TriTech
TITANIUM PARTS

Opening The Door To PM

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TriTech Titanium Parts LLC
Detroit, Michigan

Powder Met2023 AMPM 2023
JUNE 18–21 • CAESARS PALACE • LAS VEGAS

TriTech Personnel

The Authors…… two people involved.

Robert Swenson is the CEO at TriTech Titanium Parts. Robert is a 46-year veteran of the metals industry. With experience in HSLA, superalloys, specialty metals, and titanium. Robert was a graduate of Purdue University in Metallurgical Engineering and Harvard Business School with a MBA. The TriTech business includes 3D Binderjet Printing, Metal Injection Molding, and Investment Casting. TriTech is in Detroit, Michigan.

Victor Villarini is Engineering manager at TriTech. Victor is a mechanical engineer from Wayne State University and has worked with all three TriTech processes. He has developed TriTech into a skilled work center for net shape titanium parts.

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BJP and MIM Titanium

Opening the Door to PM ……

How BJP Creates Opportunities for Powder Metallurgy for Titanium.

The binderjet printing process is gaining interest for many PM applications. There is not any startup cost to look at a new part. Parts can be designed and printed to fit any application. The binderjet process can produce very complex shapes like lattice structures and internal passageways. In these cases, the binderjet process will be the best and lowest cost method of production, as unique products are being produced that cannot be otherwise achieved (except for PBF which is more expensive). Another path is to use the binderjet process to prototype parts that can eventually become high volume. When volumes get great enough there is a cost advantage to switch to metal injection molding. The economic factors include part cost for each technology, tooling cost for metal injection molding, and the transition point for switching from printing to molding. Often the base case for the part is to be machined, and maybe from a different material like stainless steel or aluminum. The presentation will look at two examples of development and the benefits of each technology.

TriTech Overview

- TriTech Titanium Parts was formed on April 5, 2022.
  - A spin-off from AmeriTi Manufacturing Company.
  - Located in Detroit, Michigan. ISO 9001:2015 Certified.
  - The production operations of the “parts business” started in 2015.
- TriTech’s business plan offers three technologies for the customer.
  - Investment Casting.
  - Metal Injection Molding.
  - Binderjet Printing. First production scale printer. Desktop Metal P1.
- All three processes produce Net Shape Parts.
  - There is a best technology for each part and each customer.
- Markets.
  - Industrial equipment, hand tools, and firearms.
  - Oil and gas, underwater, medical, and aerospace.

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Discussion Topics

- Technology Review.
- Process Cost.
- Positives and Negatives and Trade – Offs.
- Conclusions.

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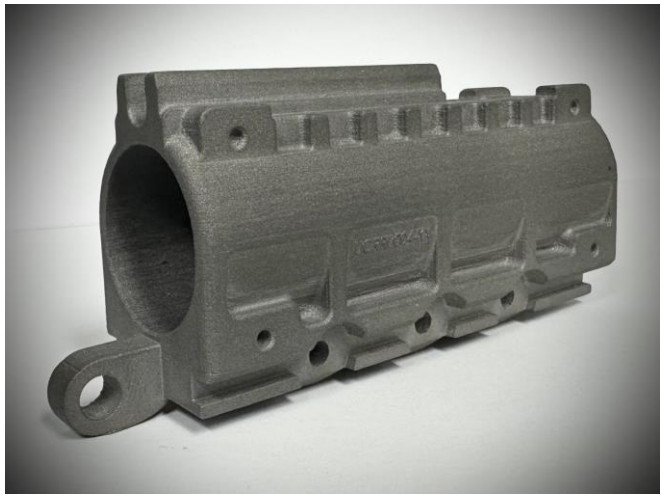
Metal Injection Molding



Capability

- Titanium Alloys … Grade 5 (64) and Grade 2 (CP).
- Tolerances … +/- 0.5% (or better) … or +/- 0.001” or .002”.
- Up to 250 grams.
- Complex shapes, but limited to injection.

Metal Injection Molding

- Injection
- Solvent De-bind
- Thermal De-bind
- Sinter

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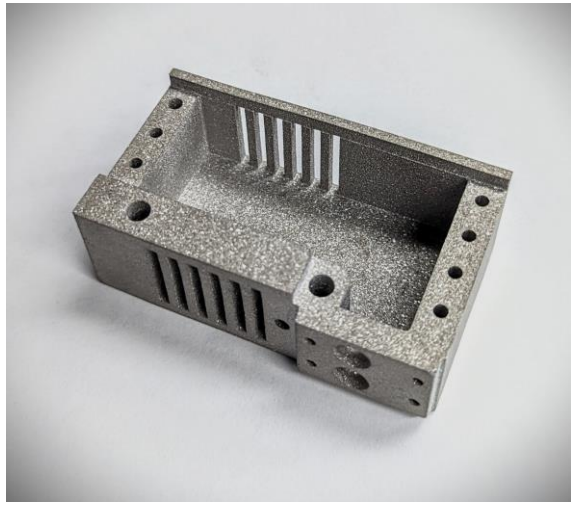
Binderjet Printing



Capability

- Titanium Alloys … Grade 5 (64).
- Tolerances … +/- 1% (or better) … or +/- .005” to .007”.
- Up to 500 grams.
- Complex shapes … lattice structures and internal passages.

