SKULD

A Platform Technology for faster, cheaper, better metal parts

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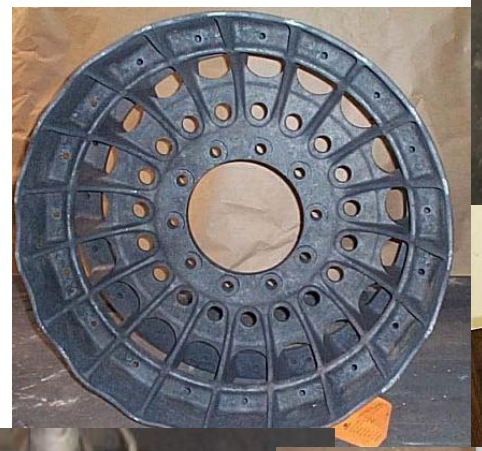
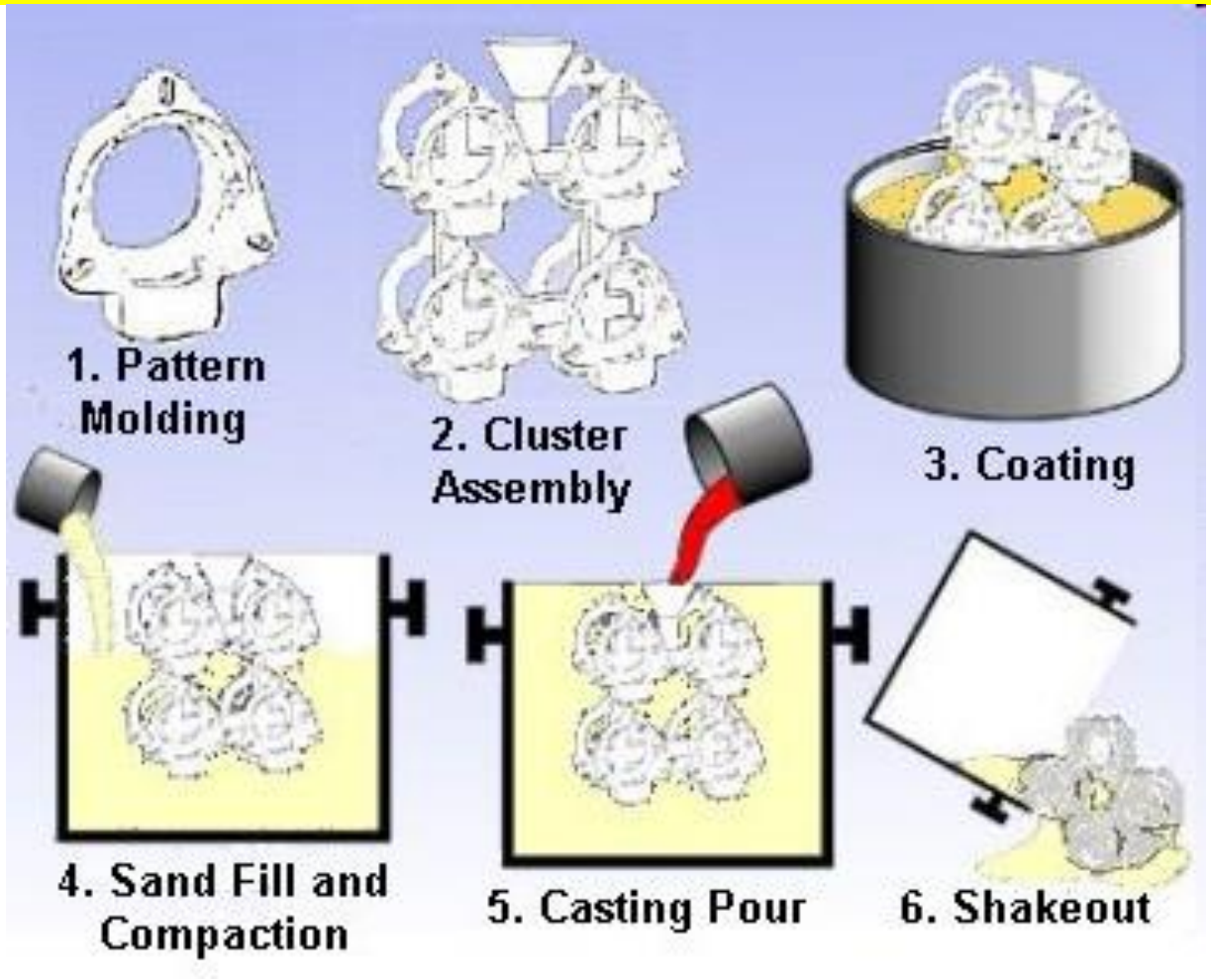
PROBLEM: LOST FOAM CASTING IS MOST EFFICIENT CASTING METHOD BUT UNCOMMON

