SUMMER INSTITUTE FOR ENGINEERING AND TECHNOLOGY EDUCATION

MATERIALS ENGINEERING

INTRODUCTION TO MATERIALS ENGINEERING

CONCEPT

This module introduces the materials engineering discipline and discusses its history, educational requirements, and possible career paths.

OBJECTIVES

- To expose the reader to the type of work materials engineers perform.
- To give the reader an idea about the courses a student would be required to take to pursue a degree in materials engineering.
- To explain about the career opportunities for materials engineers.

INTRODUCTION AND HISTORY

Materials engineering is a general term used to classify a group of engineering specialties that are concerned with the development, production, fabrication, and use of materials in specific technologies. Materials engineers are concerned with the chemistry and physics of matter. They engineer materials to advance the production and performance of today's world. These engineers create new materials and find new applications of existing materials that you may find in your furniture, your automobile, throughout your home, inside your computer, and packaging of the food you eat. The discipline of materials engineering is usually broken down into four engineering specialties that are grouped according to material types: metals, ceramics, plastics, and composites.

Petroleum and mining engineering are sometimes grouped under materials engineering and will be included for completion.

Metallurgical Engineering:

Metallurgy finds its roots thousands of years ago during the Bronze and Iron Ages. Between 7,000 and 4,000 BC, copper metallurgy was developed in Asia Minor. In 2,000 BC the Iron Age came, but developed slowly until the Romans used iron for their military needs in the first and second centuries.

Metals make up 70% of the earth's elements. Today, they are used for transportation, industry, agriculture, and communication systems. Metallurgical engineers are concerned with the production of metals from ores and the development of metallic alloys.

Ceramic Engineering:

Ceramics from around 10,000 BC, have been found excellently preserved in their earliest form, clay pots. About 8,000 years ago, in present day Turkey, the clay was heated until it was smooth and was hardened for use as dishes. Around 4,000 BC, an incredible material, glass, was discovered by the Phoenicians. Ceramics are nonmetallic, inorganic materials that are usually produced from raw abundant and inexpensive materials. Some modern uses of ceramics are:

- Heat shield tiles on the space shuttle,
- Bricks, cement and construction materials for homes, buildings, and structures,
- Fiber optics to replace copper electrical wires for electronic and telephone communications,
- High voltage insulators on power lines,
- The building blocks of integrated circuits: computer chips, resistors, capacitors, electronic sensors, etc., and
- Replacements for human bones and teeth that are lightweight and strong.

Ceramic engineers are concerned with products manufactured or used at high temperatures (1000 ºF) and the physical and chemical processes used in their manufacture.

Polymers Engineering:

Polymers engineers develop and find new applications for plastics and other *polymers* (materials made by combining chains of hydrocarbon molecules). Today, polymers are being used where wood, metal, and glass have traditionally been used.

Polymers are made by engineering the combination of hydrogen and carbon atoms and the arrangement of the chains they form. With engineered plastics, the materials engineer is revolutionizing the way we use materials. Polymers have many properties that make them more favorable than metals or ceramics in certain conditions. Many polymers:

- are less dense than metals or ceramics,
- resist atmospheric and other forms of corrosion,
- offer good compatibility with human tissue, or
- exhibit excellent resistance to the conduction of electrical current.

These and other properties might allow a polymer to be used more effectively in place of metals or ceramic materials.

Rubber is a natural occurring polymer. The super-material known as Kevlar is a man-made polymer. Kevlar is used in bullet-proof vests, windsurfing sails, and underwater cables that are 20 times stronger than steel.

Composite Engineering:

Composite engineers are concerned with combining materials to make better materials. To form composite materials: metals are usually woven into a fabric, and then coated with an engineered plastic resin. This results in a material that is clearly superior to the original materials. Glass-fiber-reinforced plastic, fiberglass, is an example of a composite material. Individually the glass

fibers are very strong, but susceptible to mechanical abrasions and moisture attach. The plastic resin is comparatively weak but resists moisture penetration and protects the glass from abrasions. Together, fiberglass exhibits the strength of the glass fibers and the durability of the plastic resin.

Composites, which are strong and lightweight, are used in the space, aircraft, and automobile industry. This gives greater fuel efficiency for aircraft and automobiles. Also, a technology like the military's stealth technology, is only made possible by composites that are engineered to absorb radar, rather than reflect it.

Petroleum Engineering:

Petroleum engineers are concerned with all phase of the production of petroleum. They are concerned with the exploration, extraction, storage, and transportation of crude oil and natural gas.

Mining Engineering

This field encompasses the exploration, location, development, and operation of mines for extracting coal, metallic ores such as copper and zinc, and other minerals.

