Topic: Transitioning Makers to Manufacturers

In recent years, the variety and value of the manufactured products that an individual or a small team can design and prototype has increased due to lower costs of desktop equipment, the availability of CAD software, shared Makerspaces, simplified software, innovative financing models, and more. However, transitioning from making to manufacturing requires more than that. It requires an understanding of feasible materials, manufacturing constraints, costs, and the ability to design for ease of manufacturing.

Many entrepreneurs and makers do not have a basic understanding of manufacturing issues, much less the needed expertise or a formal manufacturing education. This limits their ability to form productive relationships with venture capitalists, the supply chain, and manufacturers.

The goal of this session is to identify innovative approaches to democratize manufacturing knowledge to help innovators learn what they need to know to successfully engage with the manufacturing ecosystem. We need to identify existing resources, including software tools and best practices, that can lower barriers to accessing this specialized knowledge of efficiently transitioning a functional prototype into a manufacturable product ready for market. We will briefly discuss a "Manufacturing 101" curriculum outline developed through a recent MForesight workshop and review the suggested education modules and training methods.

There is a wealth of knowledge and know-how in manufacturing, but that knowledge is spread across many books, videos, tool suppliers, engineers, machinists and tradespeople. The challenge in democratizing manufacturing is providing the right information to the right people at the right time. How do we bring this knowledge to the finger-tips of innovators as they are conceptualizing their design on a CAD tool? For instance, are there intelligent design tools where the software can only create designs that are easily manufacturable or can detect design aspects that are not manufacturable and suggest alternate solutions?

We look forward to hearing your thoughts on the following questions:

- What innovations enable manufacturing knowledge to be shared easily and broadly?
- How can Intelligent CAD systems resources be made more affordable or available for entrepreneurs and makers?
- What are other existing useful resources and best practices?
- How can MEPs be utilized to help educate entrepreneurs?
- What does your organization or another organization you know of do to address these challenges?
- What are some success stories that illustrate a process of educating an entrepreneur or start-up, or providing access to the tools needed?

Please email Sridhar Kota (kota@umich.edu) your thoughts on this topic by August 1 so that we can synthesize your ideas and present them to participants at the beginning of the session, enabling a more productive discussion.

Topic: Process Innovation and Low Volume Manufacturing

You have all been invited to this workshop because you have a strong background and point of view. In order for this to be an efficient and interactive session I'd like to request that each of you prepare a bit of a 'positon paper' that we can use to spur a lively, productive, provocative discussion, and most important, one that will lead to policy input that will guide our nation's manufacturing agenda in this competitive world.

We don't want to constrain the form or content of your position paper. It can be a few bullet points, a page of prose, a few curated links with explanation, or a rant that you record with your camera as you often see on YouTube. These should not take long to read (or produce), but should possibly lead to some long periods of pondering among the readers. We will use our time in DC to discuss how to refine and combine these ideas to have the most impact.

Please collect your ideas on what kinds of hardware, software, ecosystems, education systems, cultures, practices or government programs would enable great, sustainable and world-bettering products and manufacturing processes (ideally with short lead time and minimal capital investment). Also consider the makers/students/entrepreneurs who will use these products. Be provocative. Give us something you are passionate about.

Please email Glenn Daehn (daehn.1@osu.edu) your thoughts on this topic by August 1 so that we can synthesize your ideas and present them to participants at the beginning of the session, enabling a more productive discussion. These will be used to start a strawman consensus view.

The next several pages provide one example that you can use to get going:

Two Elements that can put the United States ahead in Short Run Manufacturing

Glenn Daehn, College of Engineering, Ohio State University & Exec. Dir. Ohio Manuf. Institute -- July 15, 2016

Preface and Importance:

Producing raw materials and the ultimate products we use every day consumes about one third of our energy and produces a similar amount of our greenhouse gas emission. If we can learn to use less material and produce better (lighter, more durable, more recyclable) products we can develop a society that is more sustainable and materially better off. Key barriers to this are that we have a limited number of manufacturing processes and most of these are based on large sunk investments in presses, dies and similar machines that producers trust and know how to use. If we can move to new, scalable, rapidly-deployed and low-capital processes that produce components that are strong, light and can be used in safety-critical applications, that can be a true game changer. High performance products have two crucial elements, an optimized topology (or shape) and excellent appropriate materials properties (strength, toughness, corrosion resistance, etc.). Additive manufacturing can provide topology, but the optimization of materials properties has just begun. Reforms in how we educate and how we see the roles of universities can help us develop a new generation of needed and innovative processes. Below these ideas are briefly expanded and an example is given as to how they can work together.

