ABBOTT FURNACE

Advancements in Continuous Processing of Soft Magnetic Composites

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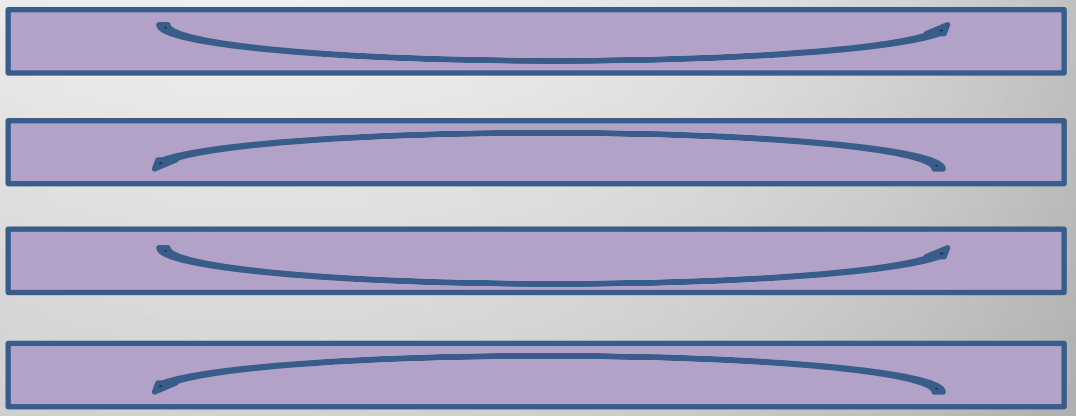
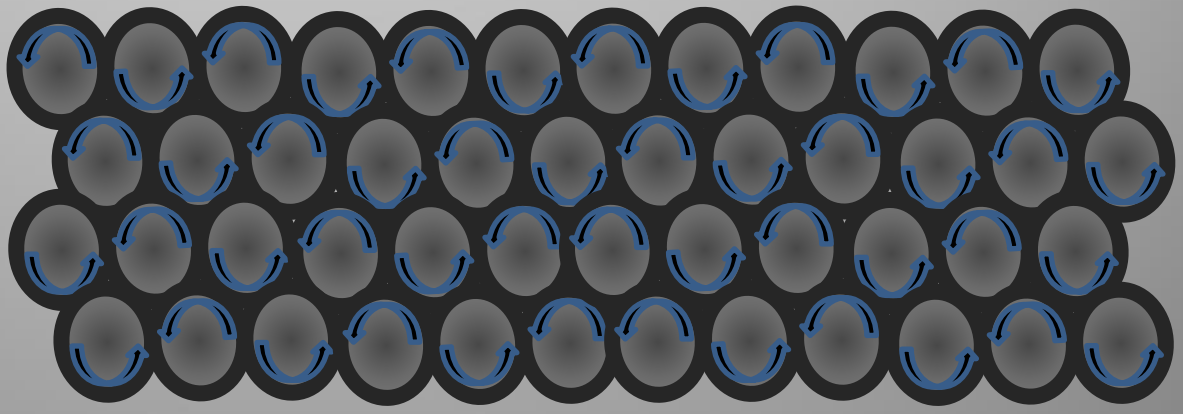
Abbott Furnace Company