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Binderjet Printing

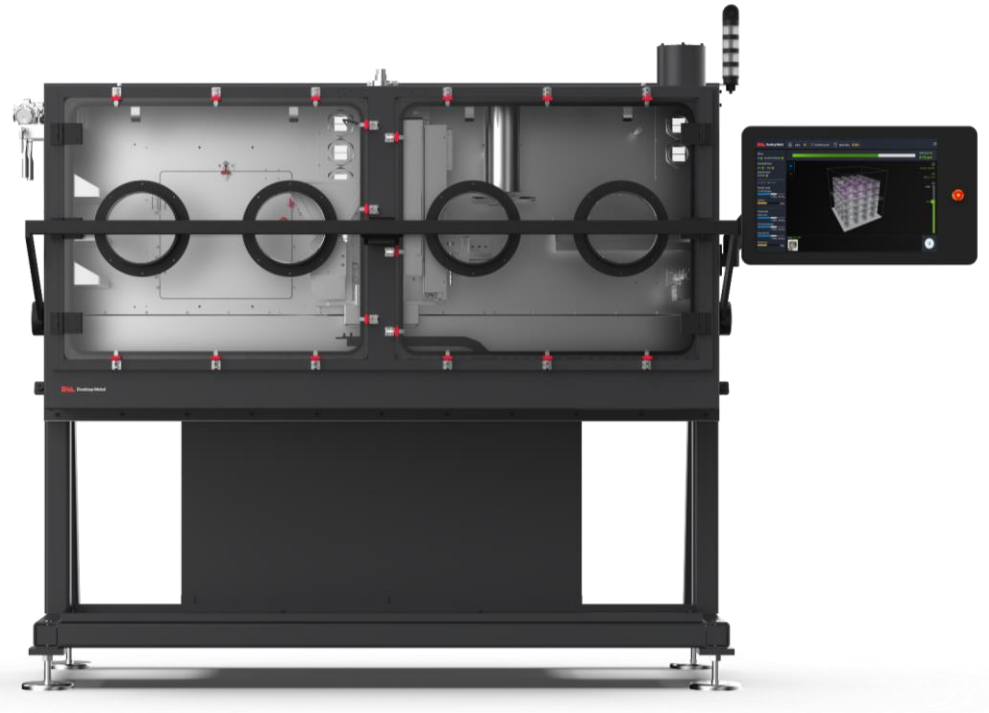
Binderjet Printing

Printing

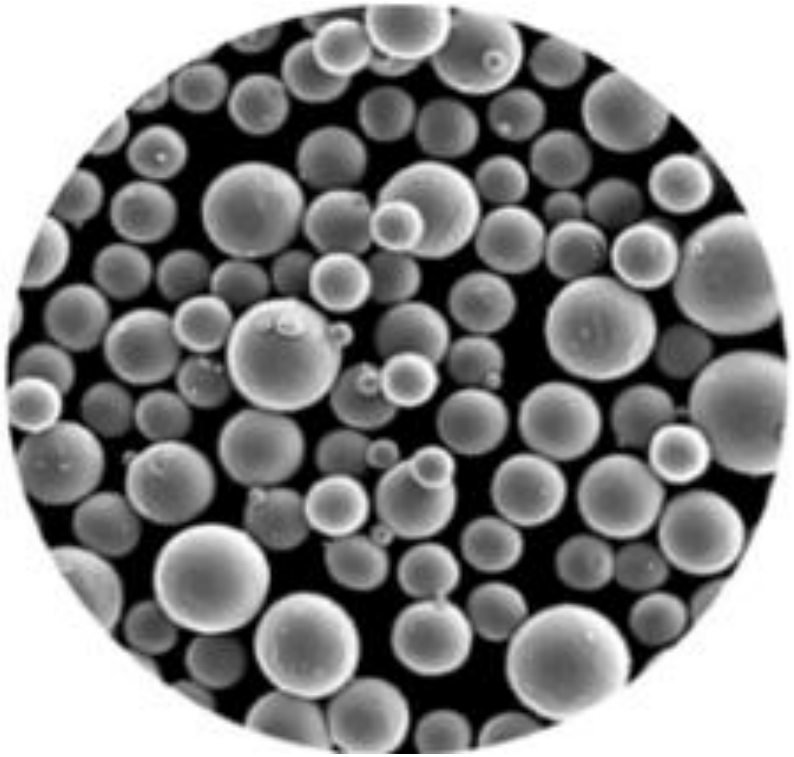
Curing

De-powder

Sinter

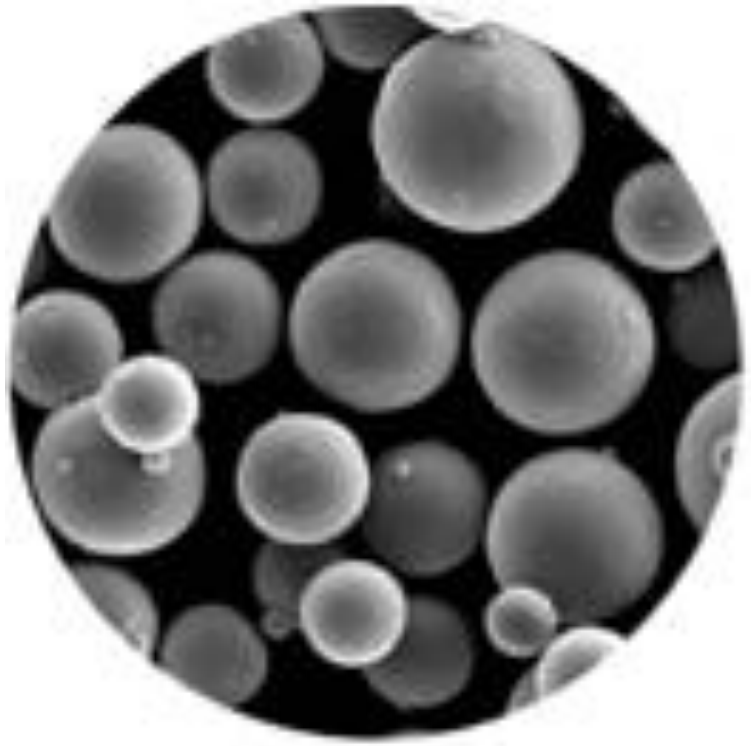


Spherical Ti Powder



SMALLER

- 25 um x down
- Higher O_2
- Higher density
- Smoother surface



LARGER

- 45 um x down
- Lower O_2
- Lower density
- Rougher surface

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Properties – Ti 64

As-Sintered	MIM	BJP	ASTM F2885 (MIM)
Tensile Strength (MPa)	950	950	896
Yield Strength (MPa)	925	925	827
% Elongation	**11**	**10**	10
Density (g/cm³)	99 %	96/97%	4.42
C	.03 to .05%	.06 to .08%	.08%
O_2	.17 to .23%	.19 to .25%	.20%
After HIP	**MIM**	**BJP**	**ASTM F2885 (MIM)**
% Elongation	**14**	**13**	10
Density (g/cm³)	100 %	100 %	4.42

- Elongation and density are dependent on the sintering cycle.
- HIP always helps!

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Cost Discussion

For the next slides ….. Comparison of MIM and BJP.

- The binderjet work has been performed on a Desktop Metal P1.
- Low volume is defined as < 5,000 parts per year.
- High volume is > 5,000 parts per year.
- Today ……. BJP does not have a robust high-volume process.
  - Needs larger build box for productivity (increase part density).
  - Needs higher green strength for de-powdering.
  - Needs higher green strength for yield (reduce broken parts).
- In the next slides, the high-volume LOW-cost figures for BJP assume the issues are solved.
- There are alternative technologies with larger build box size and higher green strength, but then there are C and O_2 problems.

