AC 2011-2451: INCLUSION OF GREEN ENERGY MANUFACTURING CONTENTS IN AN INTRODUCTORY COURSE ON MANUFACTURING PROCESSES AND SYSTEMS

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Inclusion of green energy manufacturing contents in an introductory course on manufacturing processes and systems

Abstract

IMSE 250 is an introductory course on manufacturing processes and systems at Kansas State University. This course covers various conventional and unconventional manufacturing processes. Workpiece materials involved are primarily engineering materials (including metals, ceramics, plastics, and composites). Green energy manufacturing is considered a new worldwide industry. Countries that take leadership positions in this industry will have a global competitive advantage. To enhance the global competitiveness of the U.S. in green energy manufacturing, a great need exists for a skilled workforce that has been trained in this field. In order to expose Kansas State University students to green energy manufacturing, some green energy manufacturing contents have been added to IMSE 250 recently. This paper first presents the rationale of including green energy manufacturing contents in IMSE 250. It then describes the green energy manufacturing contents that are included in IMSE 250. Finally, it discusses the results of a student survey about the green energy manufacturing contents in IMSE 250.

Keywords
Engineering education; Green energy manufacturing; Manufacturing process; Manufacturing system

1. Introduction

At Kansas State University, IMSE 250 (Introduction to Manufacturing Processes and Systems) is a required course for students majoring in industrial engineering and mechanical engineering. This course is also taken by students from other engineering disciplines as well as humanities and sciences. Table 1 shows the disciplines where the students who took IMSE 250 in fall 2010 came from. The course is intended to not only provide engineering students with technical knowledge for further study in their disciplines, but also expose humanities and sciences students to manufacturing engineering.

In IMSE 250, various conventional and unconventional manufacturing processes are covered, as summarized in Table 2. Workpiece materials involved are primarily engineering materials (including metals, ceramics, plastics, and composites) and semiconductor materials. Currently, green energy manufacturing is considered a new worldwide industry [1]. Countries taking leadership positions in this industry will have a global competitive advantage [2]. To enhance the global competitiveness of the U.S. in green energy manufacturing, a great need exists for a skilled workforce that has been trained in this field [3,4]. At present, there are no green energy manufacturing courses offered at Kansas State University. In order to expose Kansas State University students to green energy manufacturing, some green energy manufacturing contents have been included in IMSE 250 since fall 2009. This paper first presents the rationale of including green energy manufacturing contents in IMSE 250. It then describes what green energy

manufacturing contents are included in IMSE 250. Finally, the results of a student survey are provided on including green energy manufacturing contents in IMSE 250.

Table 1. Students' major curricula

	Curriculum
Engineering	Biological and Agricultural Engineering
	Civil Engineering
	Computer Engineering
	Electrical Engineering
	Industrial Engineering
	Mechanical Engineering
Non-Engineering	Agricultural Technology Management
	Arts and Science - Open Option
	Business Management
	Information Systems
	Life Science

Table 2. Manufacturing processes covered in IMSE 250

Conventional	Unconventional
Casting	Chemical machining
Forming	Electrochemical machining
Rolling	Mechanical
Extrusion	Abrasive flow machining
Forging	Abrasive waterjet machining
Machining	Ultrasonic machining
Turing	Rotary ultrasonic machining
Milling	Thermal
Drilling	Electron beam machining
Grinding	Laser beam machining
Honing	Plasma arc machining
Joining	Electrical discharge machining
Welding	Semiconductor manufacturing
Reviting	

2. Rationale of including green energy manufacturing contents

2.1 Enhancing students' understanding of the importance of green energy manufacturing in the U.S.

The U.S. economy has long depended on nonrenewable fossil energy sources (coal, oil, and natural gas) [5]. Supplies of fossil fuels are expected to decline in the future and become more expensive [6]. Meanwhile, their use contributes to the accumulation of greenhouse gas in the atmosphere. Therefore, an urgent need exists for green energy sources. It is important for the U.S. to invest in green energy manufacturing. The U.S. government should not accept a future in which the jobs and industries of tomorrow take root in other countries. The country needs to develop an American green energy industry, a 21st century economy that flourishes within the U.S. [7]. As President Obama said on March 19, 2009, "So we have a choice to make. We can remain one of the world's leading importers of foreign oil, or we can make the investments that will allow us to become the world's leading exporter of renewable energy …. We can let the jobs of tomorrow be created abroad, or we can create those jobs right here in America and lay the foundation for our lasting prosperity." [7]