Soft Magnetics

Conventional Steel Plates

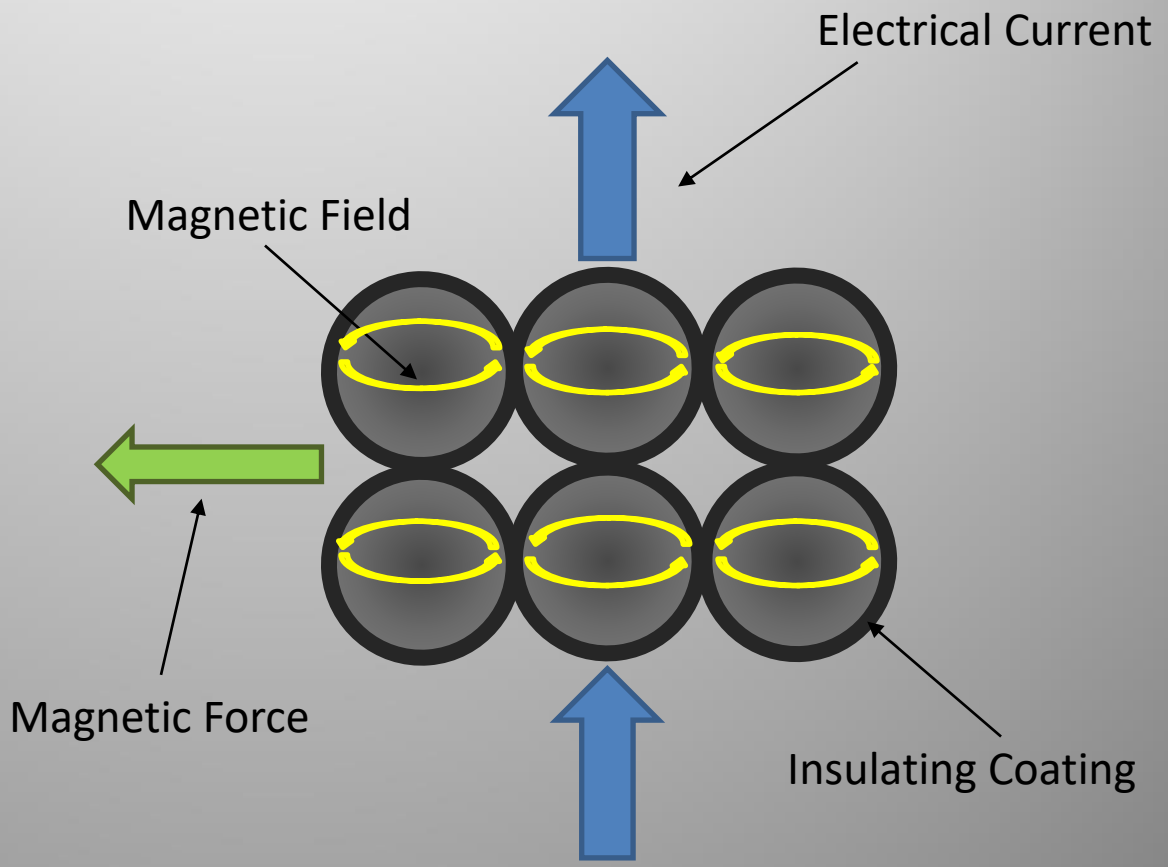


Soft Magnetic Composite



An Insulating Coating

- Most Common Soft Magnetic Composite Coating…. Iron Oxide (Somaloy 3P)

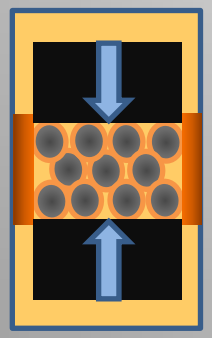


Keys to Success

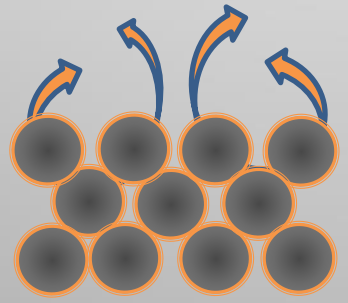
- High Density
- Very Homogeneous Insulating Coating Around the Particles