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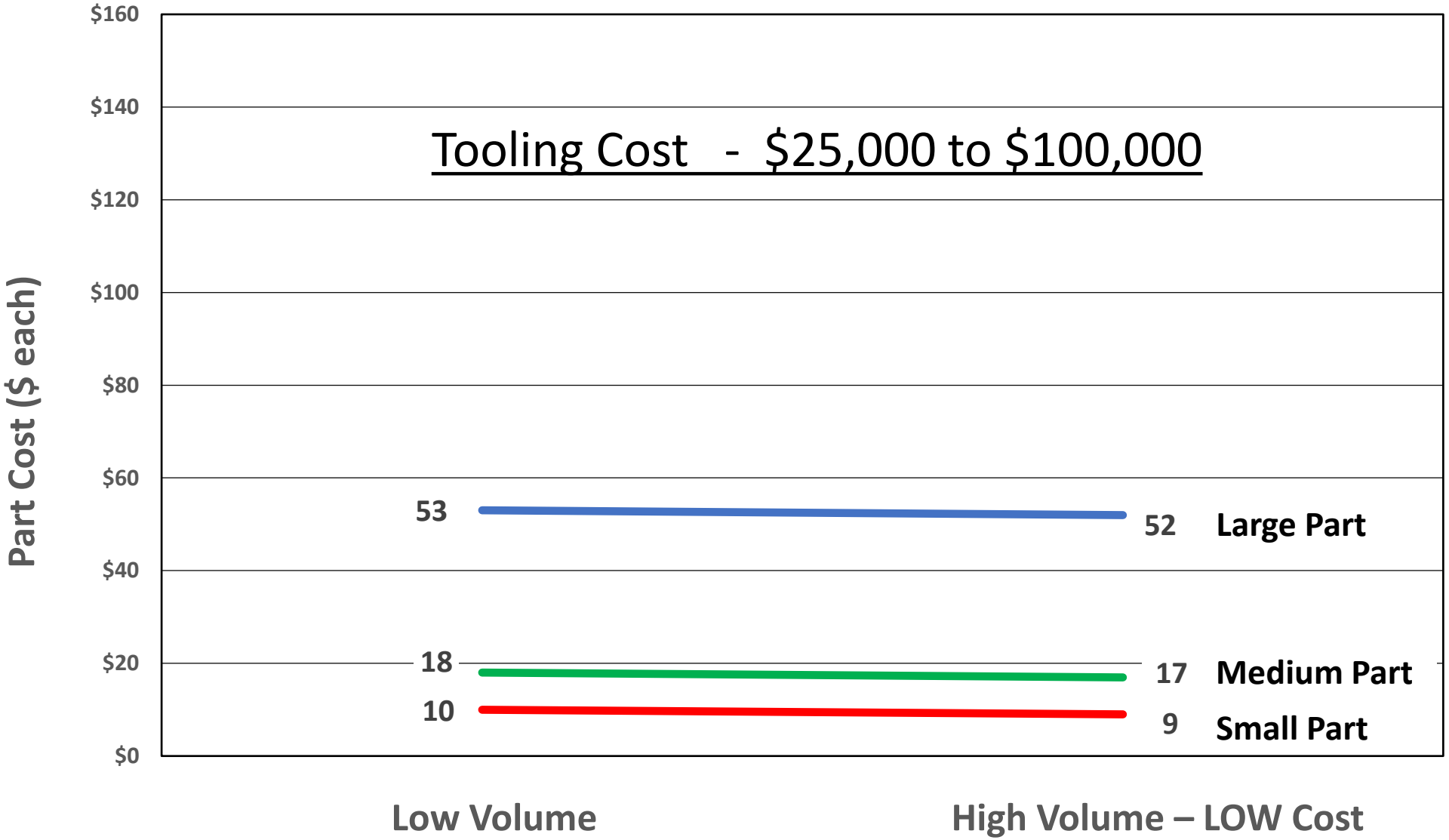
Process Cost – MIM



