Characterizing Sustainable Mechanical Engineering

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Abstract

To the informed, sustainable engineering is interdisciplinary. The study of sustainable principles covers a broad range of academic subjects, and the application of sustainable practices commands the involvement of students in various curricula. On the applied side, engineering students and graduates have come to recognize the place sustainability deserves in system and component design. Academically, sustainable engineering does not belong only to environmental engineering programs. All engineers in all disciplines need to learn the principles so they can integrate the practices in their designs.

Mechanical engineering has traditional areas of study that include thermal sciences, mechanics, design, and manufacturing. The discipline also includes emerging fields such as nanotechnology and biotechnology. Sustainability, which is the practical application of pollution prevention and resource conservation, belongs in both the traditional and emerging areas of mechanical engineering. This article discusses the relationship between sustainable and mechanical engineering and presents specific areas for future consideration and investigation.

I. Technology & Society Division of ASME

In 1972, the American Society of Mechanical Engineers (ASME) established the Technology and Society (T&S) Division to focus on how engineers and technologists affect the current and future global society. ASME created the division to respond to rising concerns about the limits of technological progress and its ensuing impacts on society. Currently, the division consists of six program committees, which include the Sustainable Engineering Committee (SE). In conjunction with the Environmental Engineering Division of ASME, SE considers the effects of the interdependence of communities, systems, environments, and societies on mutual development featuring applied and measurable sustainable practices [1].

Sustainable engineering is one focus area that cuts across disciplines identified by ASME as important to the entire Society. The SE committee has acted on behalf of its division to infuse sustainable principles in the plans and actions of mechanical engineers. An important component of the committee's mission is in educating society members and aspiring mechanical engineers in the ways of practicing engineering with the mindset of natural resource conservation [2]. The committee seeks partnerships with other technical divisions and peer professional societies to broaden the scope of traditional engineering design to include end-of-life considerations. Designing from cradle to cradle is an approach through which engineers must account for materials from resource extraction through production, use, and disposal with potential for recovery.

II. Sustainable Mechanical Engineering

Although a seminal definition of sustainable engineering is somewhat elusive, the United Nations' World Commission on Environment and Development (WCED) characterized sustainable development. In its 1987 report, Our Common Future, the commission wrote that, "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Whereas sustainable development has become a goal of environmentalism in industrialized societies, it is effectively argued elsewhere that the goal is not sought globally [3]. However, supporting the goal of environmental improvement within a developing global economy, sustainable engineering is the application of sustainable practices to products and processes.

In February 1994, ASME released the "General Position Paper on Designing for the Environment," which was endorsed by the American Association of Engineering Societies. "Designing for the Environment (DFE) is the front-end planning discipline which simultaneously takes into account impacts of design, manufacturing, lifecycle, use and disposal of products on the environment." DFE operates within a sustainable society to consider "toxicity, health and safety, service life, recycled content of manufacturing material, reuse of products, recyclability of products, energy use, manufacturing wastes, and disposal alternatives" [4].

The goal of sustainable development as adopted by engineers included creating new modes of production to increase the world's carrying capacity in order to meet increasing population and consumption trends. Tempering the desire to expand capacity is the holistic approach to ensuring the well-being of the planet by not exceeding the global ecosystem's ability to absorb and recycle human-generated wastes [5].

A peer society, the American Institute of Chemical Engineers (AIChE), maintains the Sustainable Engineering Forum. The forum "provides stimulus for defining the roles chemical engineers can play in support of achieving sustainable development." Focus areas include defining metrics for sustainability, incorporating environmental and societal benefits in product and process design, determining environmental impacts of products, process, and services, and designing with environmentally benign technologies, such as green chemistry [6]. Green chemistry focuses "on the design, manufacture, and use of chemicals that have decreased or no pollution potential" [7].

What is sustainable mechanical engineering? Mechanical engineering has maintained its strengths in its traditional disciplines that include mechanics, thermal sciences, design, and manufacturing. A National Science Foundation-sponsored workshop identified new directions for mechanical engineering in each of four emerging areas: micro/nano technology, biotechnology, information technology, and ecology/energy [8]. Within the traditional and emerging disciplines, the study and practice of mechanical engineering requires improved methods that follow sustainable ideals. Sustainable engineering is multi-disciplinary in its principles and practices, and as such, must be involved in the many areas of mechanical engineering. Opportunities exist within the ASME divisional framework for the SE Committee to play an active role in sustainability-related issues across the society.

Basic mechanical and thermal principles can become sustainable with improvements in system efficiencies. Design opportunities exist to develop products that utilize sustainable materials, which are themselves sustainable when they reach the ends of their useful lives. Products must also operate at peak efficiencies to ensure sustainable use of energy. Designers in various manufacturing industries must respect sustainable material and energy requirements for both products and processes. Design for the environment must be included along with other goals of design for manufacture, design for reliability, design for testing, etc. Micro and nano technologies should have sustainable guidelines so that materials and waste streams minimize environmental impact. Biotechnological improvements are based on recognizing the biocomplexity of material systems and the importance of understanding that complexity within sustainable engineering. Information technologies can be sustainable with minimized, efficient energy requirements. Obviously, further development in the areas of ecology and energy should include sustainable practices.