Soft Magnetic Composite Process

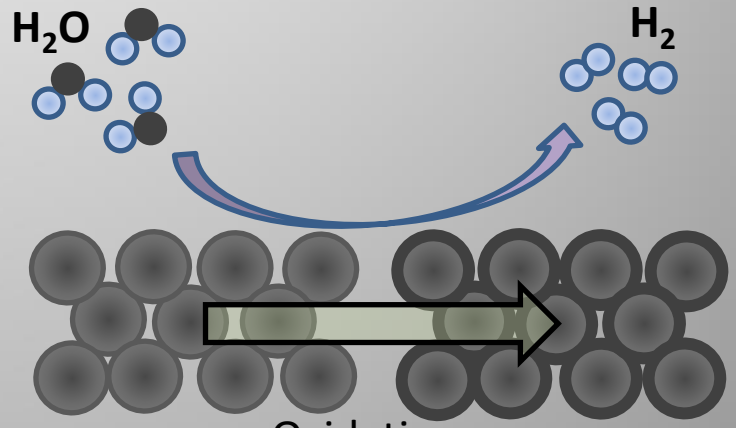
- Oxidation of Particle to Form Coating



Warm Compaction



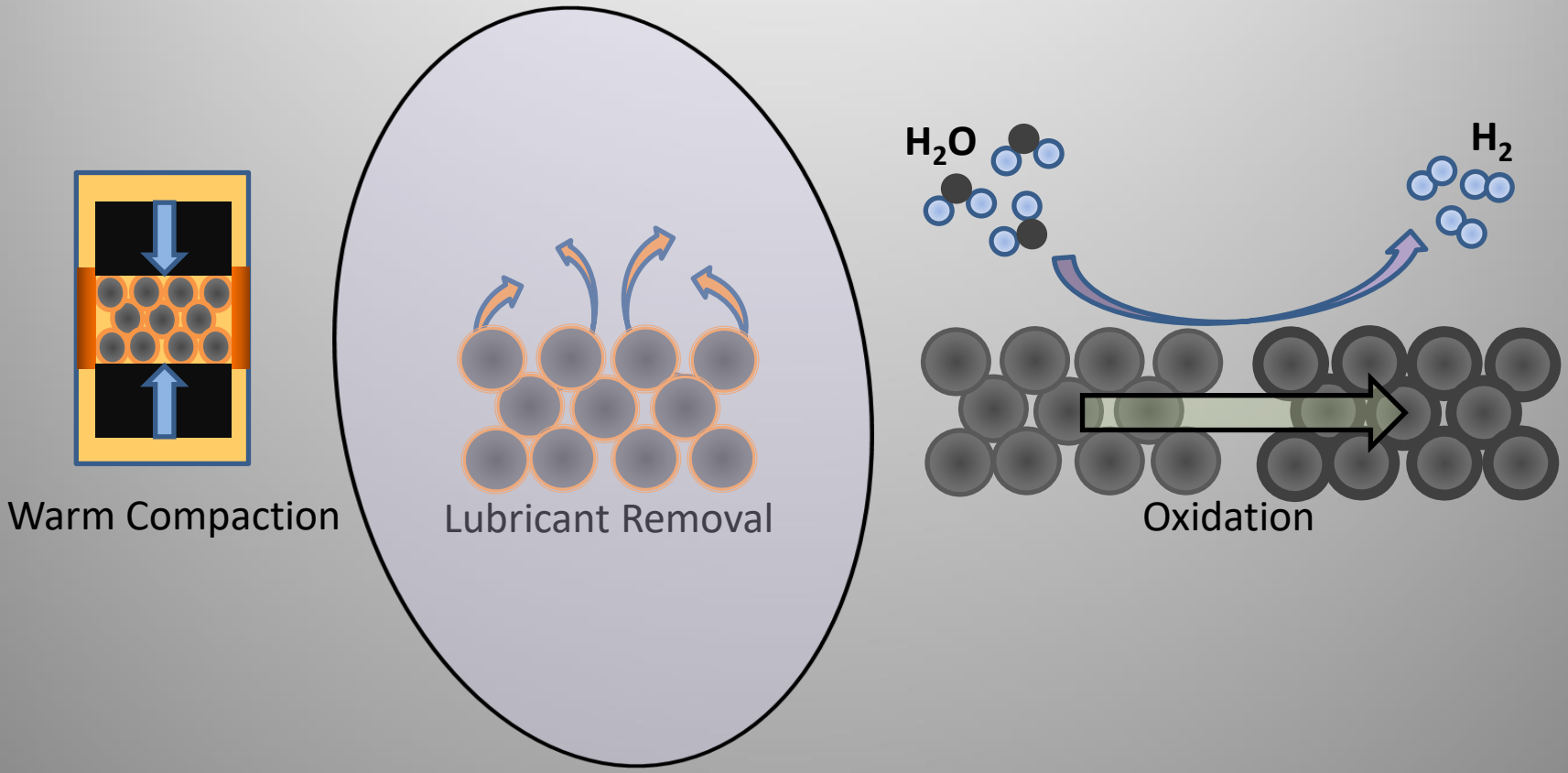
Lubricant Removal



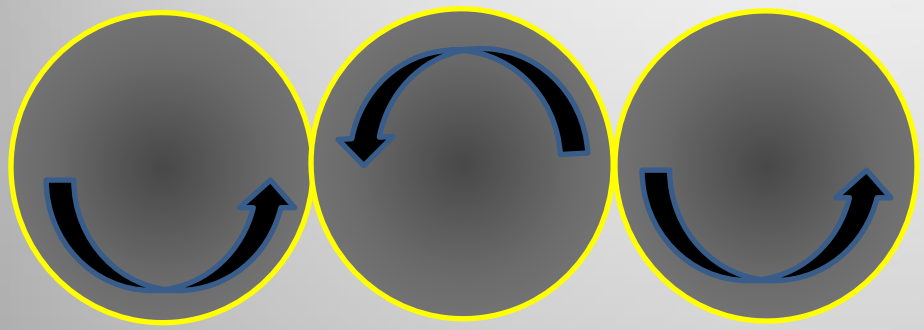
Oxidation

Soft Magnetic Composite Process

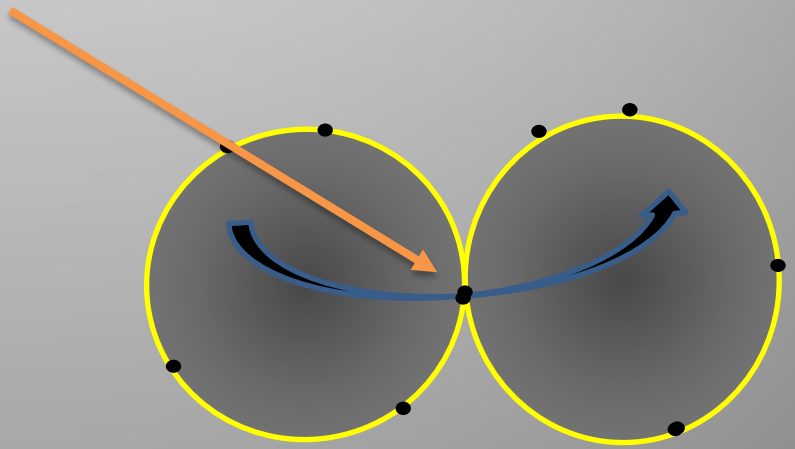
- Lubricant Removal is Critical to Success



