Trends in the Use of Additive Manufacturing in Investment Casting

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MUELLER ADDITIVE MANUFACTURING SOLUTIONS

AM in Investment Casting

27 years since 3D introduced the QuickCast build style

Using printed patterns has become the standard method for creating prototype investment castings

One of the most successful and least known applications of additive manufacturing

In spite of success, applications limited to prototype patterns, bridge production, very low volume production

Emerging trends may signal coming changes

Trends in AM in Investment Casting

New Printing Technologies

- Traditional
  - QuickCast (SLA)
  - Castform (SLS)
  - Projet Wax (Material Jetting)
  - Voxeljet (Binder Jetting)
- New printing Technologies
  - Material Extrusion
  - Digital Light Processing

Material Extrusion

Also known as Fused Deposition Modeling

- Initially developed by Stratasys
- Low end industrial printers
- Material is a filament
- PLA or variation for investment casting
- Several manufacturers

Manufacturers

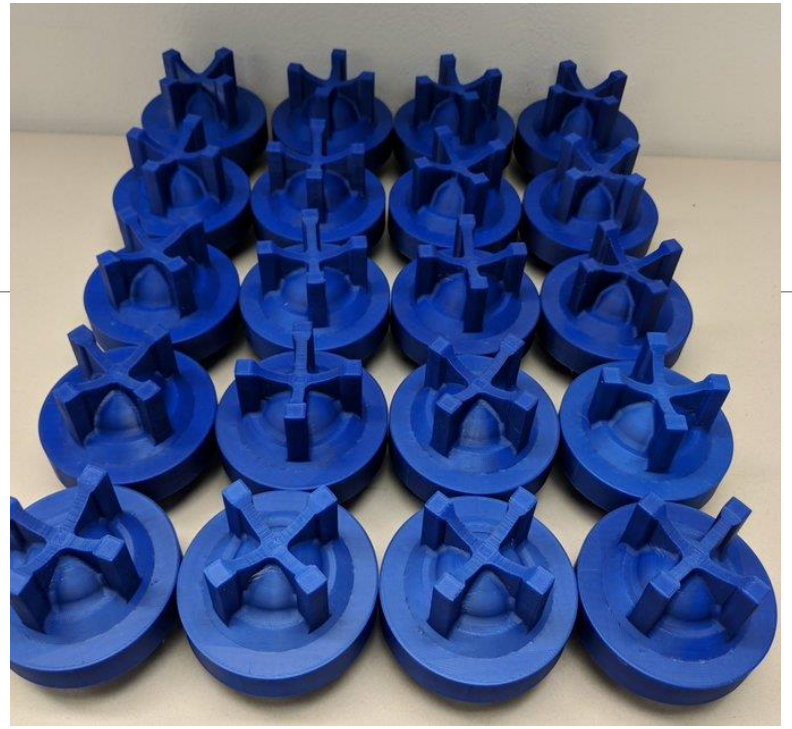
- Ultimaker
- Plural
- Stacker
- Cosine Additive
- Raise 3D
- Konica Minolta
- Big Rep
- Fusion 3
- Titan Robotics

