, all geared toward environmentally safe products and production.
1. An example is a company developing shipping containers for frozen goods that are benign. This involves the study of Pykrete, which is a mix of wood pulp and water ice.
 - a. These containers will reduce the amount of waste associated with packaging and bulk shipping for medicine and refrigerated foods.
 - b. They can be used in the fishing industry, for shipping frozen foods, and for warehousing.
 - c. This material can lower the entire life cycle cost from the container's creation to its disposal.
 2. Some companies, including HP, are researching ways to create benign products in the manufacturing of technology (e.g., monitors, hard drives, printers, and circuit boards).
 3. IBM and Ford are developing new technology to create benign manufacturing procedures, such as the Waste of Electrical and Electronic Equipment (WEEE) and the End of Life Vehicle (ELV). Ford is designing a car specifically for recycling, and IBM is designing a computer made out of 100 percent recycled plastic housing.
 4. The Department of Energy (DOE) is working with several manufacturers to create an eco-industrial park in Parkersburg, WV. It focuses on the recycling of electronics.

5. Organizations are evaluating and researching companies that employ EBM to set up guidelines and communicate methods, including the The World Technologies Evaluation Center (WTEC).
6. Examples are:
 - a. Manufacturing that uses new processing methods to replace toxic lubricants
 - b. Substituting energy usage with modification
 - c. Reducing solid, liquid, and atmospheric waste
- F. Refiguring the entire resource and supply chain can be one of the most difficult steps to adjust for environmental manufacturing. In some cases, there are only limited means to transport goods. This may be a result of the material used or the manufacturing location relative to the suppliers and distributors.
 1. New environmental manufacturing facilities are planned and designed to take advantage of the most efficient use of transportation. This includes locating the plant near resources and distributors to limit energy consumption.
 2. Existing environmental manufacturing companies are changing their sources or are requiring them to follow desired standards.
 - a. These companies require their suppliers to comply with all local environmental regulations and to be active in environmentally responsible practices.
 - b. Alternative fuels must be used for refining materials and in their transportation methods.
 - c. They try to ensure that manufacturing partners and suppliers follow all international **environmental protocols**—specific conventions or guidelines that are internationally agreed upon and recognized as standard procedures or practices.
- G. General types of environmental manufacturing can include internal changes and overall company practices.
 1. Many of these companies perform self audits for energy use and waste.
 - a. Some basic and simple rating systems can be used. Many are in the form of computer software or spreadsheets. Some are just for energy use, enabling companies to input equipment and product ratings. The software supplies the company with energy use data.
 - b. More complex software can be used to calculate a product's life cycle and supply chain cost.
 2. With this data manufactures can target areas for improvement.
 - a. These include changes for an actual building to improve energy use by adding insulation, as well as, updating any heating and cooling systems with more modern and efficient ones.
 - b. In some cases, new windows and doors are installed to save on heat loss or gain.
 - c. Internal recycling is established for all products and materials.
 - d. Old lighting and water fixtures are replaced with more efficient fixtures.

- e. Machining and manufacturing equipment is updated or replaced to conserve energy and minimize waste.

Teaching Strategy: *Have a guest speaker from a local manufacturing facility that has environmental friendly practices give a presentation on environmental manufacturing and how it has benefitted the facility. Have students take notes.*

- **Review/Summary.** Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. Questions at the ends of chapters in the textbook may also be used.
- **Application.** Use the included visual masters and lab sheet to apply the information presented in the lesson.
- **Evaluation.** Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is provided.
- **Answers to Sample Test:**

Part One: Completion

1. Sustainable and life cycle
2. systems approach
3. five
4. Energy meters
5. self-audits
6. Environmental protocols

Part Two: True/False

1. F
2. T
3. F
4. F
5. T
6. F

Part Three: Short Answer

Answers will vary. See “Content Summary”: I.E.3.