Soot Breaks the Coating

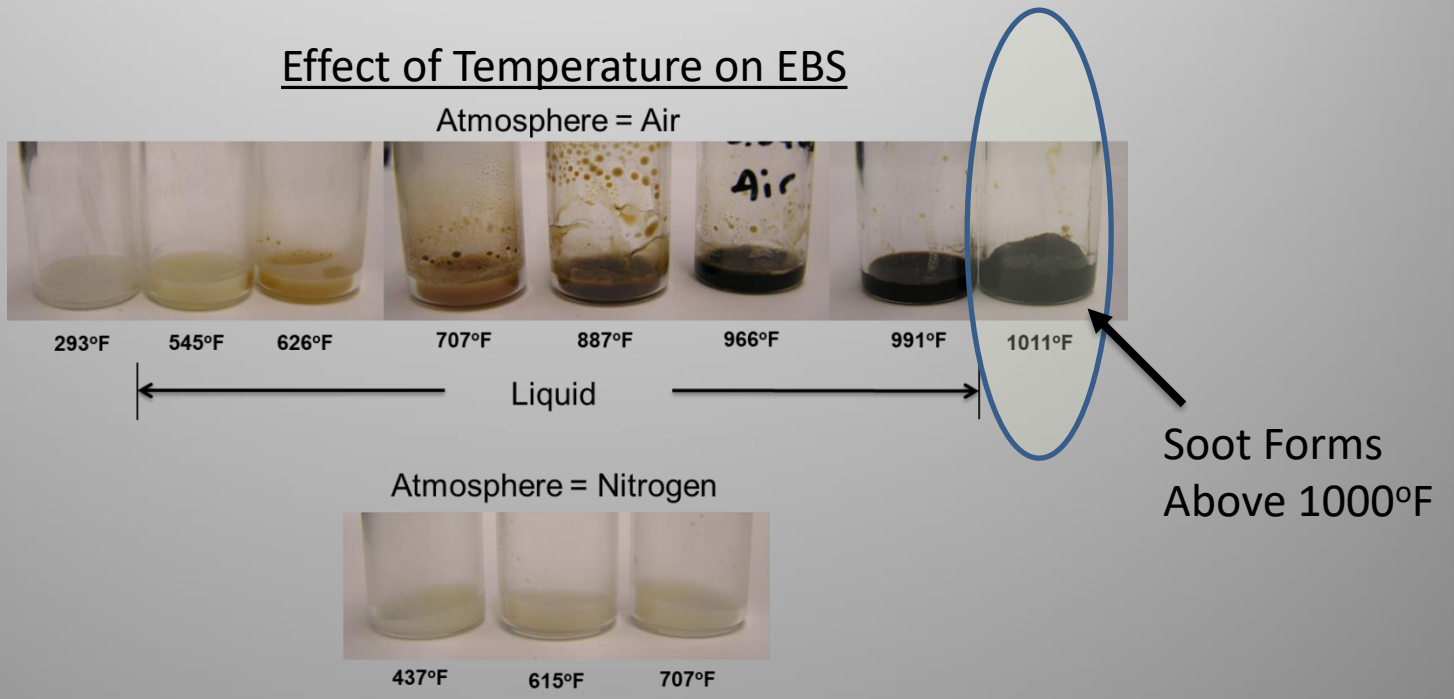


Soot Compromises the Coating



Temperature Window to Avoid Soot

- **Optimal Lubricant Removal Temperature Range for EBS: 350°F (175°C) – 1000°F (537°C)**
  - Requires Convective Heating for Temperature Control at Low Temperatures
  - Lubricant will soot if exposed to Temperatures above 1000°F



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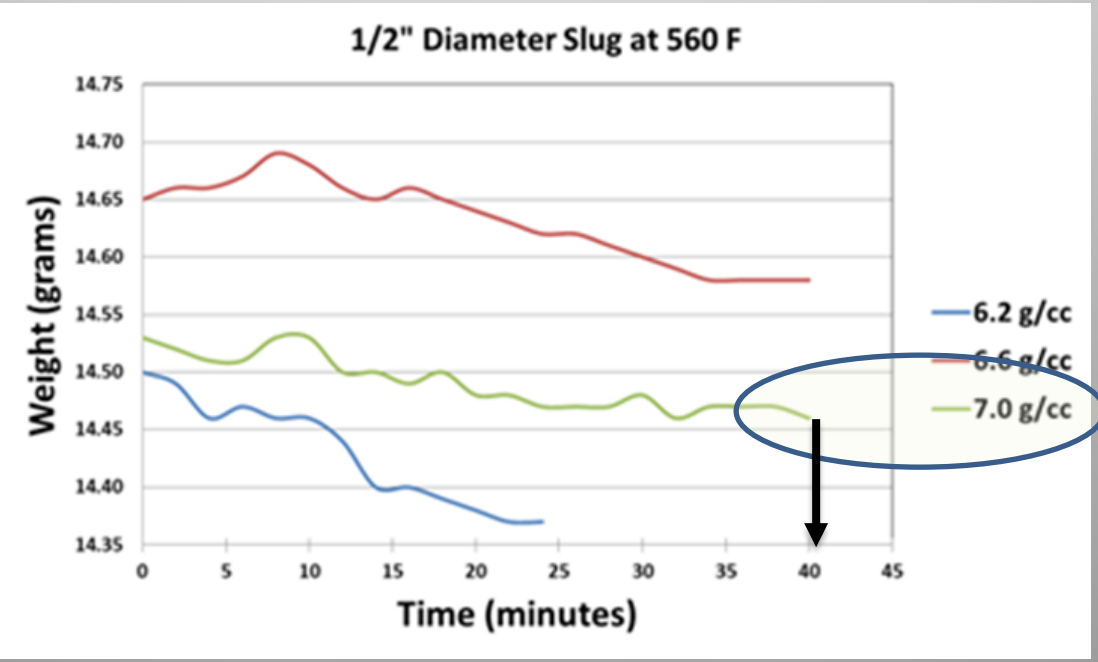
High Density = More Time to DeLube

- Time to Remove the Lubricant is a Strong Function of the Green Density.
- Time to Remove the Lubricant is NOT a LINEAR Relationship with the Green Density.



