Conexus Indiana - Summary of Peer-to-Peer Forum event held 12-06-19

Original Topic

> **"003 Additive Next Steps**
> **Opportunity:** Host company has implemented 3D printing into aspects of their design engineering team's process for prototyping. The host company is interested to explore expanding their use of additive techniques, and specifically how other manufacturers have been able to scale-up from a prototype additive process to use in a production environment. Near-term potential exists in areas such as tooling production. Host is seeking to network with other manufacturers taking similar steps.
> **Host profile:** Manufacturer in Shelby County, IN
> **Potential Peers:** Manufacturers working with additive techniques beyond prototyping."

Location: Freudenberg-NOK Sealing Technologies (FST), 487 W Main St #9745, Morristown, IN 46161
Web meeting available for distance peers

Date: Fri 12/6, 9AM-12:30.

Agenda:

(20 min)	Introductions (3-5 min ea)
(5 min)	Peer-to-Peer Concept / Ground Rules / Expectations
(15 min)	FST Overview
(20 min)	FST Topic Status, Experience, Interest
(60 min)	General Dialogue
(30 min)	Tour of FST
(45 min)	Lunch hosted by FST

Peer Participants

Freudenberg-NOK Sealing Technologies - Host
Conexus Indiana
Cummins
Purdue MEP
Samtec
*Contact list available to participants.

Peer-to-Peer Concept / Ground Rules / Expectations

- Host proposes I4.0 topic -> Additive next steps beyond prototyping
- Conexus assembles vetted peers.
- Peers are true peers, i.e. not a forum for sales/services pitch.
- Varied stages of experience and expertise.
- Facilitated forum where peers can share experiences, thoughts, questions. Successes and challenges.

- Goal is to create, strengthen, and promote networks of advanced expertise within IN.
- Dialogue at non-confidential / non-proprietary level.
- Notes captured by Conexus to share with participants post-event; including contact information.
- Potential for public dissemination of high-level outcomes.

FST Overview

- Static to semi-static sealing solutions requiring precision tolerances and premium compounds for aggressive applications.
- Report to Germany, but all engineering located in Morristown. Financially accountable to Germany, but generally runs independently in Morristown.
- Global footprint $8B with North America about $1B. Morristown to break $80M this year. 382 employees (322 hourly and 60 salary). 85k SQ. ~84% auto, ~16% general, ~257 customers, 420 active part numbers.
- Several awards won in recent years.
- Growing aggressively. $20M in 2009 to $80M 2019.
- Focus on lean Toyota methodologies.
- Parts for engine, transmission, fuel, driveline.
- Engineering test lab for full product testing, including Ultimaker S5 3D printer
- Full design development process: Concept, 3D model, FEA, Prototyping, mold flow simulations, DVP&R, Fixture Dev, DV Testing, Production Release.

FST Topic Status, Experience, Interest

- Recently purchased a Ultimaker S5 3D printer: dual extrusion, open filament. Good for some FST prototyping, but not full product finish. Useful for fit and form considerations but not performance. Additive material performs differently from FST production materials. i.e. once vulcanized it will not become fluid again when reheated. Good entry into the additive space.
- Additive for tooling is of interest. Transfer Mold Cavity Examples:
    - Currently machined in house. (lathe, mill, etc)
    - 440C Stainless, hardened to 56-60 Rc
    - Hard chrome plated.
    - Tight tolerances required: basic (±0.002), high quality (±0.001), critical areas (±0.0005) and extreme cases at (±0.0003)
    - Challenge is that rubber flashes through mold gaps much smaller than what plastic does.
    - Prototype tooling is expected to last at least a couple hundred parts and possibly up to 2-3K depending on the part being produced. Production tools are expected to last hundreds of thousands; maybe 0.5M on average. FST has tools that are 10-15 years old and still run every day. It depends on the tooling material (hardened steel vs brass) and the design/materials of the production parts.

Themes Emerged from Open Discussion

Post Processing: Sometimes additive gets thought of as all or nothing, i.e. you either have to print to the desired final finish or you might as well continue with traditional fabrication methods. Maybe oversize the print and then strip off a little (acid bath, milling, etc.). Many of the materials are soluble, so you can dissolve away excess material. Or you can undersized and then plate on top.

Tolerances: There is some frustration with tolerance 'gray area'. Printer machine OEM's will give you layer height specs, but often hesitate to give overall tolerance specs because of issues like shrinkage. Hesitancy is understandable to a degree as variance depends highly on material, technology, process implementation, part geometry (size and complexity), environmental parameters, etc.

Machine Learning: OEM's like Markforged are working to integrate machine learning features to better predict shrinkage, and the prediction is expected to get better with time the more you use the printer. It can theoretically get to very tight tolerance the more parts are run and the more similar the parts are. But even then, it might still be best to aim for 95% of where you need to be and then use post-processing to finish off the build to final spec.

Process sophistication: Interesting discussion around thinking in terms of process. While 3D printing and additive manufacturing are usually treated as interchangeable terms there is starting to be a difference between them. Additive is turning into a multiple step process with 3D printing being a step. For example, one additive technology cycle might be print, bath, sintering oven, scanner, and then feedback to the front end. That's just one technology process; there are several other technique cycles for which bodies like ASTM are developing and tracking standards for.