Key Point: Reduces lost wax investment casting process time from 3 weeks to less than 1 day. But requires tooling to injection mold foam. Tooling issue led to use in only ultra high volume use cases.

Examples





SOLUTION – MACHINE FOAMS
MCDONALD STEEL RAPID REPLACEMENT GEAR

- Steel rolling mill built in 1926 (US Steel)
- Main drive gear failed in 2009, entire plant down
- No Spare
- No CAD (actual paper prints)
- Gear 24” diameter, 4 inch thick
- 120 lbs., 1060 steel
- Lead time to obtain steel and machine it: 12 weeks
- Reverse Engineered and Delivered: 4 days
- Net/near net shape: Gear teeth accurate as cast, ground bore slightly
- Still in use as of March 2022

NEW SOLUTION: ADDITIVE MANUFACTURING EVAPORATIVE CASTING (AMEC)

Polymer 3D Printing

Lost Foam Investment Casting

Burning a Biopolymer

Achieve Replica Part

AMEC COMPARISON TO ALTERNATIVES

Eliminates time and cost of Tooling

10X Better Accuracy Than Sand Casting, including printed sand

10X Faster Than Investment Casting, including additive version

10X+ Cheaper Than Direct Additive Manufacturing

Significantly easier to Qualify Known Cast Materials

OVERVIEW OF AMEC PROCESS

3D print the desired shape's surface in a plastic.

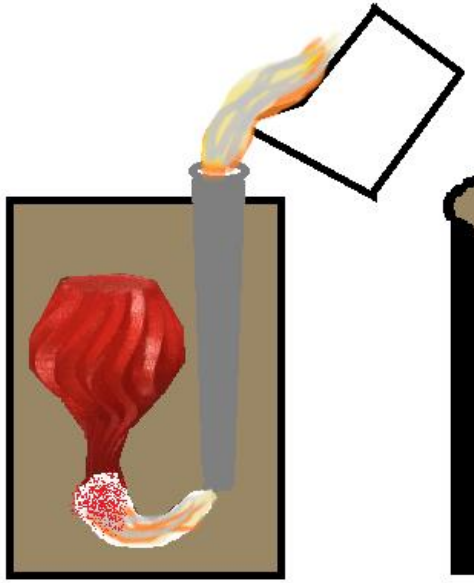
Superheated metal is poured on it to vaporize it similar to lost foam casting.

Solidify and leave behind a metal replica.