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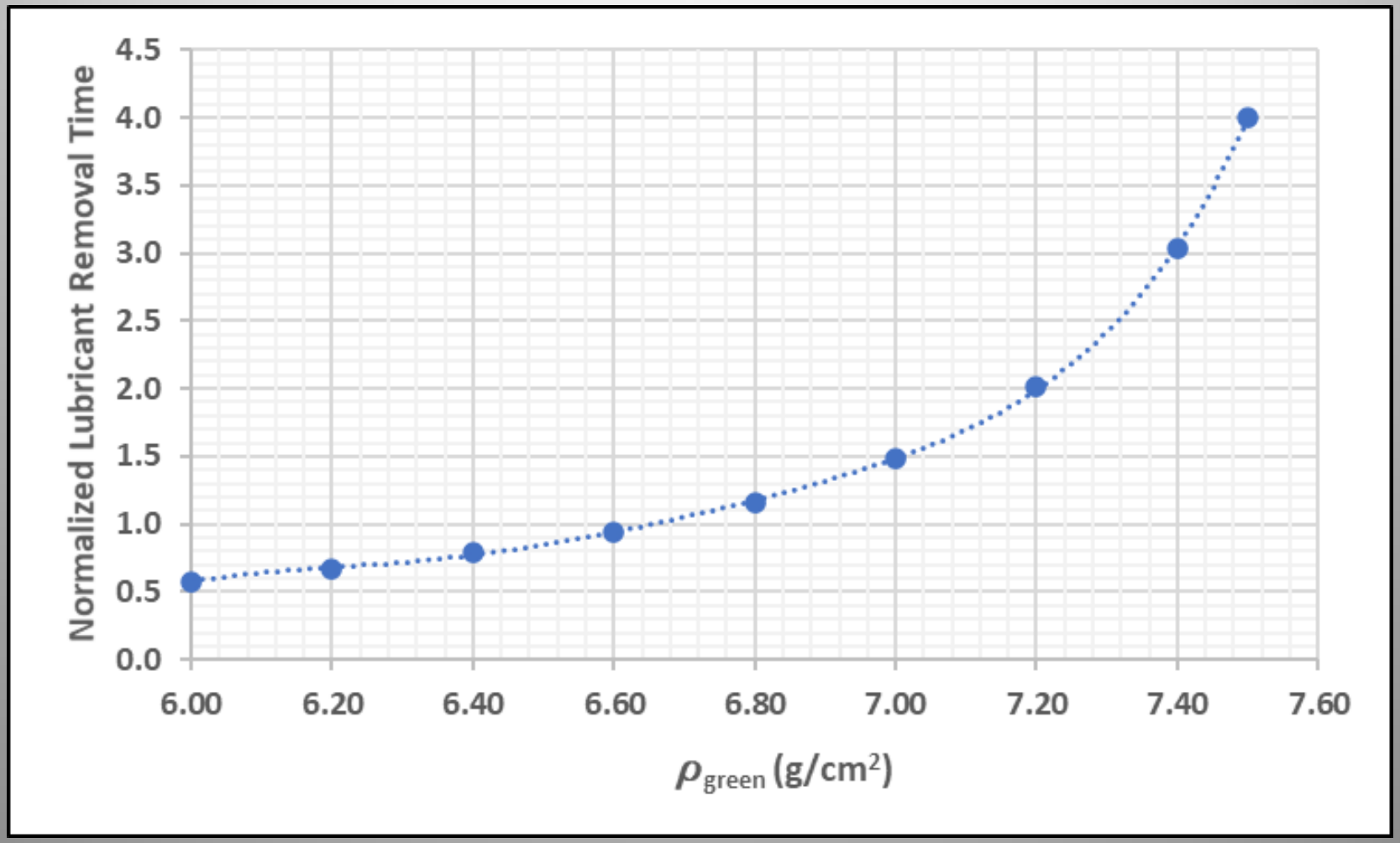
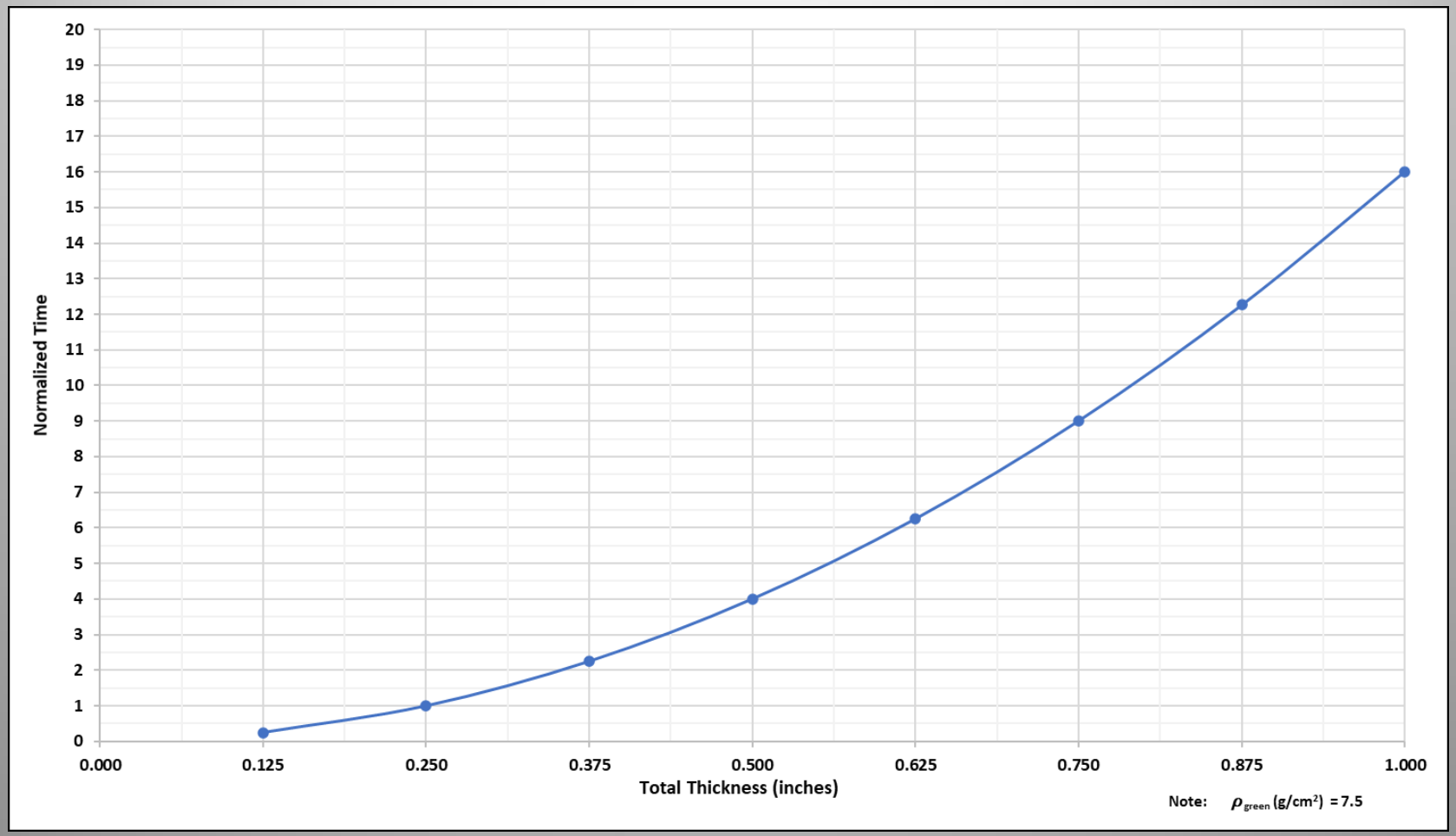
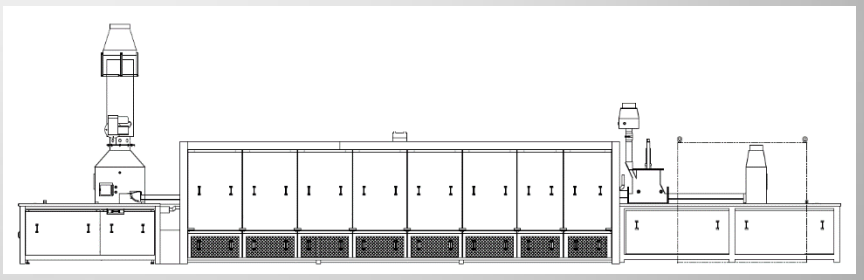
Lubricant Removal Time vs Density