1) *Education*

We need STEM-Educated people to understand and appreciate the science and skills that form the foundation for manufacturing. K-12 and University programs should bolster this.

A key challenge is the mind boggling complexity of what we call 'manufacturing'. We rely on many types of processes (plastic forming, casting, molding, machining, joining, powder processing, coating, mechanical surface treatments) and sub-processes (tool and die making, design, CAD, analysis, certification/validation, etc.). Each have different jargon and bases in science and engineering. Future high-volume makers need to at least be aware of what they don't know and be able to access that information. In part this requires that they not only have good analysis tools, but proper respect for the range of skills that are required to manufacture, and they must know how to access and assess these skills.

2) *Expanding The Role of Universities*

Universities should change from a focus on "research and analysis" to one that is much more inclusive to real-world "impact and synthesis" of ideas and skills. Process Innovation would be one appropriate focus area.

Universities have been too hung up on the idea that they are providers of *research*. NSF and similar agencies see their role as fostering novelty and high quality peer reviewed research. Universities follow the money and this attitude has been limiting. Universities also can be hotbeds for design and synthesis for impact in solving real problems. NSF and other federal agencies shy away from impact as being a criterion for making awards. Universities are perfectly positioned to be challenged to pose large and interdisciplinary solutions to real problems and use their breadth to develop innovative designs or processes to provide new technologies and trained personnel to make a difference. One such relevant question to this group may be: "How do we create products with great topology, material properties and do this with minimal investment of time and money?". This question requires innovation and synthesis of ideas. A couple very new answers have been developed to this broad question. Ablation casting is one (http://content.yudu.com/web/y5b2/0A1snzj/ModernCastingApr2015/flash/resources/22.htm . Several others have been chronicled here (60 Excellent Innovations in Metal Forming: http://www.springer.com/us/book/9783662463116 . One more ambitious that brings together interdisciplinary synthesis for impact and education follows.

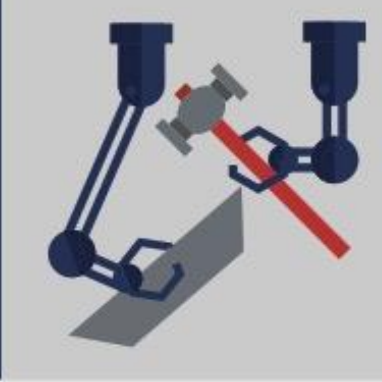
Robotic Blacksmithing – an Example of a game changing technology we need to develop

The attached flyer gives a vision for a technology of Robotic Blacksmithing, that as far as we know has not been done yet. This is a follow on form CNC machining and additive manufacturing, and could be called metamorphic manufacturing. The evolution of this can provide gains for US manufacturing and sustainability. The prize approach is an experiment that is intended to foster education and impact.

BUILDING 21ST CENTURY MANUFACTURING TALENT

The LIFT Prize in Robotic Blacksmithing: Igniting Student Interest in Manufacturing Skills and Innovation

An Education & Workforce Development Initiative for LIFT...Lightweight Innovations for Tomorrow



THE PROBLEM: MANUFACTURING TECHNOLOGY ADVANCING, WORKFORCE SUPPLY STAGNATING

Manufacturing has undergone a revolution around additive manufacturing, 3-D printers, and CNC machines. This keystone industry is more automated, requiring workers to have advanced technical and mathematical skills to program, run, and maintain complex machinery necessary for 21st century production. New manufacturing processes are emerging through LIFT and its partners such as agile processing which provides the opportunity to improve material properties, reducing waste and producing repeatable shapes while minimizing tooling and cost.