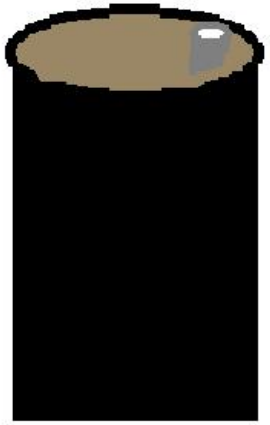
Print PLA &
Glue to foam Gating

Apply Ceramic
Coating

Melt Metal



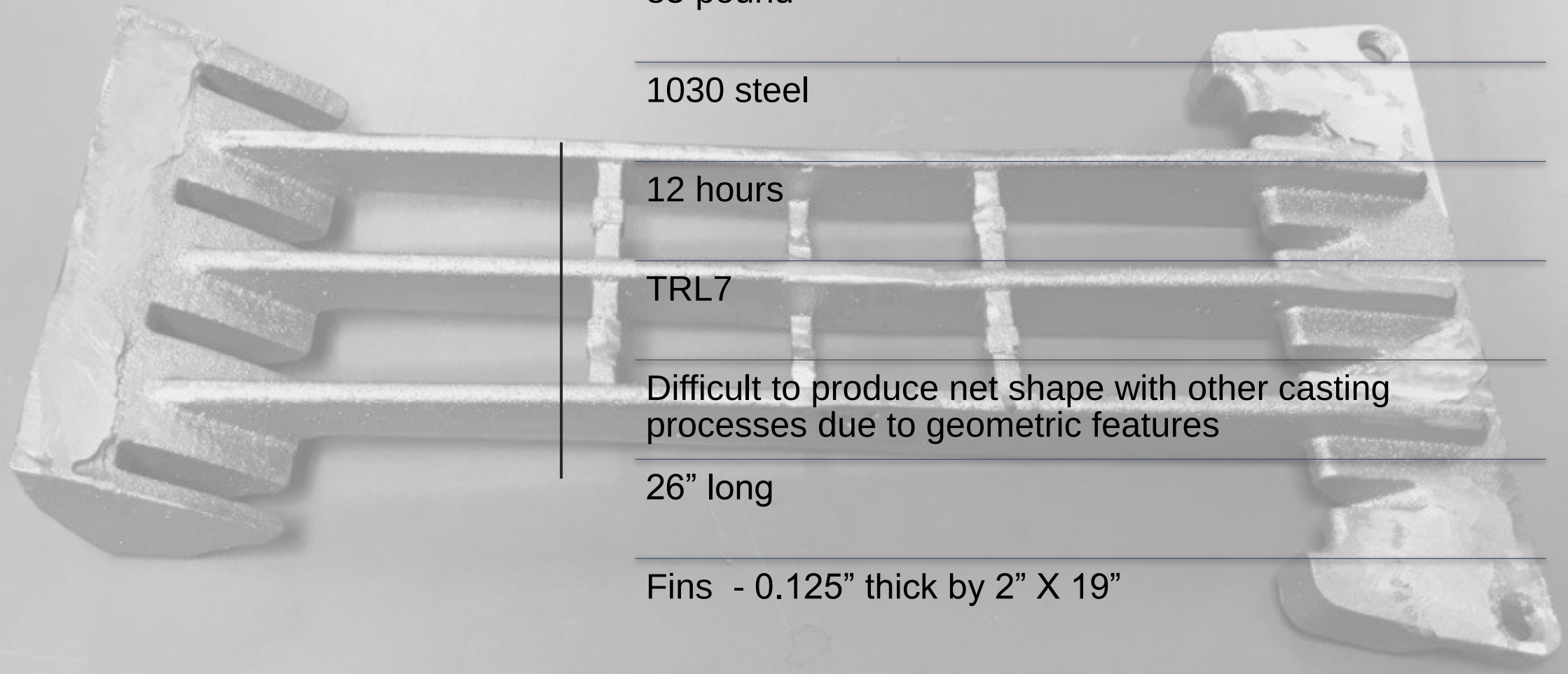
Pack in Loose Sand &
Pour Metal to Vaporize PLA
(Cutaway View)