Lubricant Removal Time vs Thickness



New Process - The Nautilus



Process - Flexibility

- Temperature, Atmosphere Flow Rate, and Atmosphere Composition *are Independent variables*.
  - Convective Heating in the Lubricant Removal Zone
  - Atmosphere Flow Rate and Composition Controlled by Independent Injection
  - Independent injection of oxidizing constituents

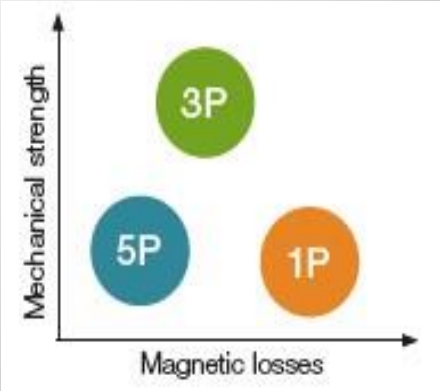
SMC Materials / Processing

The Somaloy product family

The Somaloy product family includes 3 groups;

1P, 3P and 5P with different performance levels (P):

- Somaloy 1P Baseline
- Somaloy 3P Mechanical strength, permeability
- Somaloy 5P Lowest losses



www.hoganas.com/electromagnetic

Somaloy 700HR 800MPa

	Compaction			Nautilus			
				"DeLube"		"Sintering"	
Material	Temp. (F)	Pres. (Psi)	Density (g/cc)	Temp. (F)	Atmopshere	Temp. (F)	Atmopshere
1P	70	116030	7.45	< 1000	Air	986	Air
3P	176	116030	7.52	< 1000	Air	986	Steam
5P	212	116030	7.5	< 1000	Nitrogen	1202	Nitrogen