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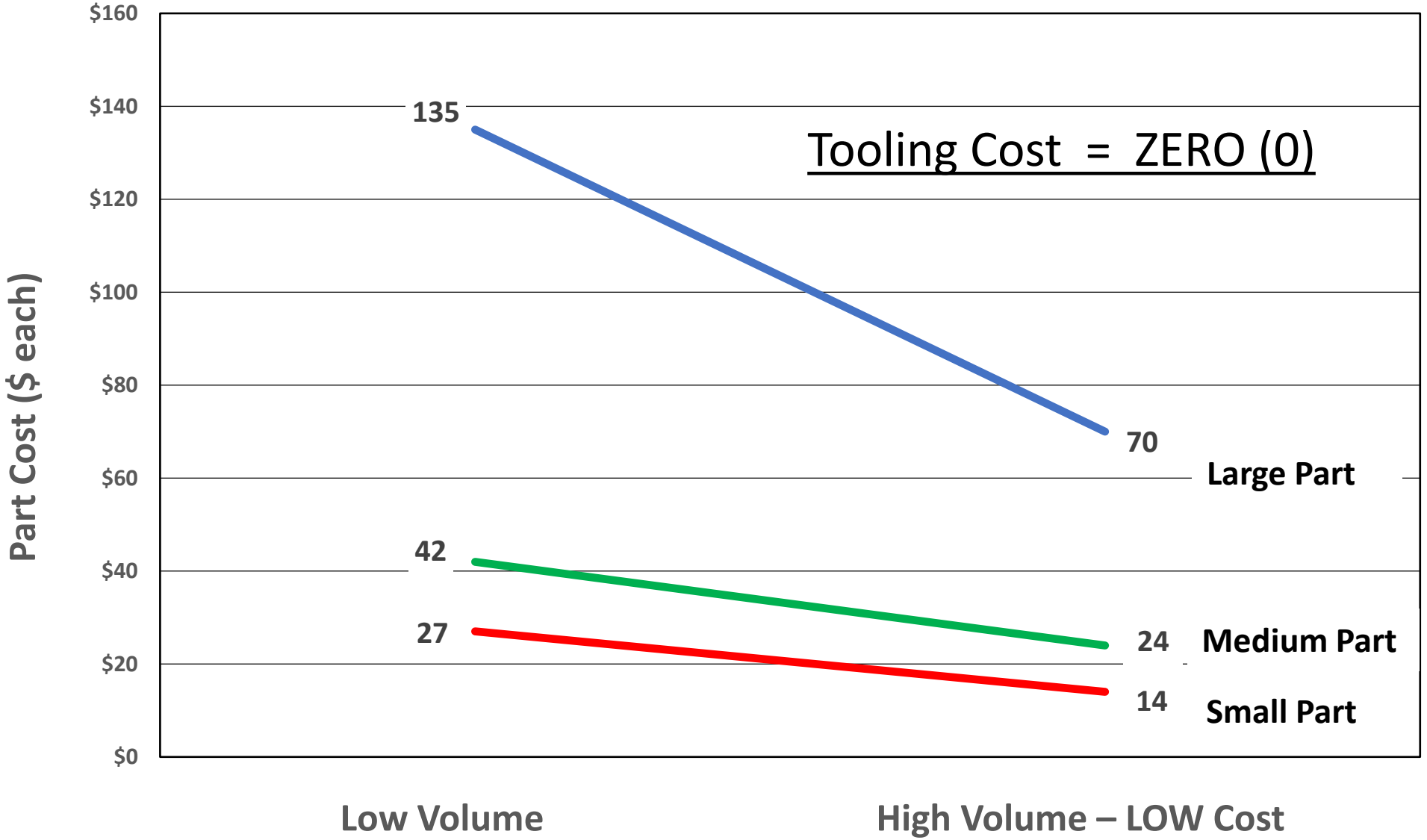
Process Cost – BJP



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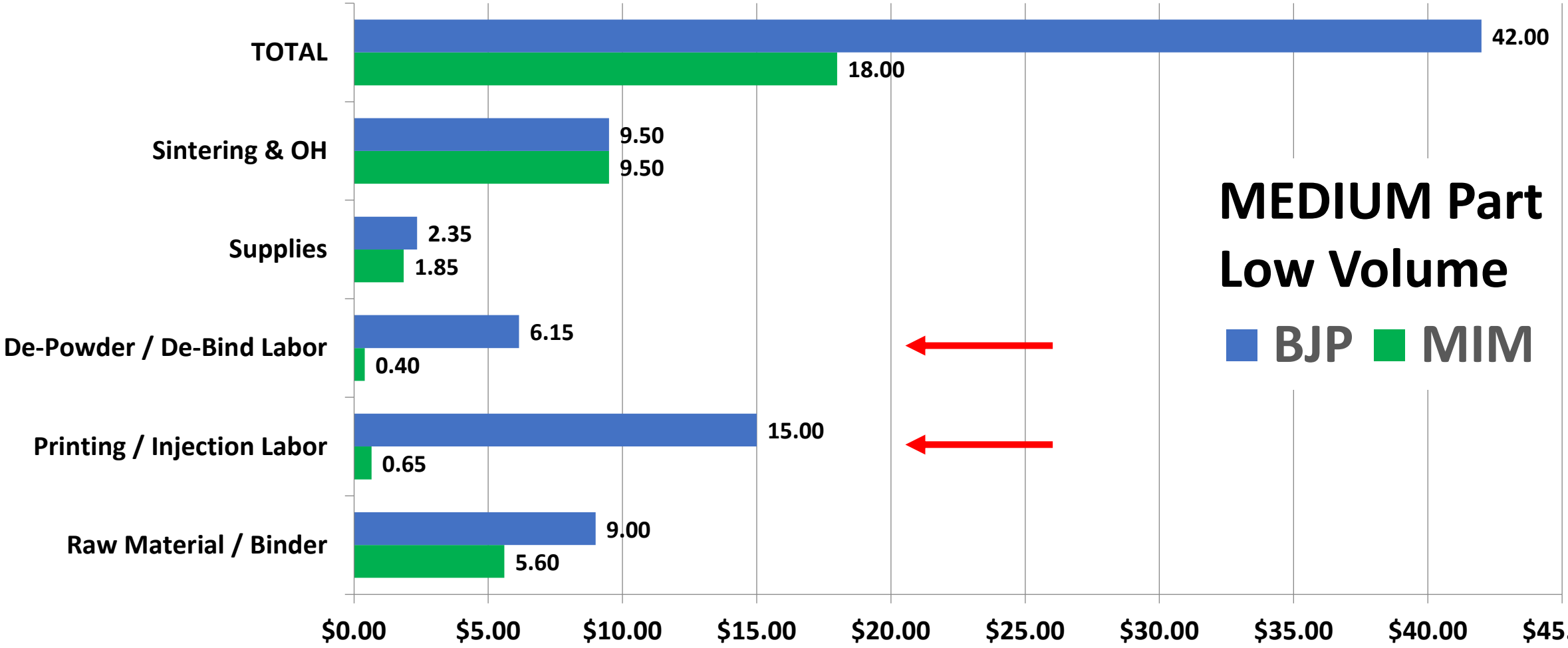
Process Cost – BJP vs. MIM