THE JOB

To face the opportunities and challenges of tomorrow, materials engineers can apply their skills to areas such as: research, food, discovery, development, energy, conservation, production and pollution. Material engineers will constantly be improving the quality of life by engineering new materials to replace older, nonrenewable resources.

Possible areas of employment and tasks that materials engineers may be faced with are highlighted below.

- **Research.** Unlocking the secrets of nature and discovering basic knowledge about materials that can benefit people everywhere.
- **Extractive Engineering.** Responsible for retrieving materials from their natural state as well as from recycled materials.
- **Process Engineering.** Insuring high quality, consistency, and efficiency of producing the materials.
- **Applications Engineering.** Develop new materials, new ways, and new processes to develop or improve virtually any product.
- **Management.** Due to their insight into solving and understanding problems, engineers make excellent managers.
- **Sales Engineering.** Because of their technical background, materials engineers are useful to successfully match materials with products and products with applications.
- **Service Engineering.** Needed to help solve problems the customer may have.
- **Consulting.** Hired by growing companies who do not employ materials engineers, but want to gain a competitive edge.

- **Writing and Teaching.** Materials Engineers with communication skills can promote technology and train the next generation of problem solvers by teaching or publishing about their field experience.

EDUCATION

Since materials engineering is a broad categorization of many types of engineering, it can often be found as a specialization of chemical, industrial, mechanical, civil, and possibly even electrical engineering.

Many of these disciplines can overlap into the materials engineering area. If you are interested in pursuing some form of materials engineering in college and as a career, it is a good idea to have a firm background in these high school courses:

- Mathematics
- Chemistry
- Physics
- Computer programming

CAREER OPTIONS

Materials engineers are in high demand as technology and its needs grow.

- **Materials producing companies.** To produce better materials cleaner and more efficiently.
- **Manufacturing companies.** To effectively manufacture products such as cars, appliances, computers, airplanes, electronics, machinery, and medicine. Materials engineers serve an important function to improve: materials, processes, product reliability and safety, chemical processing, paper, plastics, and textiles.
- **Service Companies.** Airlines, railroads, and utilities rely on materials engineers to maintain safe reliable service.
- **Consulting Firms.** These provide companies, government agencies, and institutions with outside help and advice in identifying problems, and finding better and more economical solutions.
- **Government.** As a consumer, promoter, and regulator of materials, products and technology, the government needs materials engineers or scientists to provide accurate information on which to base public policy and regulations.
- **Research Institutes.** They might work under contract of the government or a private company, to work on researching tomorrow's products, processes, and materials today.
- **Publishers.** The flow of information is vital to problem solving. Materials engineers who have excellent communication skills may work to write books, create instructional videos, develop training programs, or submit articles to magazines and journals, so that tomorrow's problem solvers may be better trained.

BIBLIOGRAPHY

BEAKLEY, GEORGE C. AND H. W. LEACH, *Engineering: An Introduction to a Creative Profession, 4th Edition.* New York: Macmillan Publishing Co., Inc., 1982.

Careers in Engineering, VGM Professional Careers Series. Lincolnwood, Illinois: VGM Career Horizons, 1989.

THORNTON, PETER A. AND VITO J. COLANGELO, *Fundamentals of Engineering Materials.* Englewood Cliffs, N.J.: Prentic-Hall, Inc., 1985.

WRIGHT, PAUL H., *Introduction to Engineering, Second Edition.* New York: John Wiley & Sons, Inc., 1994.

OTHER RESOURCES

BORGFORD, CHRISTIE L., AND SUMMER, LEE R. SUMMERLIN, *Chemical Activities: Teacher Edition*, American Chemical Society, Washington, D.C., 1988.

WOODWARD, LINDA, *Polymers All Around You!* A copy may be ordered from:

Terrific Science Press
Miami University Middletown
4200 East University Blvd.
Middletown, OH 45042

For each copy requested, send a check or money order for $4.00. This price includes shipping and handling.

WORLD WIDE WEB RESOURCES

Microworlds - Exploring the Structure of Materials: **http://www.lbl.gov/MicroWorlds/**

FOR MORE INFORMATION

Write to the following organizations:

- ASM[1] International
  Materials Park, OH 44073
- The Metallurgical Society of AIME[2]
  420 Commonwealth Drive
  Warrendale, PA 15086
- National Institute of Ceramic Engineers
  65 Ceramic Drive
  Columbus, OH 43214
- American Ceramic Society
  757 Brooks Edge Plaza Drive
  Westerville, OH 43081
- POLYED National Information Center
  c/o Dr. John Droske
  Un iversity of Wisconsin -- Stevens Point
  Stevens Point, WI 54481

[1] **A**merican **S**ociety for **M**etals

[2] **A**merican **I**nstitute of **M**ining **E**ngineers