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► Part One: Completion

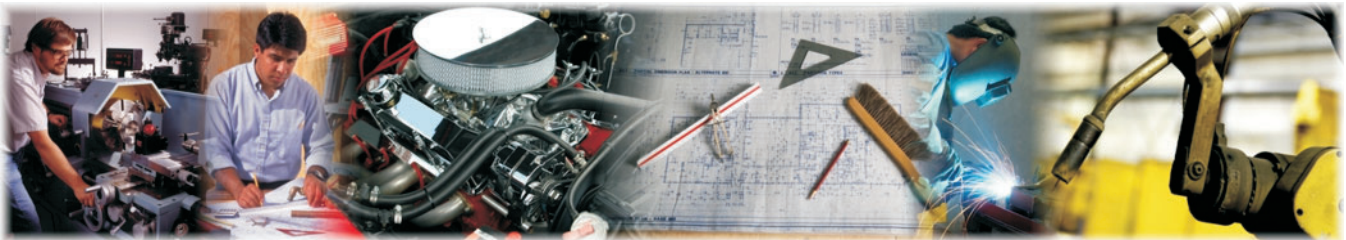
Instructions: Provide the word or words to complete the following statements.

1. _____ manufacturing addresses the product and how it is manufactured.
2. This fully organized _____ is created to coordinate recycling and the life cycle cost of products.
3. The ISO 20140 has _____ parts that focus on different aspects of manufacturing and the environment.
4. _____ are being installed that track and locate where and how much energy each element of operation requires.
5. Many environmental manufacturers perform _____ for energy use and waste.
6. _____ are specific conventions or guidelines that are internationally agreed upon and recognized as standard procedures or practices.

► Part Two: True/False

Instructions: Write *T* for true or *F* for false.

- _____ 1. The systems approach separates the relationships between all aspects of product design, manufacturing, and distribution.
- _____ 2. The ISO is one organization addressing energy use, material resources, and pollution.



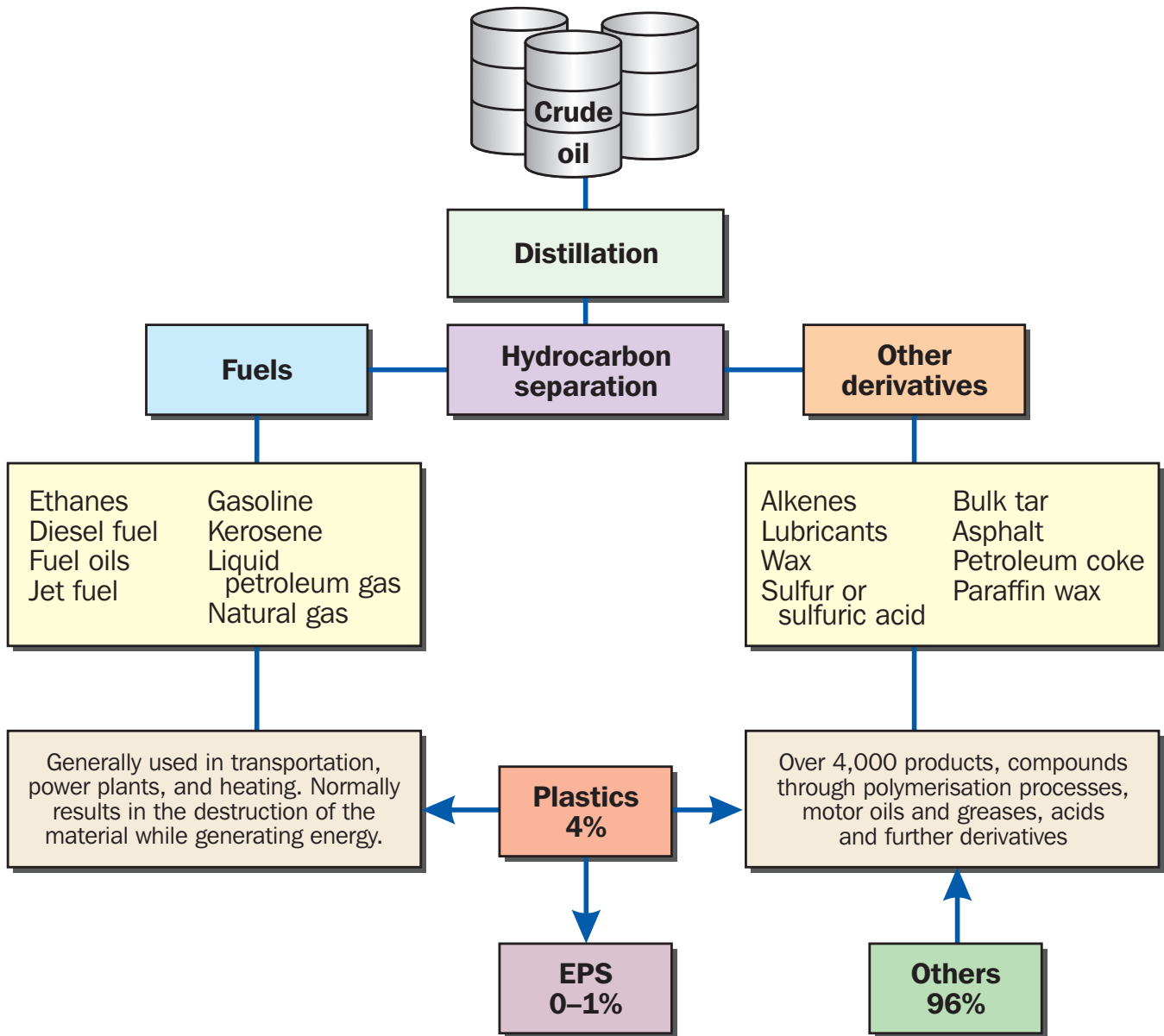
- _____ 3. There are no standards that evaluate the impact on the environment caused by machine tools.
- _____ 4. It is not necessary for existing products and facilities to modify manufacturing systems to become environmental manufacturers.
- _____ 5. An example of benign manufacturing is a company developing shipping containers for frozen goods.
- _____ 6. Requiring suppliers to comply with all local environmental regulations is not how companies make their supply and resource chain environmentally responsible.