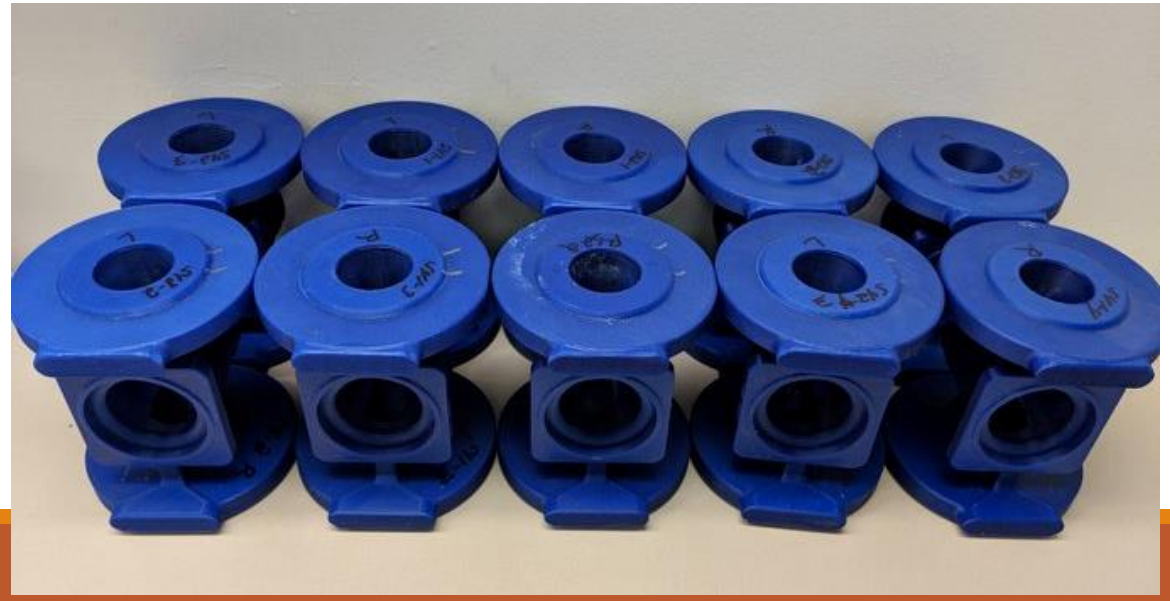
Material Extrusion Printers

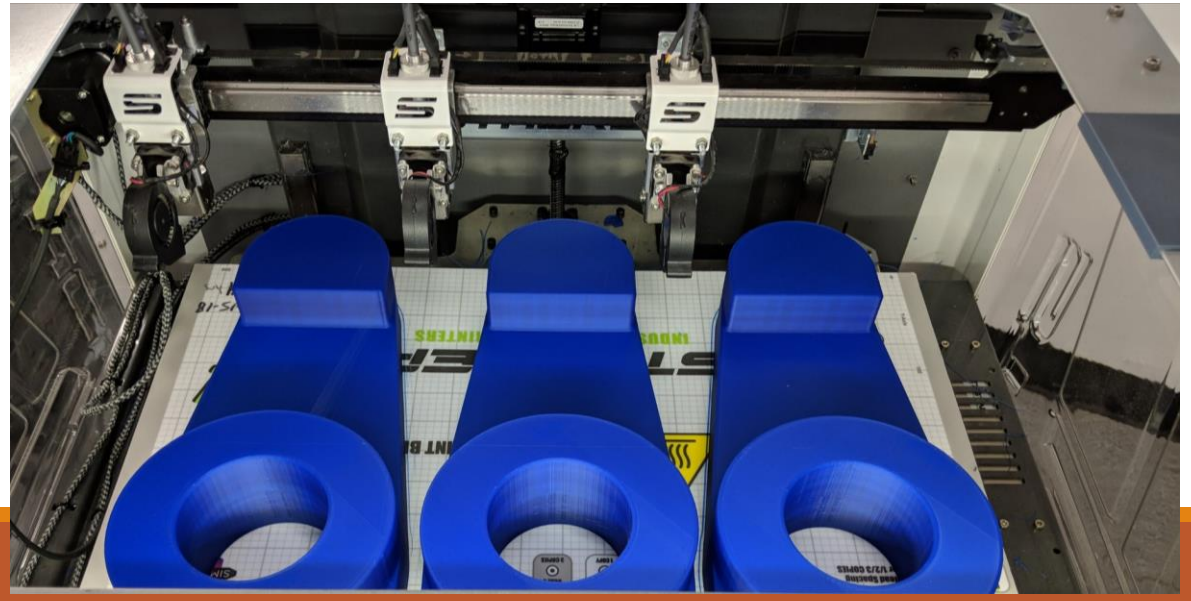
- Wide range of build enveolopes
- Some use pellets
- Some have multiple heads to print multiple copies simultaneously
- Some print multiple materials

PLA Patterns

Photos Courtesy of Spectra 3D







Digital Light Processing

Similar to stereolithography

- Instead of laser, uses digital projector
- Cures entire layer at once
- Significantly faster
- Builds upside down

Manufacturers

- Envisiontec
- Formlabs
- Carbon
- Figure 4 from 3D Systems
- Intrepid Automation

DLP Investment Casting

Trends in AM in Investment Casting

New Printing Technologies

Lower Printer Cost

Manufacturer	Model	Cost
3D Systems	ProX 800	$400,000
3D Systems	Projet 2500IC	$70,000
Voxeljet	VX1000	$800,000
Stacker	S4	$12,000
Cosine AM	AM1	$72,000
Ultimaker	S5	$6,000
Titan Robotics	Atlas 2.0	$24,000
Formlabs	3L	$10,000