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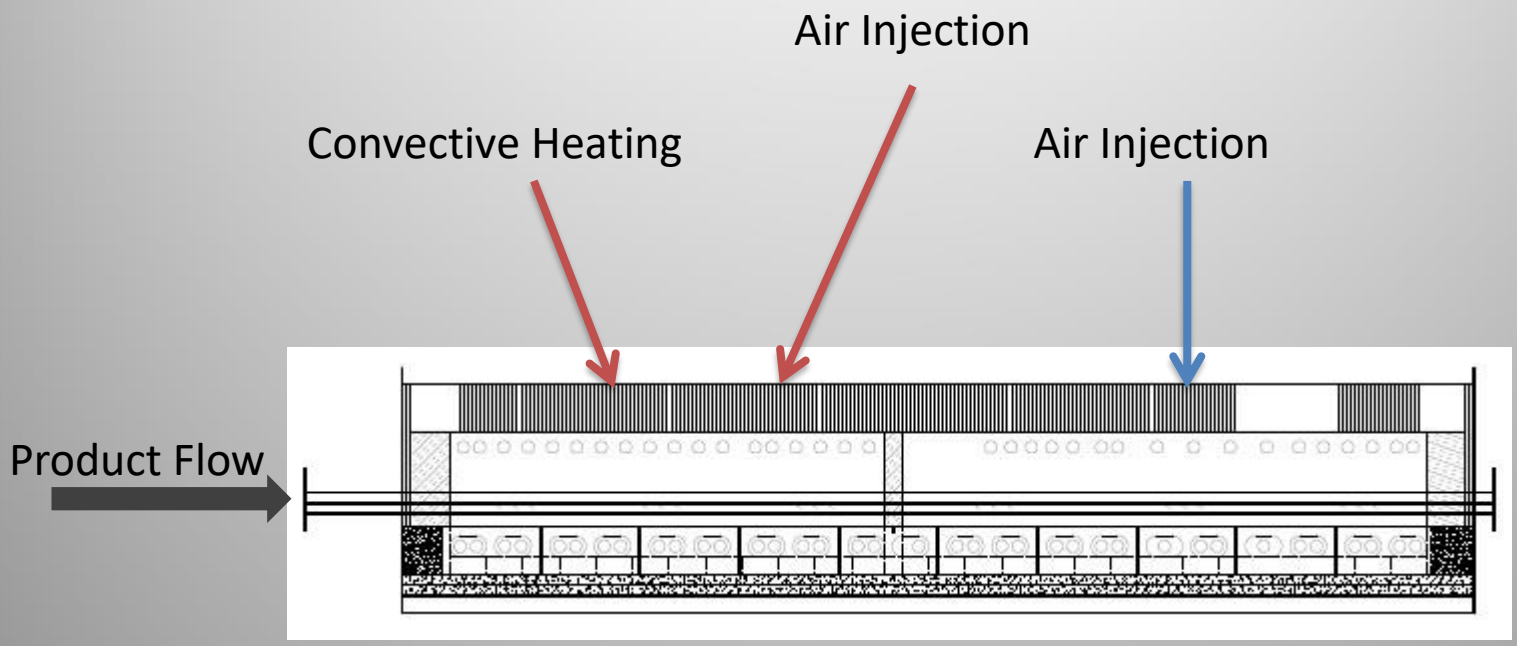
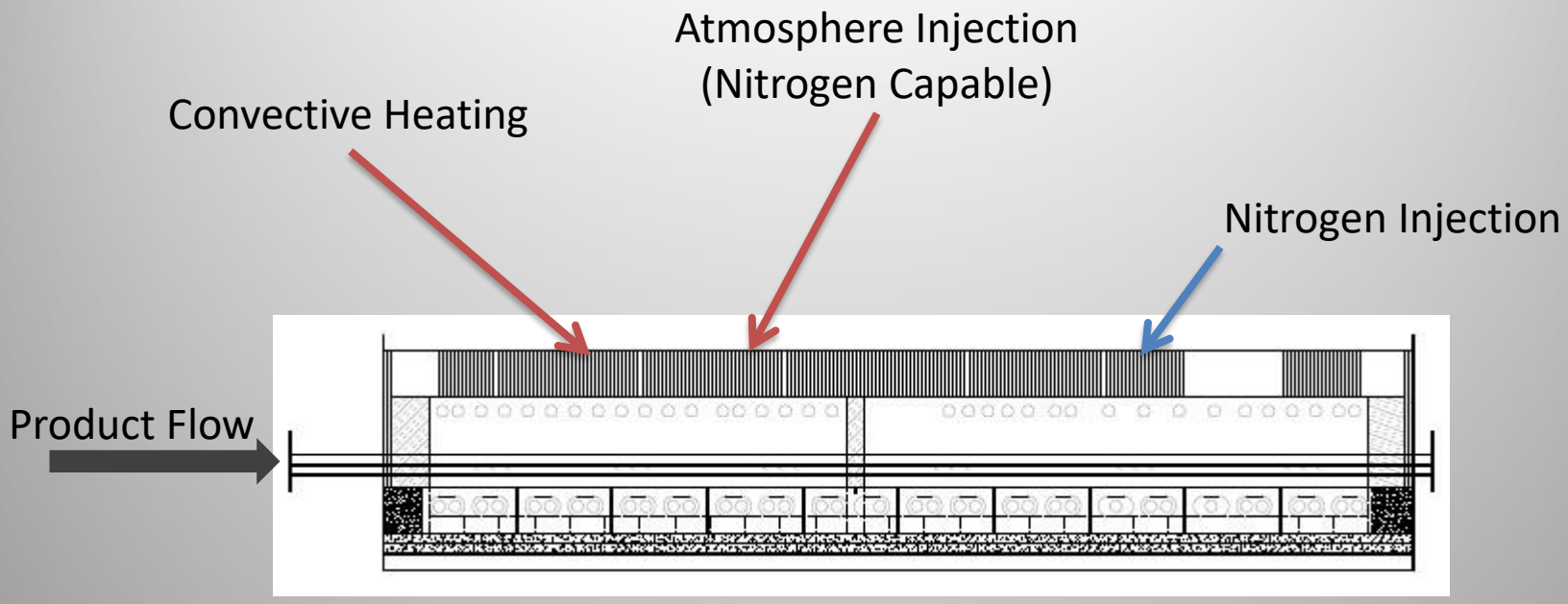
New Process – 1P