► **Part Three: Short Answer**

Instructions: Answer the following.

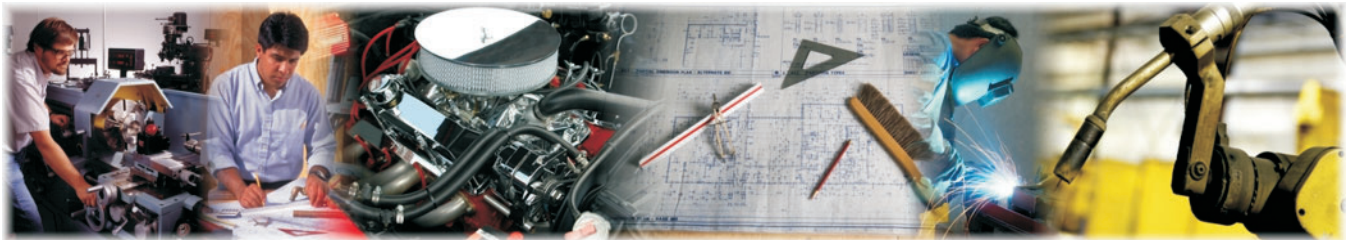
What are some examples of benign manufacturing being developed by Ford and IBM?

DIAGRAM OF ALTERNATIVE ENERGY/FUEL USAGE IN ENVIRONMENTAL MANUFACTURING



ENVIRONMENTAL MANUFACTURING CATEGORIES

- ◆ Sustainable and life cycle manufacturing
- ◆ Standards and regulations for performance
- ◆ Alternative product and production plans
- ◆ Environmentally benign manufacturing (EBM)
- ◆ Resource and supply chain
- ◆ General types of environmental manufacturing



Identify Environmental Manufacturing Techniques of an Existing Company

Purpose

The purpose of this activity is to develop knowledge of the different methods used in environmental manufacturing.

Objective

Identify methods of environmental manufacturing.

Materials

- ◆ Internet access
- ◆ computer
- ◆ printer
- ◆ lab sheet
- ◆ writing utensil
- ◆ paper

Procedure

1. Research a company that has developed environmental manufacturing techniques.
2. Perform a search on the Internet (or at your local library) for companies that consider themselves environmental manufacturers. This should be easy if you type in the phrase “environmental manufacturing companies.”
3. Once you find a company that states it is an environmental manufacturer, look for an information page on its Web site that explains why and how the company is an environmental manufacturer.
4. Read through the text and create a list of the ways in which the company excels as an environmental manufacturer. The list can be organized according to the different elements or categories of manufacturing, including product design and development, resource supply and shipping, the manufacturing process, and distribution.