Experimentation is key: Experimenting around with when to print and when to not print is important for a couple reasons. 1) It captures the most obvious value of additive, which is rapid innovation. Fail fast, fix fast, recover fast. 2) It opens creativity within the culture. Its low cost of operation allows you to "try it vs. overthink it". Benefits and applications are found that would never have been found otherwise, and that is empowering for talent.

Culture resistance: Folks are sometimes set in their ways; especially the highly skilled and experienced specialists that additive may impact. If additive is not a direct, drop-in replacement for something within their existing and normal workflow without requiring post-processing or some other change, then they might be overly critical of its value. Look for early wins to get them engaged and invested in rethinking process. The real value early on might be laying cultural groundwork rather than direct and immediate savings.

Alternative materials: The availability of printable materials is expanding quickly, and it's not just about printable versions of traditional materials. Additive opens up options for new material combinations to explore. For instance, composites can become much easier with additive. Markforged is unique and impressive in their approach of how they tackled carbon fiber solutions early. EOS is really advanced with a long history and worth looking at as well.

Purdue MEP Workshops: MEP will be hosting workshops at the Purdue Polytechnic campus in Anderson using their lab with several 3D printing machines. The first workshop(Jan 24) will start basic with fundamentals and printing some parts. The second (Jan 31st) will look at various technologies and trends, and is aimed at putting more info in the hands of people looking to make an investment in additive. Future workshops are likely on things like how to take care of the machines, designing for additive, etc.

Designing for additive: It is a big mindset change; not only for part design but for overall process as well.

It's a journey to additive: Investing in the core 3D printing equipment and its accessories is likely to only be a fraction of the investment. You have to think about your workflow and infrastructure. Issues like material storage, material handling, heat treating, environmental controls, and several other considerations come into play to various degrees depending on the additive platform and use case. For example, platforms that use exposed powder can create a number of challenges just in terms of EH&S. It's not uncommon for a full journey to true production to be an investment that tops $1M and takes several years to implement and validate. The key is to consider the whole process before making a critical investment decision.

Landscape is rapidly evolving: Costs are falling quickly and best practices are changing on the scale of months rather than years. You have to accept that hardware you invest in today is likely to get iterated upon and surpassed soon after it's up and running; within a few years at most. If that's a concern, then look at the OEM's that offer after-market updates and support. OEM's might have to get creative with more of a lease model. The equipment might become commodity with the value being in design knowledge, expertise, and IP.

Talent pool is limited: It's a real struggle to find a capable and competent workforce. It's a new skillset. It's an advanced skillset. It's a very small pool of experts. They are well networked with each other, and are very often hindered by NDA's. There is also a limited number of good academic programs generating new grads in the area. Univ of Louisville appears to be an early shining star with some excellent resources and classes around metal selective metal sintering.

Standardization is still immature: It's an issue. Right now an additive technician/engineer cannot move between materials and machines nearly as easily as a CNC technician can move between various machines and materials. It will happen, but it will take 5+ yrs. ASTM standards recognize 7 technologies and list if growing.

Central server processing models: Some of the newer ideas and advanced features (machine learning, etc) of some platforms require uploading data (designs, printer performance, part scans, etc.) through a service bureau of the OEM. There are often good technical reasons for it, but it raises a host of issues to carefully consider, including: intellectual property, confidentiality, data chain of custody/control requirements, cyber-security, connectivity/bandwidth, revision control, OEM use of data, and etc.

Leverage outside resources: Don't aim to do it all. Do some and get outside help. Find the right balance.

Sandbox environment: Setup an extremely well-defined sandbox with some criteria for when and why to use additive, and then try auxiliary things with it. But keep track of which uses hit the criteria of original intention and which are auxiliary. This is important for the cultural aspect. It has to work for use cases that hit the original intention in order to have credibility. But it doesn't have to work, and very often won't, for those out-of-the-box auxiliary experimentations. Don't let those experimentations be seen as failures or faults of the machine or the people involved with the machine. If you jump in too quickly without considering this then setbacks get taken out of context and distort perspective. Expectations should be different for 'inside the box' vs 'outside the box'.

Body of knowledge: It's immense, growing and evolving, but it's not centrally located. You need to do your homework. Broad discussion about the potential for a central repository and/or resource map for IN. Perhaps an opportunity for Conexus and Purdue MEP to collaborate?

Additive Use Cases Discussed:

- Complex products (high component count) with a long service life can pose a challenge with suppliers not being around long enough to support 20-25yrs product lifespan. Additive can address some of these "no source parts".
- Global operations in remote locations often do not have a robust ecosystem of 3rd party services and supply chain. Additive can be a way to address.
- Fixtures, jigs, and other production aids can be developed, innovated and iterated upon in collaboration with the production operators who ultimately make use of them. This is ideal for kaizen events that often lead to ideas for custom or special-use hardware. It might also helpful in situations where a production process is tailored for a customer.
- Situations where multiple design variations need to be physically tested and there is not enough time to serially develop tooling one at a time can lead to an expensive and wasteful process of producing multiple tools knowing that most will be failures. Additive can cut the iteration time and the cost.

<u>**Wrap-up**</u>

This was a pilot of the Conexus Peer-to-Peer concept. It was the first event held. The open question was whether it should be a 'one and done' format for this particular topic or if it should be a regular and standing working group. The general response was that it should be a standing discussion that grows participation and rotates to different host locations. Samtec and Cummins both indicated interest in hosting in the future.