As an industry of tomorrow, the prosperity of green energy industry needs participation of today's college students. It is essential to make today's college students (some of them will be the future policy makers) understand the importance of green energy manufacturing and the significance of developing and using green energy in the U.S.. With more comprehensive understanding of the current energy situation in the U.S., college students could be more supportive of green energy industry.

2.2 Enhancing students' knowledge about green energy manufacturing

Green energy manufacturing will create new jobs that will pay well and cannot be outsourced [8]. It is estimated that about 680,000 direct manufacturing jobs and nearly 2 million indirect jobs might be created by future investments in green energy manufacturing [8]. A great need exists for a skilled workforce that has been trained in this field. A survey (conducted by the authors of this paper and their colleagues) [9] shows that universities in more than half of states in the U.S. offer renewable energy related courses, including solar energy, bioenergy, wind energy, and fuel cell in different aspects, levels, and departments. However, none of them emphasizes manufacturing aspects of all forms of renewable energy. At Kansas State University, there are no introductory level courses that cover manufacturing of all sources of green energy. Therefore, the lectures on green energy manufacturing in IMSE 250 (which covers the introductory information of all sources of green energy) will be informative to the students, even through these several lectures are not sufficient to train qualified workforce in this field.

2.3 Inspiring students' interest in green energy manufacturing

After taking IMSE 250, students are expected to have a general idea of green energy manufacturing. The prospect and benefits of green energy manufacturing may inspire students' interest in this field. They may want to learn more about green energy manufacturing (e.g.,

taking some higher-level courses that focused on green energy). Meanwhile, they may find that green energy manufacturing is a very good topic for their course projects and research.

3. Included contents on green energy manufacturing

3.1 Overview of energy consumption in the U.S.

An overview of energy consumption in the U.S. and the world was presented to provide some background to the students. Different types of energy sources were introduced, especially fossil fuels and green energy sources. A comparison of the consumption between fossil fuels and green energy sources was made to show that the predominant energy source in the U.S. and the world at present is fossil fuel.

Some major challenges related to energy were explained, such as increasing energy demand, energy dependence, and global warming. The significance and benefits of developing and using green energy sources were then presented. In order for students to have a better understanding on the importance of green energy manufacturing, two Hollywood movie clips were used to provide the frame for class discussion on energy challenges. After watching the movie clips (which talk about aliens who come to the earth to pillage energy), students were asked a question:

What can we do to help with the energy challenges?
As an individual;
As a nation;
As humanity.

Students were given one minute to discuss with their neighbors. A few students were picked to share their answers to the class.

3.2 Potentials of different types of green energy

Six types of green energy were introduced in IMSE 250: hydroelectric, geothermal, ocean, wind, biofuels, and solar. The working principles of each type were described. The theoretical potential of each type of green energy in the U.S. was presented as well as their current development situations. The benefits and challenges of developing each type were also discussed.

3.3 Manufacturing processes of some types of green energy

Due to limited time, the lectures only covered manufacturing processes of some types of green energy, especially the biofuels made from cellulosic biomass and algae. The manufacturing process flows of biofuels were presented. The major steps were explained. Furthermore, two video clips were provided to show students how to make solar panels and wind turbines.

4. Results of student survey

After taking the lectures about green energy manufacturing, most students had much better understanding of the importance of green energy manufacturing in the U.S., as evidenced by their responses to a survey question, “How much do these materials enhance your understanding

of the need to develop and manufacture green energy in the U.S.?" The students' responses to the survey question are shown in Fig. 1.