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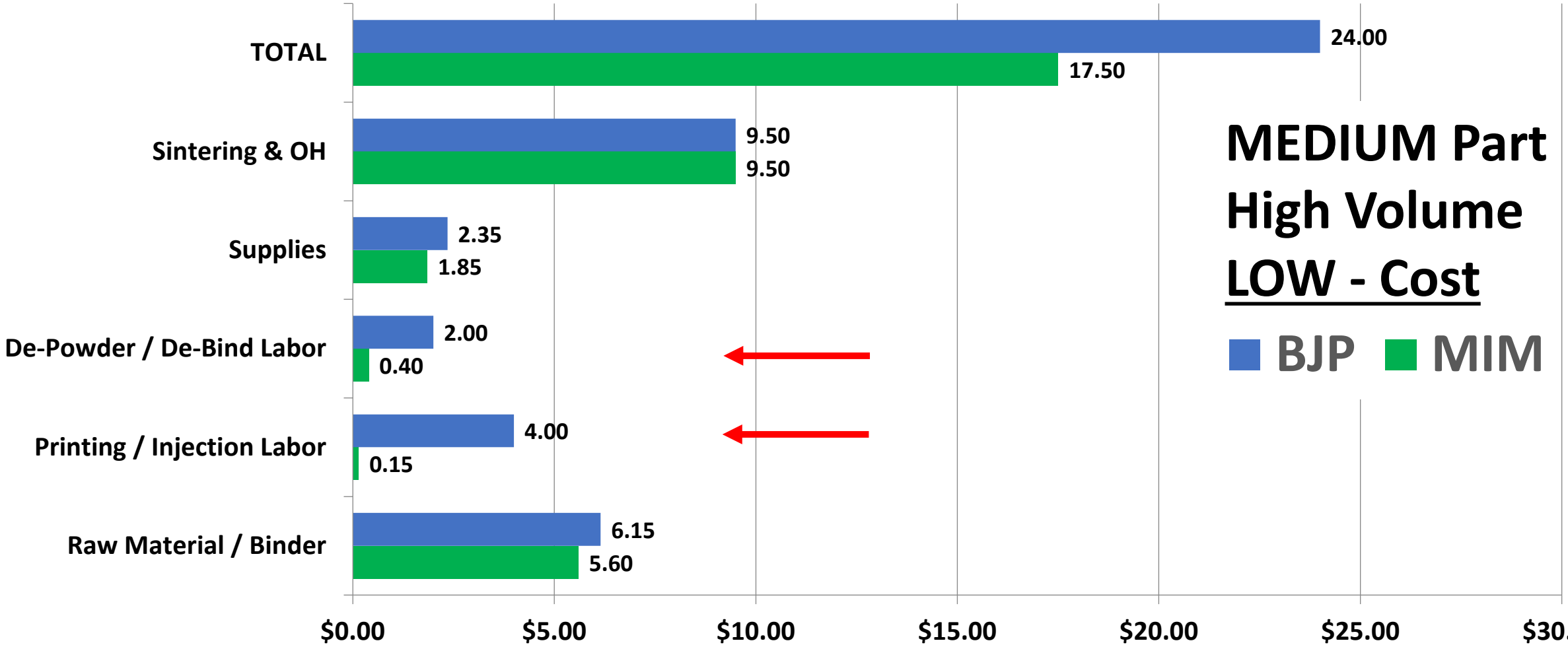
Process Cost – BJP vs. MIM