Lower Printer Cost

- No special facilities
- Limited accessory equipment
- No special power requirements
- Reduced operator skill level
- Significant reduction in exposure to hazardous materials

Trends in AM in Investment Casting

New Printing Technologies

Lower Printer Cost

Faster Printer Speeds

DLP as much as 50 times faster than SLA

Material extrusion not faster, but with lower cost of printers, can use multiple printers

Trends in AM in Investment Casting

New Printing Technologies

Lower Printer Cost

Faster Printer Speeds

Easier to Cast Materials

- Inkjet printed wax from 3D
- Material extrusion is thermoplastic material – will melt
- Improved photosensitive resins
  - Antimony free
  - Lower Ash

Trends in AM in Investment Casting

New Printing Technologies

Lower Printer Cost

Faster Printer Speeds

Easier to Cast Materials

Improved Casting Process

- Reduced cracking in autoclave
- Improved burnout procedures

Trends in AM in Investment Casting

New Printing Technologies

Lower Printer Cost

Faster Printer Speeds

Easier to Cast Materials

Improved Casting Process

Automated Post Processing

- All AM processes require post processing
  - Drain uncured resin from inside pattern
  - Remove supports
  - Smooth surface
- Manual post processing adds
  - Cost
  - Time
  - Dimensional error
  - Part to part variation
- Automated post processing systems being developed

Post Processing Technologies

Vapor Polishing

Zortrax Apoller

Trends in AM in Investment Casting

New Printing Technologies

Lower Printer Cost

Faster Printer Speeds

Easier to Cast Materials

Improved Casting Process

Automated Post Processing

Printer Automation

All current AM printers are batch printers

If the operator is not around when the job finishes, nothing is printed until he starts the next job.

Inevitably, some jobs finish in the middle of the night and no printing is done until someone comes in

If job swap time averages 3 hours, 12,5% of available time is not printing

If job swap time averages 6 hours, 25% of time is not printing.

Formlabs Automator


Dynasty
MASS PORTAL
Dynasty
ADDITIVE MANUFACTURING SYSTEM

Mass Portal

Trends in AM in Investment Casting

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Printer Automation

Tooling Applications

- IC Process Tooling
  - Setters
  - Inspection Fixtures
  - Inspection Gauges
  - Machining Fixtures
  - Wax Pattern Molds

- Many of these may be made with 3D printing
- Advantages
  - Lower Cost
  - Faster Response

What Will These Trends Lead to?

Foundry purchase of AM equipment

- No foundry is going to spend half a million dollars for a printer that supports 2% of their revenues
- But they might spend $10k
- Advantages
  - Reduced pattern costs
  - May be faster than going to a service provider
  - Not subject to service provider backlog
  - Data security

What Will These Trends Lead to?

Foundry purchase of AM equipment

Increased use for tooling applications

- Setters
- Prototype Pattern Dies

What Will These Trends Lead to?

Foundry purchase of AM equipment

Increased use for tooling applications

Ability to cast complex geometries

Growing interest in generative design and topology optimization

Design technologies used to redesign components to save weight without sacrificing strength

Often can reduce weight 50% or more

New designs are usually not moldable

Of great interest to weight sensitive industries

- Commerical aircraft
- Defense
- Automotive

What Will These Trends Lead to?

Foundry purchase of AM equipment

Increased use for tooling applications

Ability to cast complex geometries

Increased use for production

Why Aren’t Printed Patterns Used for Production?

- ✓They are too expensive
- ✓They are too slow
- ✓Insufficient quality
- ✓Too hard to cast

Will Trends Make Production More Likely?

Trend	Expensive	Slow	Quality	Castable
New Printing Technologies	✓	✓		
Lower Cost Printers	✓	✓		
Faster Print Speeds	✓	✓		
Easier to Cast	✓			✓
Improved Casting Process	✓	✓		✓
Automated Post Processing	✓	✓	✓	
Printer Automation	✓	✓		
Tooling Applications				

Trends

New Printing Technologies

Lower Printer Cost

Faster Printer Speeds

Easier to Cast Materials

Improved Casting Process

Automated Post Processing

Printer Automation

Tooling Applications

Predicted Results

Foundry purchase of AM equipment

Increased use for tooling applications

Ability to cast complex geometries

Increased use for production

Thank you!

Questions?