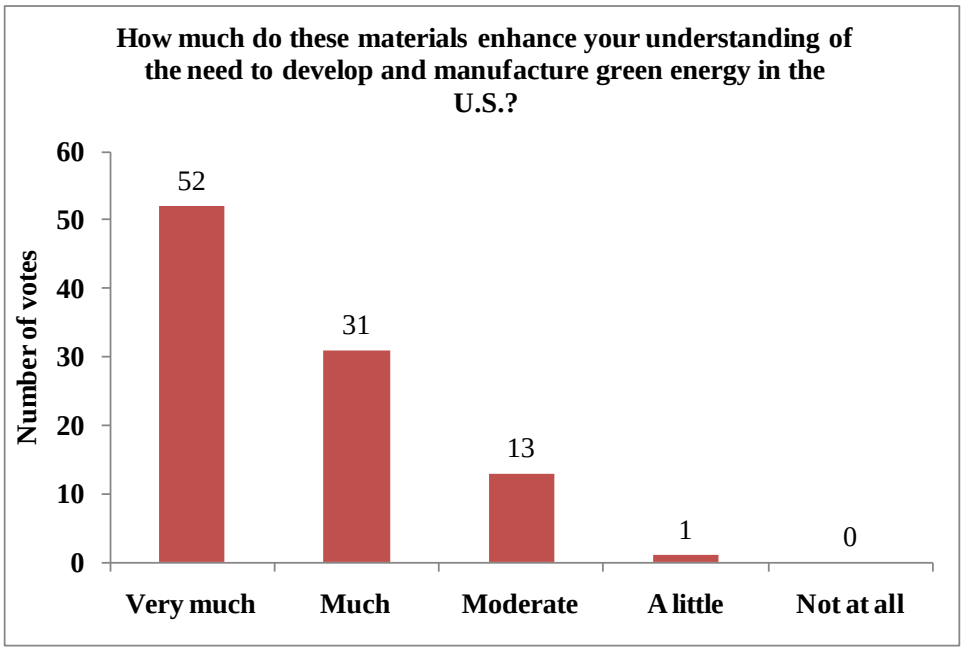

Fig. 1. Survey results on enhancement of students' understanding of the need to develop and manufacture green energy in the U.S.

One of the main goals to add green energy manufacturing contents to IMSE 250 is to enhance students' knowledge about green energy and its manufacturing. Fig. 2 shows the responses from students to a survey question, "Have these materials helped you to become more knowledgeable when talking with others on renewable energy?" It can be seen that most students become much more knowledgeable on green energy and its manufacturing after taking the lectures.

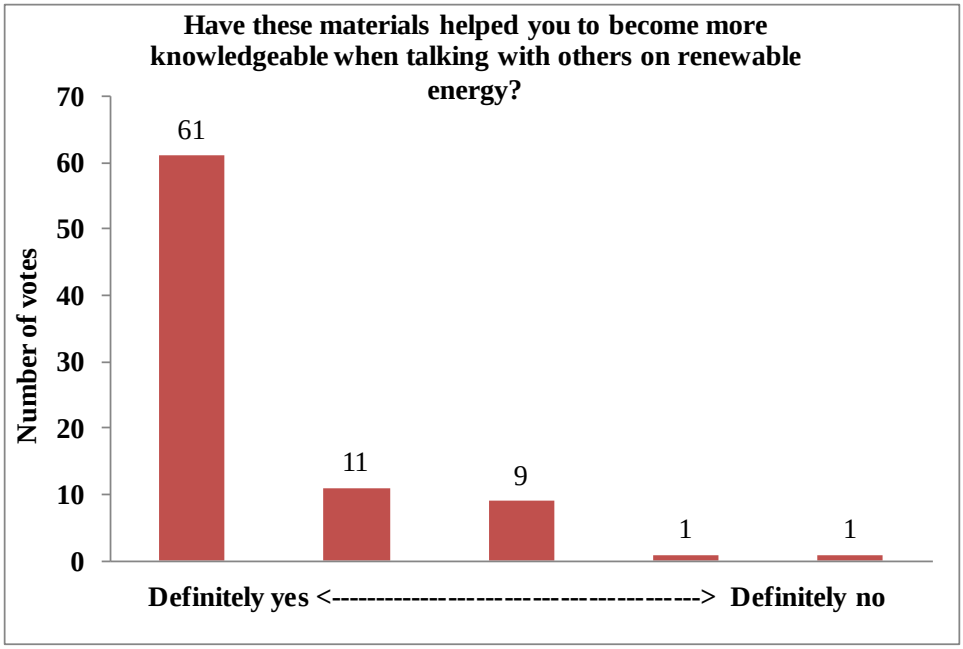

Fig. 2. Survey results on students' knowledge on green energy manufacturing

Effects of the included green energy contents on inspiring students' interest in green energy manufacturing are tested by three survey questions:

