THE FUTURE OF MANUFACTURING

Manufacturing innovation and the Manufacturing Engineering Division.

BY SCOTT SMITH, FORMER MANUFACTURING ENGINEERING DIVISION CHAIR (2005-2006)

This is the final article in a series celebrating 100 years of the Manufacturing Engineering Division (MED) of ASME. Four former division Chairs have already written about the influence of MED on Industry neXt, micro- and nanomanufacturing, and environmental sustainability, as well as its impact on Manufacturing USA.

Now, I will address the future.

In the 1990s, some thought the economies of developed nations no longer needed manufacturing. The contribution of the manufacturing sector to total gross domestic product and employment had been shrinking since the 1950s. It seemed to some that we were becoming a service economy. At best, this was inaccurate. At worst, it led to policy (and career) decisions with damaging results.

Manufacturing is the fundamental source of wealth creation driving modern economies. Manufacturing innovation "casts a long shadow." For example, integrated circuits at the heart of telephones, computers, cars, and more depend on manufacturing chips with nanometer-scale features by the millions. Without this ability, the widespread benefits derived from integrated circuits would not exist.

Manufacturing is central to humanity. For millennia, craftsmen, often working alone, made, sold, or traded manufactured goods including tools, weapons, and clothing. The origin is revealed in the etymology. The Latin roots of the word manufacture—"manu" (hand) and "factura" (a working)—literally mean "hand made." Little is literally made by hand today; most products use machinery at some point in their manufacture, and few products are made without using computers. While manufacturing has become more complex, manufacturing is still driven by innovation.

As the understanding of manufacturing's importance evolved, so did the ASME division. Originally, we were the Machine Shop Practice Division, implying that manufacturing was something of an afterthought—once the design and analysis was done, drawings were sent to the shop for fabrication. It reflected a focus on craftsmen. Later, we became the Production Engineering Division. This was better, recognizing that manufacturing involves more than machine shops, and engineering was a central component. Today, we are the Manufacturing Engineering Division, and the scope is very broad. Similarly, our journal which dates from 1959 changed from the *Journal of Engineering for Industry*, to the *Journal of Manufacturing Science and Engineering*. Manufacturing engineering includes research and development, data collection and analysis, environmental impacts, and education and workforce development at all levels.

Modern manufacturing encompasses almost all engineers—we are all working to transform ideas into affordable reality. Manufacturing is not a small boutique subset of engineering, but rather the superset that contains the rest.

Through relentless innovations of individuals and groups, manufactured goods have become more widely available, less expensive, and better. Manufacturing and innovation are inextricably linked. Innovation in manufacturing has brought us a world where even relatively poor people can afford things that would have been unthinkable luxuries, even for the richest people, just a few generations ago. Air conditioning, washing machines, transportation, televisions, and much more are available because modern manufacturing has produced them at low cost and at a large scale.

More importantly, manufacturing innovation is deflationary, meaning that it increases the buying power of existing wealth. Manufactured products today are dramatically better than their predecessors. Smartphones are both more capable and less expensive than cell phones were, and they were a dramatic improvement over rotary phones, which improved over the telegraph. The positive impact of manufacturing innovation on our quality of life is dramatically larger than traditional measures like manufacturing's share of the GDP would show.

What does the next 100 years hold for manufacturing, innovation, and the MED? Can we gather the smartest people in a room, and come out with the list of what's next for manufacturing? I think that the answer is generally no, because our track record of predicting future innovations is poor. Innovations often come as surprises to those who have not been working on them. Our record of identifying impactful innovations that already occurred is better. The roots of most transformative changes in manufacturing, generally lie in innovations that happened decades earlier. They were created by pioneers using their own vision, experiences, and insights.

The rise of additive manufacturing (AM) seems like a new trend that is revolutionizing manufacturing. The 2012 *Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing* listed AM as a top cross-cutting technology, and it was chosen as the focus for the first Institute in what is now called Manufacturing USA. But when did that innovation really occur? There are papers in the *ASME Journal of Engineering for Industry* on AM dating from around 1990. E. Sachs, J. Beaman, and many others had been working on this idea for more than 20 years before it was identified as a technology of the future. In the 1970s, the NSF funded a project on describing surfaces with triangles, hence STL (surface tessellation language, not stereolithography language as is commonly thought) was born. Innovations in materials, equipment, computation, and applications laid the foundations of AM as a future technology long before it was "what's next."

Many innovations in robotics were published in our journal in the early 1980s. Innovations in sensors, control strategies, safety and more built the background that allowed robotics to become a technology of the future. AI and machine learning have roots in our journal dating from the 1970s and 1980s. These were all fruitful areas for manufacturing innovation long before they were "what's next."

It is difficult to see the future of manufacturing, yet certain things surely will continue to be true. First, a vibrant manufacturing sector is central to economic wellbeing, and it will remain so. Second, manufacturing requires constant innovation and lifelong workforce training at all levels (from factory designer to manufacturing engineer to technician to shop worker). Finally, innovation is important. We can't know what products will be developed in the future, but the importance of innovation is timeless.

If manufacturing innovation is important, policies and investment should reflect that. Below are recommendations that I find essential.

Funding for research: New materials, processes, and knowledge that lead to innovative products have the greatest impact on a nation's wealth.

Relentless innovations: Basic research alone is not enough to make something fit for manufacturing at scale. Almost all manufacturing innovations start with a question like "Can we do this better?" or "What else could we do with what I learned?" We have an obligation to keep looking, learning, and thinking of ways to make the world a better place. We have an obligation to never be satisfied. We are all innovators with the power to change the world.

Publication platforms: The journals of MED have always been home to manufacturing innovators. Journal publications that document transformational, disruptive, and incremental innovations are an essential part of the manufacturing ecosystem. Technical conferences like MED's Manufacturing Science and Engineering Conference provide a platform for presentations and catalytic discussions.

Sector support: The size of our investment in a sector should reflect how much we value that sector. Manufacturing and manufacturing innovation are so important that the investment at all levels should be significantly higher than it is. While manufacturing is critical to many federal agencies, it is not the fundamental mission of any, so it is easy to marginalize. It may be time for an organization specifically focused on supporting manufacturing innovation. Public-private partnerships support manufacturing around the world, but equivalent programs in the U.S. are tiny. If we use a benchmark of matching the German investment in their Fraunhofer program, scaled by economy size, the American investment should be 10x larger. Engineering enrollments have increased dramatically in the past decade, but they could double and still not meet the demand in advanced manufacturing. Many companies view manufacturing as a required activity, but not innovation. A renewed focus on the critical links between manufacturing, innovation, and prosperity could be significant.

ASME Federal Fellows Program. For almost 50 years, ASME has supported members serving in the federal government advisory roles. Expanding this program to allow more engineers to help guide policy would be invaluable.

I am grateful for the service opportunities ASME provided me. I am proud of the first 100 years of our division, but the best is yet to come. We live in an age of renewed recognition of the importance of making things—a manufacturing renaissance. I have never been more excited about our future. **ME**

MedUSA, a three-robot metal additive manufacturing cell at the Department of Energy's Manufacturing Demonstration Facility at Oak Ridge National Laboratory.
Photo: ORNL/U.S. Department of Energy

SCOTT SMITH has been a member of ASME since 1980. He is group leader for Intelligent Machine Tools in the DoE's Manufacturing Demonstration Facility at Oak Ridge National Laboratory. He received ASME's Ennor Manufacturing Technology Award and Blackall Award, and is a Fellow of ASME.

Learn More: **https://event.asme.org/MSEC/About/MSEC-Centennial**