Allow to Cool
& Solidify

Obtain Metal Replica
same shape as PLA

Case Study: Boat Industry Prototype Stomp Grate



85 pound

1030 steel

12 hours

TRL7

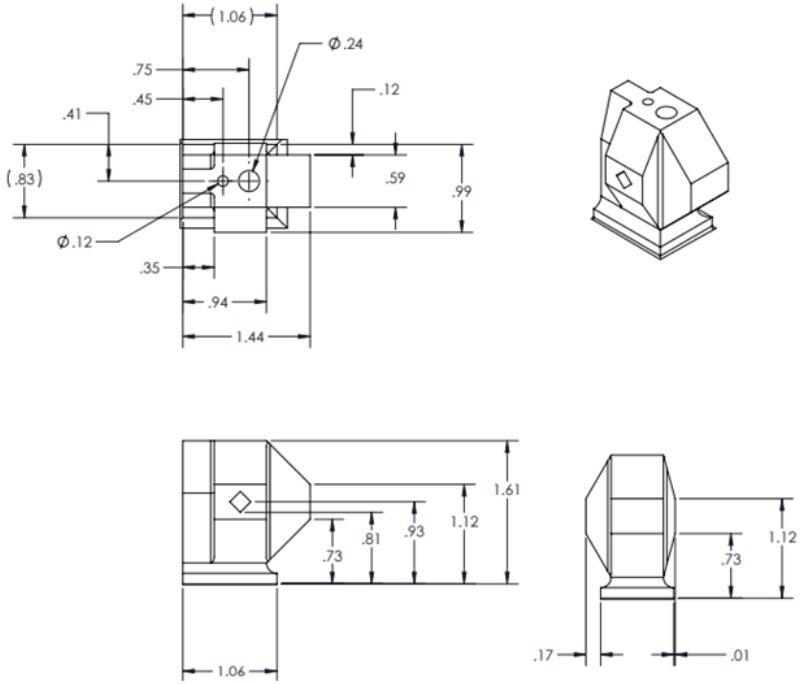
Difficult to produce net shape with other casting processes due to geometric features