- "How much are these materials interesting to you?"
- "After taking these three lectures, how much would you like to learn more about green energy and its manufacturing?"
- "We are developing a sophomore-level elective course that introduces green energy and its manufacturing (including solar, wind, biofuels, hydroelectric, geothermal, ocean, etc.). If it is offered soon, would you like to take it?"

The corresponding answers from the students are shown in Figs. 3 to 5. It can be seen that most students are very interested in the lectures about green energy manufacturing. Most students would like to learn more about green energy manufacturing. And they would like to take a sophomore-level elective course that introduces green energy and its manufacturing (including solar, wind, biofuels, hydroelectric, geothermal, ocean, etc.) if such a course is offered.

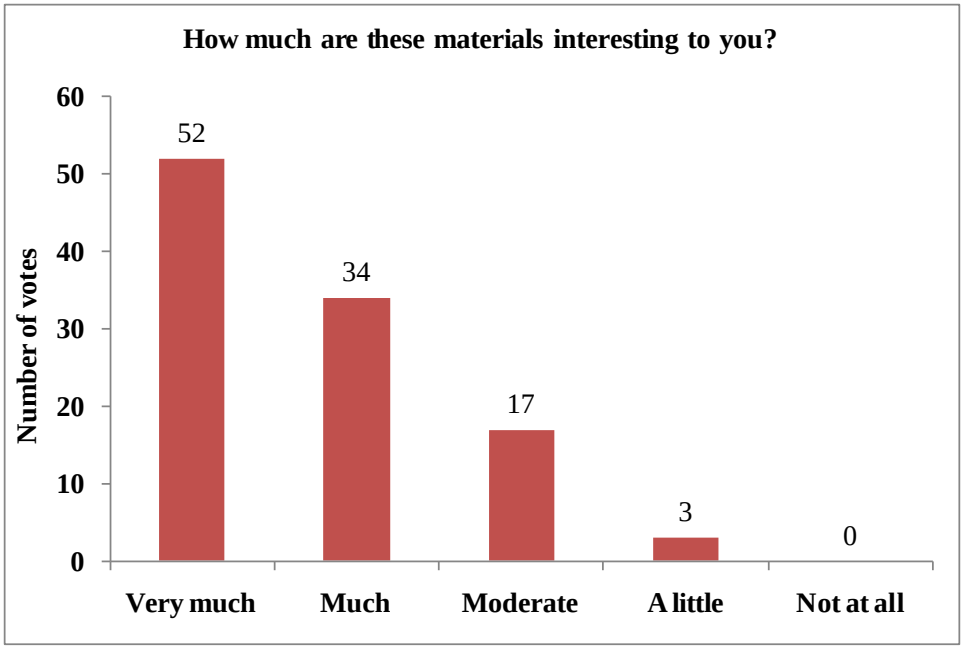