While this manufacturing renaissance is underway, fewer students are engaging in career pathways related to manufacturing, and employers are struggling to find the talent to replace their aging workforce. Currently, more than 21% of the advanced manufacturing workforce in LIFT's partner states is over age 55 and ready to retire soon. On top of this, employers in the LIFT partner states posted nearly 340,000 jobs during 2015 alone, but only 103,000 individuals completed degrees and certifications preparing them for these lucrative jobs. Postings continue to increase while sources of talent remain static. Demand is growing. Supply is stagnant.

COMPETITION: A NEW FRONTIER OF STUDENT ENGAGEMENT

To encourage students to develop the skills they need to become innovators and future manufacturing leaders, LIFT, through its Agile and Low-Cost Processing Pillar, has teamed with the Center for Design and Manufacturing Excellence (CDME) at The Ohio State University to initiate the LIFT Prize in Robotic Blacksmithing, a student competition using agile processing principles. The competition combines outreach to students, engagement with emerging cutting-edge technologies, employers working directly with students, prizes, and national recognition for the winning teams.

This competition merges the ancient skills of the blacksmith with the digital age of robotics to create new material forming capabilities called "Robotic Blacksmithing" for making useable object shapes. Like additive manufacturing and Computer Numeral Control (CNC) machining, Robotic Blacksmithing creates new methods for manufacturing, improving material properties, reducing waste, and agile manufacturing of complex and repeatable shapes with minimal tooling at low cost.

WHAT IS ROBOTIC BLACKSMITHING?

Instead of a blacksmith manipulating and forming materials by hammering, bending, twisting, or pulling, a robot is programmed to perform these movements and manipulations using a set of agile forming tools with greater efficiency and agility, and using far lighter and less expensive tools than might be used in traditional forging.

There are great opportunities for innovation in this new field to develop material forming models in a numerical or experimental modeling environment, and then translate these models into a robot environment to design and manufacture useful shapes. In the future, it is envisioned that Robotic Blacksmithing programming tools will be available to makers everywhere who seek to shape materials into objects. This technology can go beyond simple subtractive or additive manufacturing because the material can be improved by working it with deformation and heat, and sensors can record the process and assure properties. Most exciting, because the processes re-shape material, there is virtually no waste and a wide variety of materials can be processed to very high strength with other engineered properties.

Job Demand Outweighing Workforce Supply

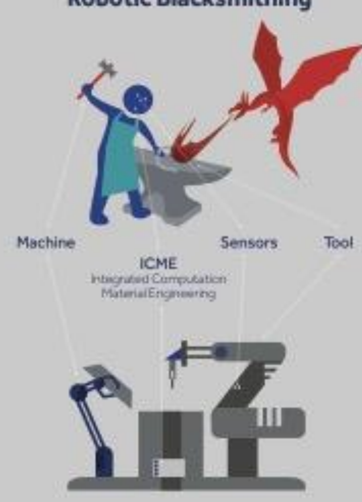
340,000

jobs were posted during 2015 but only...

103,000

individuals completed degrees and certifications preparing them for the same lucrative jobs

The Evolution of Robotic Blacksmithing



CONTINUING THE DIGITAL MANUFACTURING REVOLUTION

Robotic Blacksmithing follows on the heels of two revolutions in digital manufacturing we have already seen truly changed our world. The first was CNC, in which cutting tools process materials (plate, bar, and other wrought shapes) into more complex shapes. Instead of carving by hand, CNC machines use very large and fast metal removal tools, programmed with a digital 3-D model to subtract material from the block to create desired object features. The second manufacturing revolution was around additive manufacturing and 3-D printers, which add successive volumes of material by computer control to create complex shapes that are described by an electronic (digital) data source, such as a 3-D model. Our menu of processes and materials for additive manufacturing is expanding rapidly right now.

ELIGIBILITY

The program is open to any student team attending a U.S. high school, technical college, community college, college or university, and partnerships with regional or national companies are encouraged.

EXPECTED OUTCOMES

Students will benefit from this competition by:

- Developing and demonstrating a third robotically-controlled way of making things
- Inspiring innovation and new skills
- Showing the linkage between doing and innovation
- Showing innovation, skills, spirit and pride by competing to develop a wholly new technology

PROJECT LEAD

The Center for Design and Manufacturing Excellence at The Ohio State University

ALIGNMENT TO STRATEGIC FOCUS AREAS

Deploying educational pathways from high school, through community colleges, to universities

Ensuring more students gain STEM foundational skills

Creating enhancements to engineering curriculum using lightweighting

THE OHIO STATE UNIVERSITY

lift LIGHTWEIGHT INNOVATIONS

For more information, please see lift.technology or www.roboticblacksmithing.com.