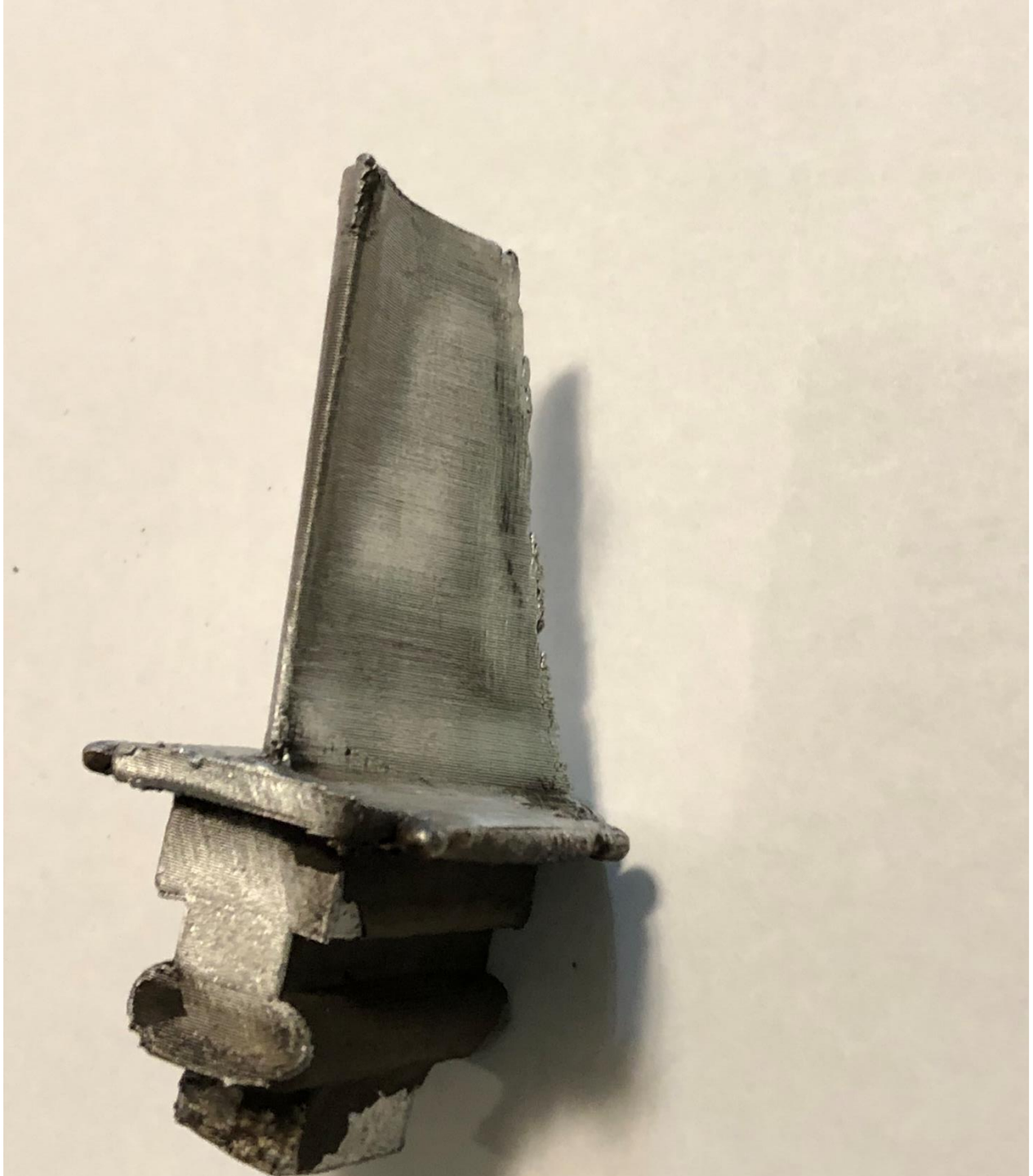
26” long

Fins - 0.125” thick by 2” X 19”

US Air Force Rapid Sustainability Office's 2020 Advanced Manufacturing Olympics

- AlMag 35, no heat treat needed
- Overhangs
- Fins as thin as 1mm