Fig. 3. Survey results on students' interest in green energy manufacturing

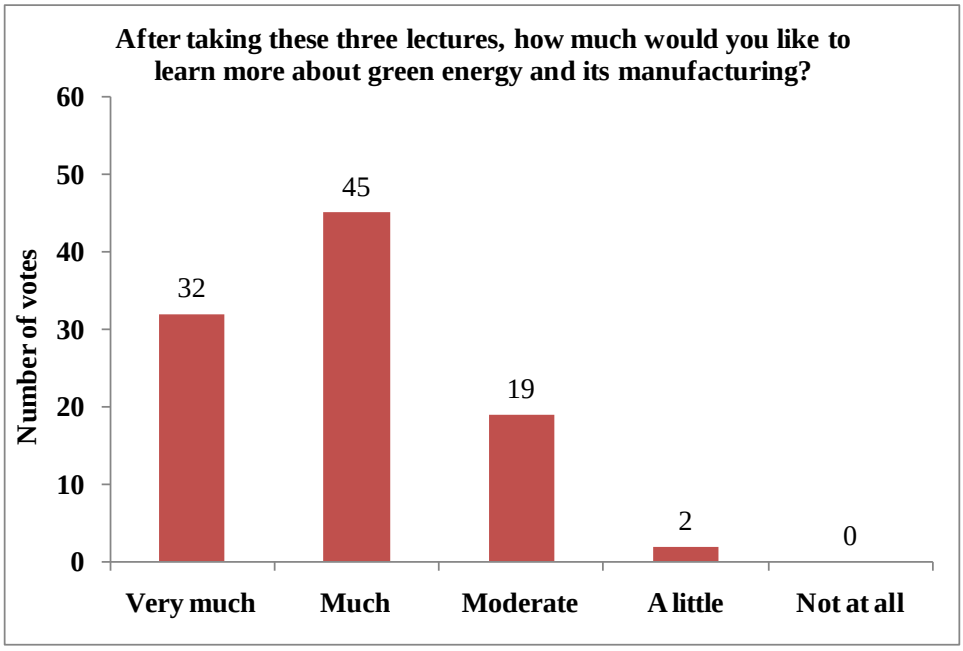

Fig. 4. Survey results on learning more about green energy manufacturing

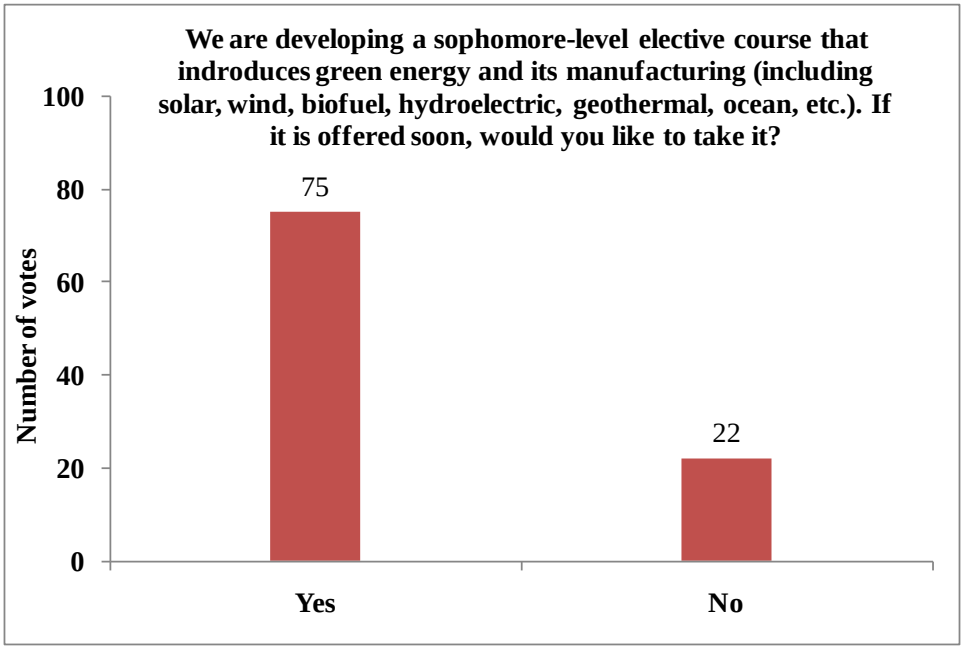

Fig. 5. Survey results on taking a specific class about green energy manufacturing

5. Concluding Remarks

The inclusion of green energy manufacturing contents in IMSE 250 has shown encouraging results. It can enhance students' understanding of the importance of green energy manufacturing in the U.S., increase students' knowledge about green energy manufacturing, and inspire students' interest in green energy manufacturing. The instructors will continue improving the green energy manufacturing contents, and explore the possibilities to create a sophomore-level course to introduce more about green energy manufacturing to engineering students at Kansas State University.

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