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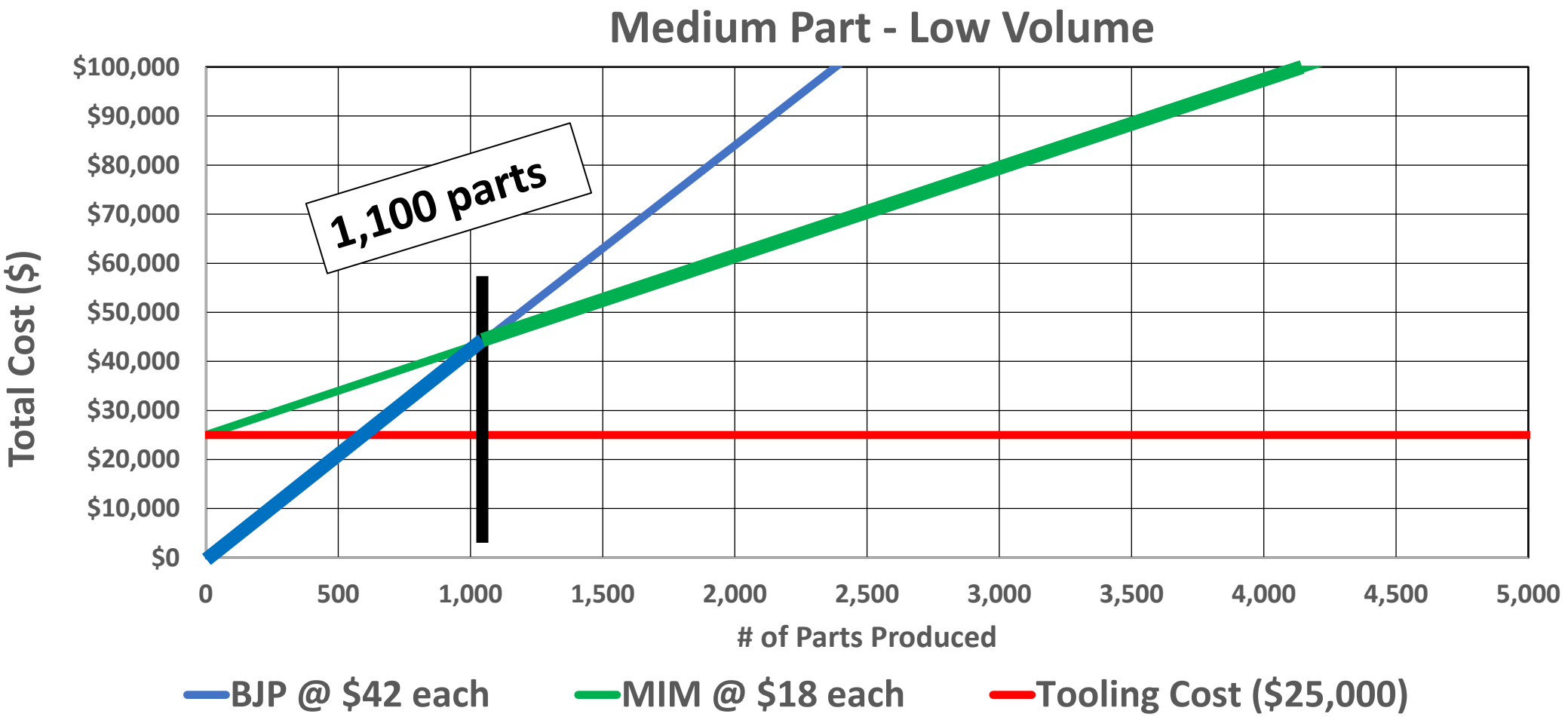
MIM Tooling Payback