- 0.125" through hole
- Made in 13 hours
- Made with $180 desktop printer





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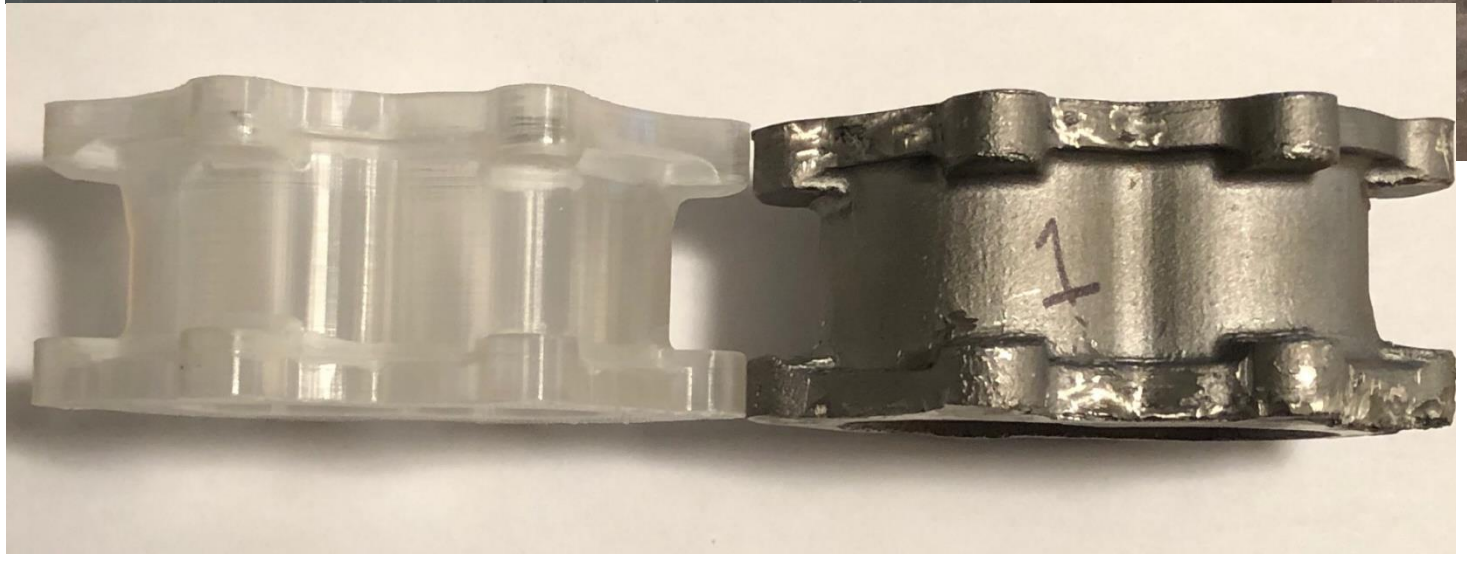
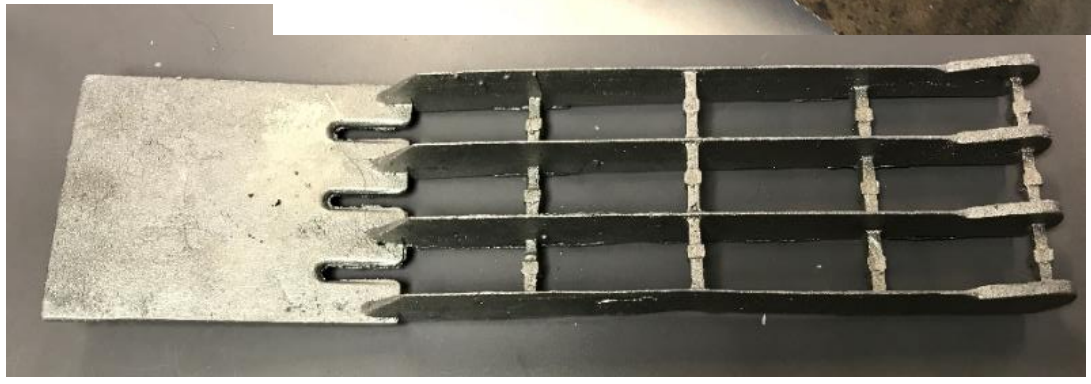
Example Parts