For questions about LIFT Education & Workforce initiatives, contact Director Emily DeRocco at ederocco@lift.technology.

For technical questions on the LIFT Prize in Robotic Blacksmithing, please contact Glenn Daehn at daehn.1@osu.edu.

ABOUT THE COMPETITION

Full rules for this competition will be released in mid-September 2016, with the first prize being offered about the end of 2016. Groups may begin forming teams, partnering with industry and planning now.

The competition will be organized in a phased approach with three phases increasing in difficulty:

First Phase

CNC Shaping of Plasticine /Clay

In the first phase, student teams will develop and program a single system to develop three different shapes that will be specified with the competition rules.

Student teams will be evaluated based on the following criteria:

- Component quality
- Process time
- Public documentation of the journey and of approach

Second Phase

CNC Shaping of Metal

Third Phase

CNC Shaping with Thermomechanical Processing

Prizes

$50,000

Winning teams will receive recognition and include total cash awards of at least $50,000.

Topic: Lower Barriers-to-access to Established Supply Chains for Manufacturing Entrepreneurs

It has been widely recognized over the last decade that manufacturing underpins our economy and is the foundation of a strong middle class. Manufacturing is also a key driver in technology development and innovation. The nation's ability to compete in the global marketplace and its security lies on its ability to be a leader in innovation…and manufacturing plays and important role in driving innovation.

The effect of manufacturing goes far beyond the obvious as the associated direct and indirect supply chain and support structures are woven throughout the economy and the communities in which we all work, live and play. Whether it be the OEM's at the "top of the food chain", small and medium sized business that support the OEM(s), the education and workforce development community, universities and national labs involved with research and development or the cultural, arts recreation and increasingly food related activities and enterprises, all are components of the greater "manufacturing community."

In order for the U.S. to grow and sustain its manufacturing base and maintain it's all important leadership in innovation, a focus must be placed on supply chain development and support. While in the past a simple supplier/vendor relationship may have sufficed where a business would simply procure a part or service from a low-cost, reliable supplier; that is no longer good enough if one is effectively competing in the global marketplace. OEMs must provide value to customers and in order to do so, must capture value from the supply chain. Close-knit relationships with co-located suppliers that have the ability to integrate R&D activities and improve products, processes and services in real time that provide a competitive advantage to the ultimate customer are considered more and more the norm.

A major focus of MForesight is to identify ways to improve supply chain connectivity and innovation. This topic of discussion will be to explore ways to lower barriers-to-access to established supply chains for manufacturing entrepreneurs. The discussion will focus on technical and non-technical barriers, emerging trends and in general improving access to the supply chain, including:

- New technologies that are reducing barriers to entry to the supply chain
- New technologies needed to further reduce barriers to the supply chain
- Effect of new business models on supply chains

In advance of and to help facilitate the discussion, below are some thought provoking ideas/questions/ topics to be considered:

- What are the more innovative ways OEMs and SMEs working together to provide innovative, cost effective solutions or what are some suggestions to do so?
- What can be done to create experiential learning environments that leverage the collective strength of stakeholders to help drive real time product and process innovation within the supply chain as well as workforce development?
- What assets exist to help facilitate product and process innovation and better connectivity within the supply chain? For example, are their institutions or organizations that could play more of a role in supporting such activities (i.e.: MEPs, maker spaces, NNMI Institutes, etc.)
- What can be done to promote more progressive interactions between OEMs and SME's that that more directly meet real time manufacturing challenges?
- What gaps or road blocks exist that are impediments to advancing supply chain development/innovation and/or to any of the activities above?
- What role could/should the Federal government play in supporting supply chain development?
- Are there targeted areas on this topic that should be studied in more detail?

Please email Mike Russo (mike.russo@globalfoundries.com) your thoughts by August 1 so that we can synthesize all your ideas and present them to the participants at the beginning of the session enabling a more productive discussion.