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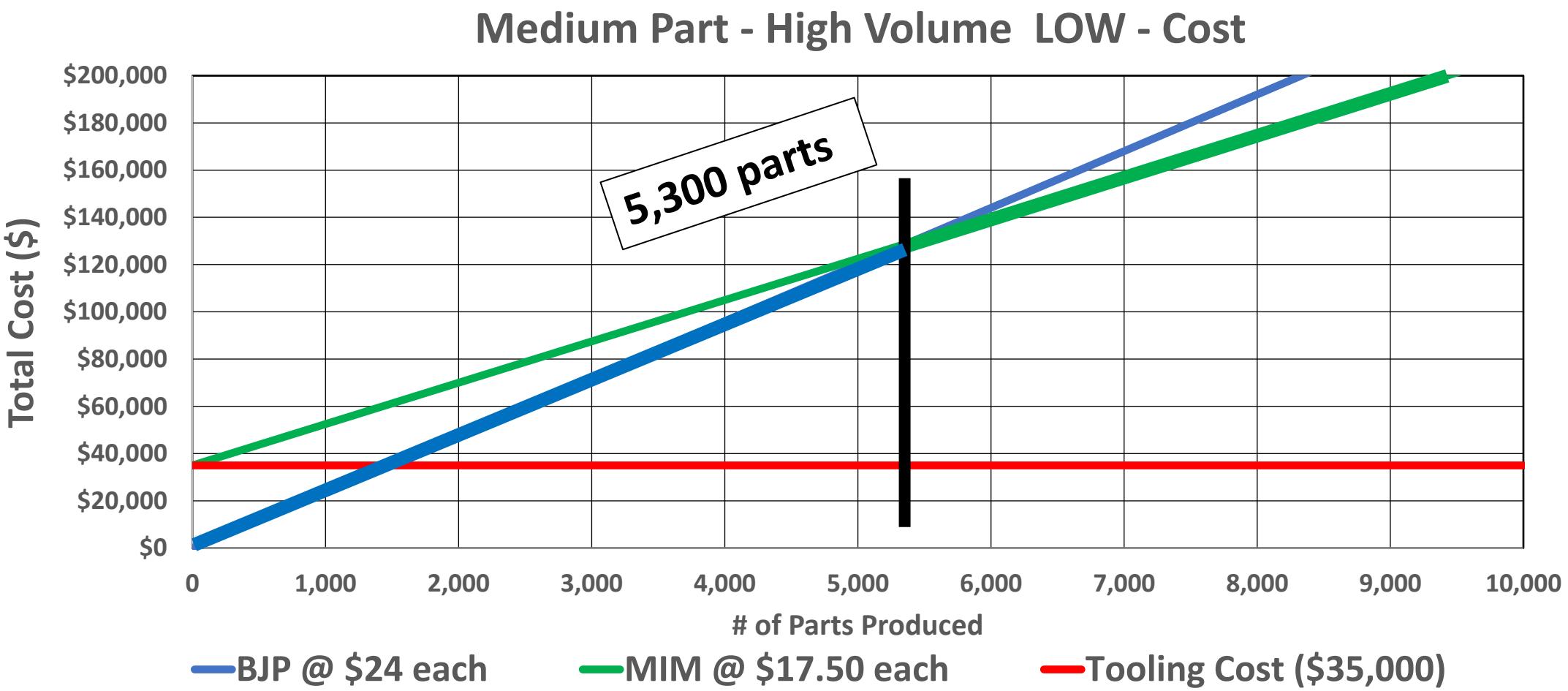
MIM Tooling Payback



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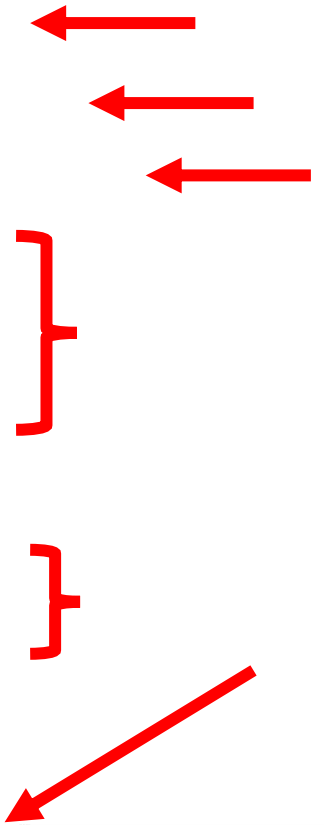
MIM and BJP Comparison

	Metal Injection Molding	Binderjet Printing
Sintered Density	99%	96%
Surface Roughness (Ra)	.6 um	6 um
Green Strength	20 MPa	5 MPa ***
Part Cost	1.00	1.5 to 2.5X
Tooling Cost	$$$	-0-
Tooling Lead Time	Long	-0-
Design Changes	$$$	-0-
Shrink Rate	14%	19%
Lattice Structures	N	Y
Internal Passages	N	Y
XYZ variation	N	Y (limited)
Chemistry	Y	Y
Mechanical Properties	Y	Y



*** There are higher green strengths, but in turn higher O_2 and C.

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MIM Summary

- Stable and well-developed process.
  - Surface.
  - Tolerances.
  - Repeatability.
  - Mechanical Properties.
  - Chemistry.
- Low part cost.
- Offset by high tooling expense and long lead time.
- Some restrictions with part complexity.

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BJP Summary

- Commercial production is 9 months old. Still developing……
  - Surface.
  - Chemistry and Properties.
  - Repeatability.
- BJP cost improvements **will come** from ……. reducing labor.
  - Larger build box = higher part density (better productivity).
  - Greater green strength = faster de-powdering.
  - Greater green strength = higher yields (fewer broken parts).
- Immediate startup with -0- tooling expense and lead time.
- Great for prototype work … and … Great for lower volumes.
- Freedom for complex shapes. Parts that cannot be MIM or machined.

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Conclusions

The Door is Wide Open for BJP and MIM for PM Applications .

- MIM is the winner with precision and low part cost ….. but expensive tooling.
- BJP is the winner with -0- investment for tooling.
- Also the winner for part complexity and customization.
- BJP will make the technical improvements and reduce cost. Developing technology.
- Larger part size is the next challenge for MIM and BJP because of shrink and distortion when sintering;
- Fusion processes will have their place for larger parts.
- MIM and BJP have the advantage of a stress-relieved finished part and lower cost.
- Net shape parts by PM are the best!

Thank You

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