AMEC PROCESS NOT TO BE CONFUSED WITH TRADITIONAL INVESTMENT CASTING

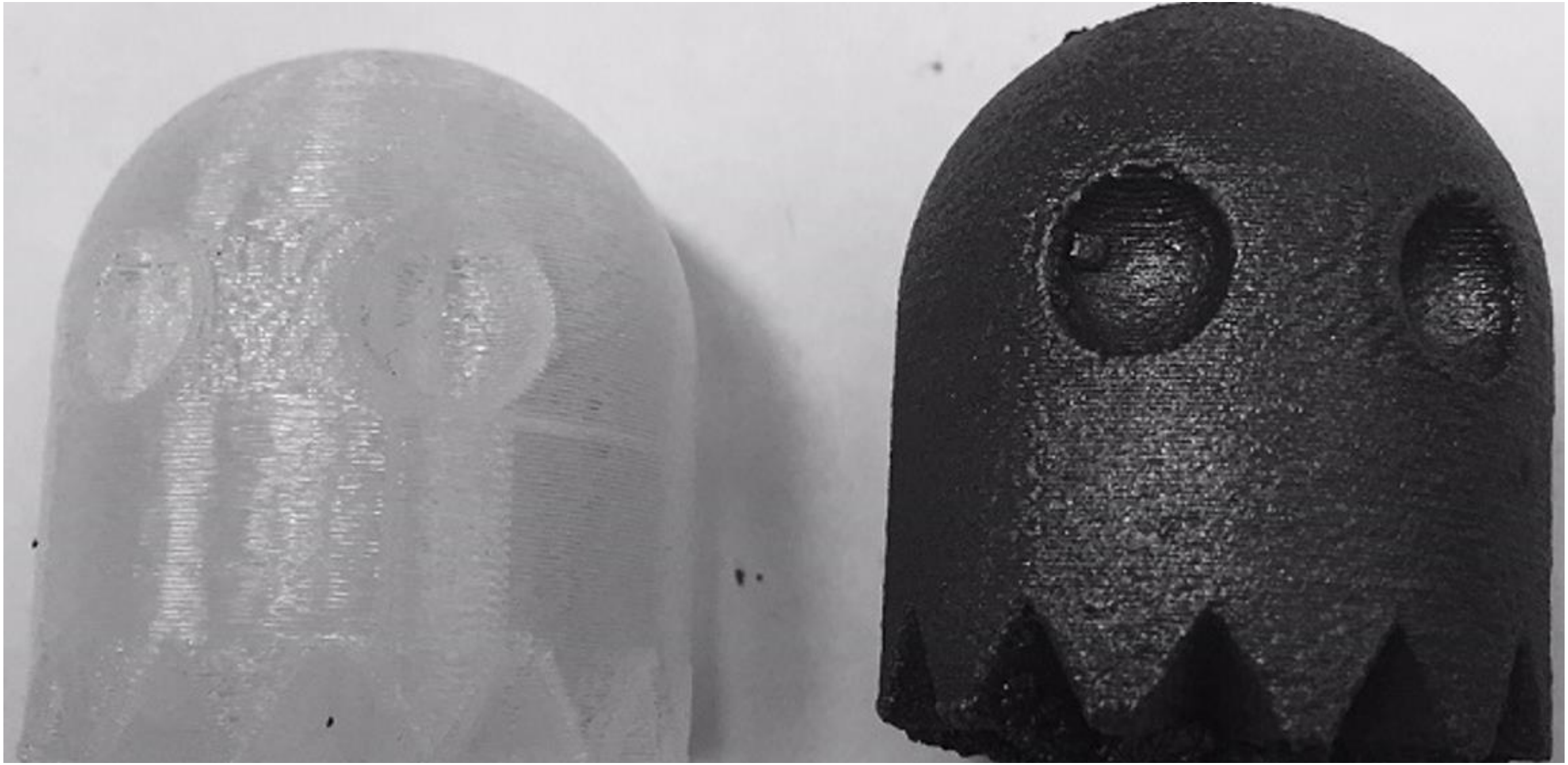
Lost Wax/Lost PLA/Lost Print

- Thick Investment ~0.25”
- Multiple layer investment w/ drying steps
- Burn out step
- Preheat mold step
- Removal of coating step
- Free standing mold
- Hollow mold
- Tolerances: as good as 0.2%
- Process time takes ~2-3 weeks

LFC/AMEC Differences

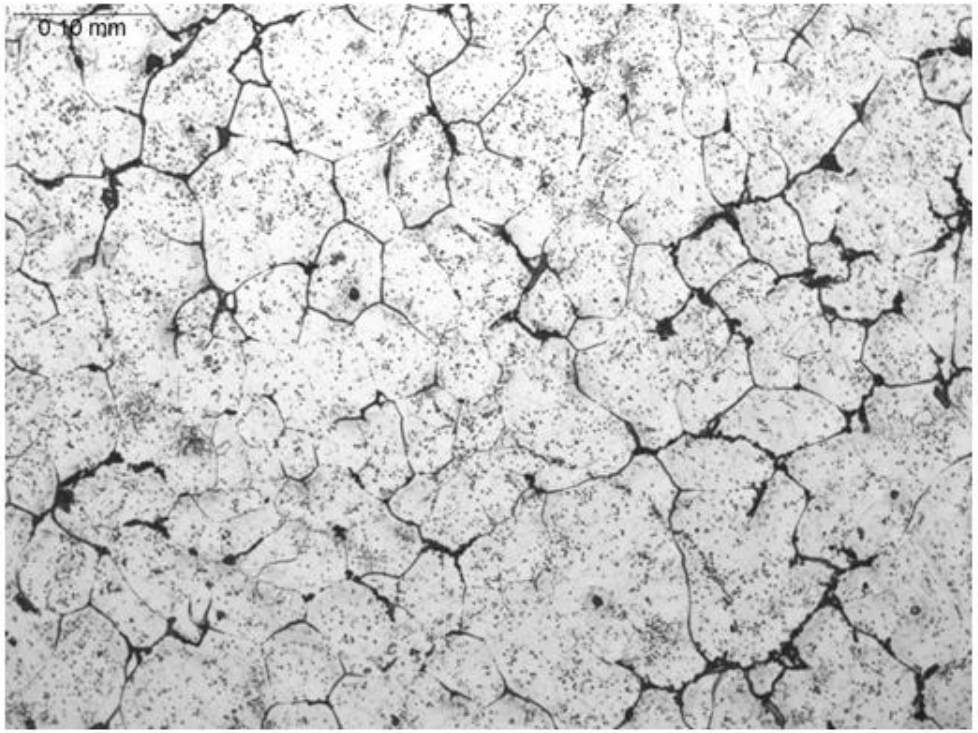
- Thin investment ~0.003”
- 1 Layer
- No burn out
- No preheating
- Coating just falls off
- Compacted in fluidized bed of sand/beads
- Full mold
- Tolerances: as good as 0.3%
- Process time as little as 12 hours

