Impacts of 3D Printing on Manufacturing and the Lubricants Industry

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Agenda

▪ A Bit of Historical Context
▪ Intro to 3D Printing
▪ 3D Printing’s Impact Today
▪ 3D Printing’s Impact Tomorrow
▪ Implications for the Lubricants Industry
▪ Closing
A Bit of Historical Context
We have previously experienced three industrial revolutions

First (1760-1830): Steam Machines

Second (1870-1914): Electricity, Oil, and Gas

We are in the midst of the Fourth Industrial Revolution

- Internet Connectivity
- Digitization
- Big Data Analytics
- Industrial Internet of Things

3D Printing is Industry 4.0's flagbearer, and the focus of our talk today
3D Printing is CAD-driven, layer-wise manufacturing process

**Steps:**
1. CAD-based 3D model
2. .STL file
3. Sliced layers
4. AM system
5. End-part finishing

**Final Product**

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3D Printing actually has a fairly long and storied history

1980s – SLA Invented
▪ Chuck Hull patents first “Stereo Lithography Apparatus”

2010s – Maker Movement
▪ Patents expirations empower the maker movement (and a lot of hype)

2020s – Production 3DP
▪ Rise of fast and production-viable machines
3D Printing is a catch all term used for a wide variety of distinct additive manufacturing processes.

- Powder Bed Fusion
- Binder Jetting
- Vat Photopolymerization
- Material Jetting
- Extrusion
- Sheet Lamination
- Directed Energy Deposition
- Cold Spray
3D Printers support a wide band of end product sizes

From the Micro...

...to the Macro

Size is no longer the restriction it once was
3D Printing technologies can process a wide variety of materials:

- Plastic
- Resin
- Silicone
- Sand
- Metal
- Ceramic
- Composites
- Concrete
3D Printing technology offers a number of key advantages over traditional manufacturing processes:

- Complexity is “free”
- Rapid iteration
- No tooling required
- Reduced waste
- Gradient material control
- Heavily automated
- Extreme design freedom including organic geometries
3D Printing falls short of traditional processes on a number of key dimensions

- Standards and design rules in development
- Layer-wise process will never be economically advantageous for many geometries
- Many systems don’t provide “production-level” reliability
- Pricier input material costs
- Incomplete material library
- Greater prevalence of anisotropic material properties
- Post-processing is the norm
3D Printing’s Impact Today
3D Printing is utilized today across the product lifecycle.

Prototypes

Production Parts

Tools

Replacement Parts
Prototyping was a natural fit for 3D Printing from the beginning

- Rapid design iteration
- No tooling costs
- Massively expedited product development timelines
3D Printed tooling is a common input to other manufacturing processes

- Custom jigs and fixtures
- End effectors
- Injection molding tool inserts
- Patterns for molds
- Localized problem solving, ergonomic enhancement, etc.

Image Credit: NIST, 3Diligent
3D Printing is increasingly used for on-demand replacement parts.

Wrenches in Space  
Trains in Germany  
Planes in LA*
3D Printing is used for production applications when the design calls for it.
While growing rapidly, 3D Printing still represents a small sliver of the global manufacturing market.

- 3D Printing market growth generally estimated in excess of 20%
- Metal 3D Printing growth in excess of 40% for 5 straight years

Source: 2019 Wohlers Report
Further regulatory guidance and standards development are necessary for widespread adoption to occur.
3D Printing’s Promise for Tomorrow
The rise of 3D Printing will bring about a significant degree of disruption, driving a reconstitution of the supply chain.

- Higher Performance
- Inventory Elimination
- Massively Bespoke Products
- Tightened Development Cycles
- Closer to the Customer
- Control Tower Management
Rise of light-weighted, higher performance products

Adidas Futurecraft Shoe

GM Seatbelt Bracket

Topological Optimization and Generative Design tools will contribute significantly to this advancement
Rise of massively bespoke products

Patient-Specific Orthotic Aligners

Player-Specific Helmet Liners

Image Credit: Smile Direct Club

Image Credit: Carbon, Riddell
Elimination of inventory carrying costs

UPS estimates from 3-8% of the $1.8T in inventory that US companies keep in stock will be transitioned to “Made to Order”
Steadily Faster Product Development Cycles

Product development time tables can be reduced on the order of 20-80%
Because each of these benefits is best realized by moving production closer to the end user, that’s what will happen:

- Minimal labor component moves production closer
- Additive production may be inserted at the assembly, dealer/distributor, or even end consumer levels
- Will give the appearance of a supply web vs. a supply chain
- Dynamic utilization, including connected third parties, provides elastic support for production
The combination of connected machines and data flows will lead to a rethinking of the supplier relationship

- Possibility of significant supplier consolidation as niche production is replaced by 3D Printing
- Dynamic utilization of connected devices will limit the supply-demand bullwhip effect
- In this way, the operating model for supply chain management may more closely resemble a control tower
Implication for the Lubricants Industry
Some disruption to machining operations providing high “buy-to-fly” ratio parts

- Potentially adverse impact to certain machining operations
- Such customers can mitigate impact by handling post-process machining of near-net printed parts
- More commonly, displacement will be to traditionally cast or injection molded low volume parts
Consolidation of sub-assemblies for printing may cause significant disruption to manufacturers of those parts

- Bias toward consolidation of smaller parts due to 3D Printing's "free complexity"
- Suppliers providing products that are easily reverse engineered may face an increased threat

Image Credit: GrabCAD
Surface smoothing slurries may unlock a key application for 3D printing to achieve its potential.

Traditional vs. Printed Conformal Cooling

Rough As Printed Finish Typical for Metal

Enabling smooth internal passageways is a major pain point impacting this “killer app” for 3D Printing.
Significant expansion of specialty resin demand may provide an opportunity for adjacent growth

- Polyurethanes featured prominently in high speed resin systems
- Opportunities for additives may exist to enhance material properties
Closing
We are in the midst of the Fourth Industrial Revolution, defined by **connectivity and big data**

3D Printing – which embodies this shift – is a catch-all term describing a **diverse set of layer-wise manufacturing processes**

3D Printing’s impact is currently felt **across the product lifecycle**, although the range of production applications it supports is still fairly narrow

As companies embrace the design freedom and related performance gains of 3D Printing, the **supply chain impacts will be significant**

Advances in 3D Printing will **directly impact lower volume casting and injection molding** more than machining, although **consolidation may impact customer mix**
Questions?

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Thank you!