III. Potential Collaborations among Divisions

Sustainable mechanical engineering presents many opportunities for the Society and its members to take leading roles in improved methods. Many other technical divisions are potential partners for Technology & Society and its committees, especially Sustainable Engineering (SE). An inter-divisional crosscutting approach enables more holistic solutions by involving various disciplines. ASME can benefit from such an approach as it taps the diverse knowledge base of its constituents. Identification of some of those opportunities arose during the discussions at the various conferences and leadership meetings, and they are here to illustrate their potentials.

The Advanced Energy Systems Division focuses on energy, power, and fuels of a variety of systems. The division has committees that include Fuel Cell Power Systems and Hydrogen Technologies. Representatives have identified hydrogen power, fuel cells, and energy alternatives in general as potential collaborative efforts with SE.

The Environmental Engineering Division (EED) is involved in all issues that pertain to the global environment. The division's original focus was pollution control for the emissions from electrical power plants. Although this is still an issue, the division now includes the development and application of air, water, and solid pollution technologies in its functions. EED promotes further development of the multi-disciplinary areas concerning the environment with committees that include Pollution Prevention and Minimization, Environmental Policy, and Environmental Communications. The division and the Sustainable Engineering Committee have mutual working interest in practicing pollution prevention and decreasing environmental impact.

The Management Division continues to be part of the same Technical Group as T&S, so the ties to SE are already established. Management representatives have suggested there were various topics providing opportunities to collaborate with SE. Managing environmentally related initiatives in pollution prevention and green engineering are two possibilities. As the Management Division focuses on professional education and training, another common interest with SEC is in promoting the management of sustainable practices in mechanical engineering.

The primary focus of the Power Division is the continued development of steam and hydropower generation and use. The division supports engineering interests in power production equipment and facilities including design, research, operation, and maintenance. Environmental effects and economics of power systems are included, which suggests a logical opportunity for collaboration with SE. Power Division representatives have suggested investigating environmental controls as a cost issue.

The Solar Engineering Division does have working interests in solar energy, but its scope has grown to include other renewable energy sources. Specific areas of focus include energy conservation, solar design in buildings, space applications for solar design, bioconversion, and wind energy. Discussions have identified a common interest with SE in advanced methods of renewable energy research and development.

The Solid Waste Handling Division also has a wide variety of interests, which stem from a focus on the design, construction, and operation of solid waste processing facilities and systems. Specific issues include landfills, composting, biodegradable materials, corrosion, and transportation of wastes. The last issue was a topic of discussion among Solid Waste Handling, SE, and the Rail Transportation Division members. The other area for collaboration between Solid Waste Handling and SE is the potential green design practice of using solid waste as raw material and an energy resource.

IV. Sustainable Engineering at the Annual Conference

At the 2004 International Mechanical Engineering Congress and Exposition (IMECE), which is ASME's annual conference, the Sustainable Engineering Committee hosted a planning session for future conferences. With the focus on infusing sustainable engineering principles and practices in ASME, the planning committee identified potential topics for IMECE 2005. Representatives of the Solar Engineering Division and the Environmental Engineering Division participated. Meeting attendees crafted a basic framework from which they identified a series of technical sessions. Table 1 shows the suggested track topics broken into five fundamental areas. Although the original plan for sixteen technical sessions did not fully materialize, the framework did provide the basis from which sessions were developed and integrated with other conference tracks.

Areas	Topics
People	Sustainable cities
	Developing countries
	Ethics
Planet (natural resources)	Water
	Air
	Energy
	Waste
	Waste-to-energy
Products	Recycling
	Life cycle analysis
	Green buildings
	Energy
Processes	Green chemistry
	Design for the environment
	Industrial ecology
Profit	Economics
	Total life cycle cost

Table 1 - Potential SE Track Topics

The Sustainable Engineering Track for IMECE 2005 had ten technical sessions with diverse topics. The committee members agreed to keep the scope of the sessions focused on a few of the topics identified in order to present a multi-day program that conference attendees found met their specialized needs. Sustainable Mechanical Engineering is broad in scope, but the conference track was to be attractive to industry personnel who could only attend for a day or two. Beyond the technical sessions, workshops and tours provided additional opportunities for discussion of sustainable principles.

The goal for IMECE 2006 is to include sustainable engineering within many tracks across the whole of the society. Extending beyond the sponsorship of T&S, Environmental Engineering and Solar Engineering Division sessions will include sustainability as it applies to mechanical engineers. A society-wide inclusive approach to sustainable engineering is more proactive than the more narrowly focused single division sessions. As the collaborations with peer divisions become more evident, ASME members will see more examples of how sustainable engineering practices can be applied to mechanical engineering disciplines.

V. Summary

Sustainable engineering transcends the various engineering disciplines, and it transcends the working divisions of ASME. Academia already includes sustainable engineering in multi-disciplinary courses that go beyond the bounds of the engineering curricula to include students and programs across campus [9].

Expectations for industries to do business in a sustainable manner are increasing as regulations on the global scale force alternatives to using toxic materials. Consumer awareness and marketing potential are also drivers toward corporate environmental stewardship. Competing with sustainable goals is leading companies to forming collaborative partnerships with like-minded organizations. ASME members and peers have begun and should continue discussing potentially sustainable collaborations.

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