WYSIWYG: EXAMPLE OF DETAIL CAPABILITY



Who Cares: Qualification is Key

Aluminum 535.0 (aka Almag 35)
Traditional Casting



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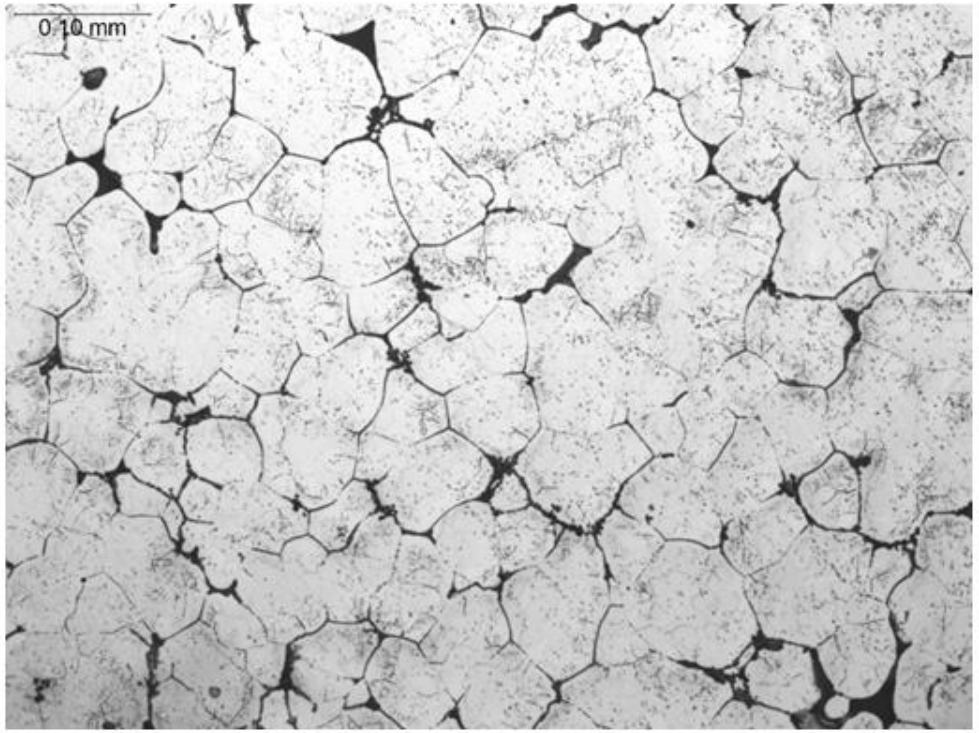
AMEC



Key Point: AMEC Provides known materials with known properties making qualification faster.

AMEC Alloy Capabilities

Trials Done

Grey Iron – All Standard Grades
Ductile Iron – All Standard Grades
Steels – 1030, 1040, 1060, 8620, Blak OX
Stainless Steel 304, 316
Aluminum A356, A535 (aka Almag 35)
Brass – C844
CP Copper
Commercially pure (CP) Copper

Current R&D

A356 and A535
Stainless 316L
Inconel 713c, 625, & 718

Current Inquiries & Planned Trials

4340 steel
416 Stainless
Invar
Kovar

Likely Feasible

All cast irons (grey, ductile, white, malleable, CGI)
Most steel alloys
Copper alloys including brass and bronzes
Aluminum cast alloys
Some Nickel cast alloys
Normally vacuum melted materials may be feasible but have properties somewhat less due to oxidation during melting/casting

Likely Not Feasible

Titanium
Magnesium
Very Low Carbon Steels (<0.015%)
VIM-VAR Steels

FOR MORE INFORMATION

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