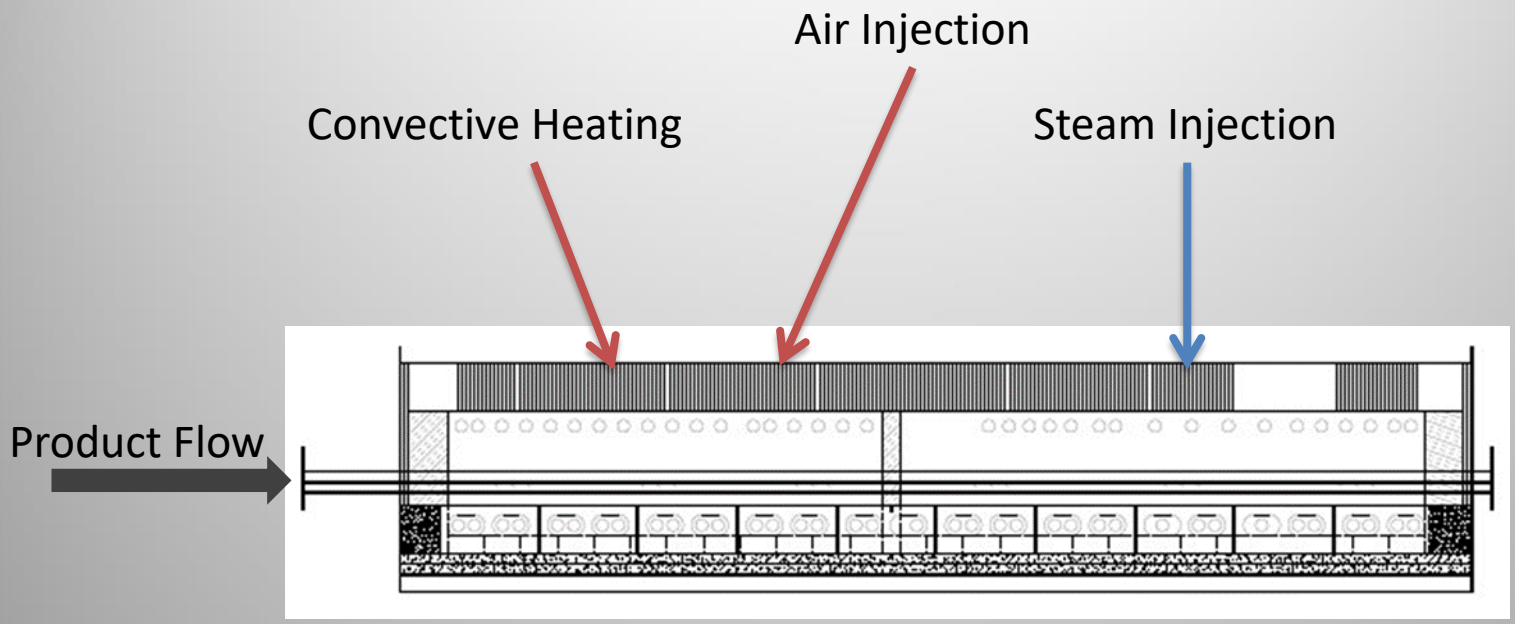
Electrically Heated with Elements Above and Below the Muffle

New Process – 5P

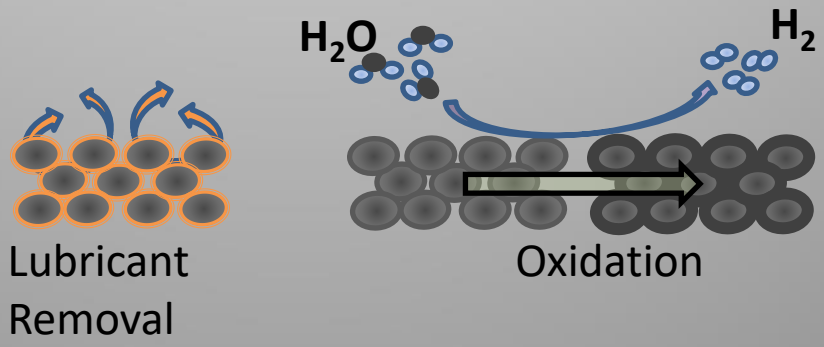


Electrically Heated with Elements Above and Below the Muffle

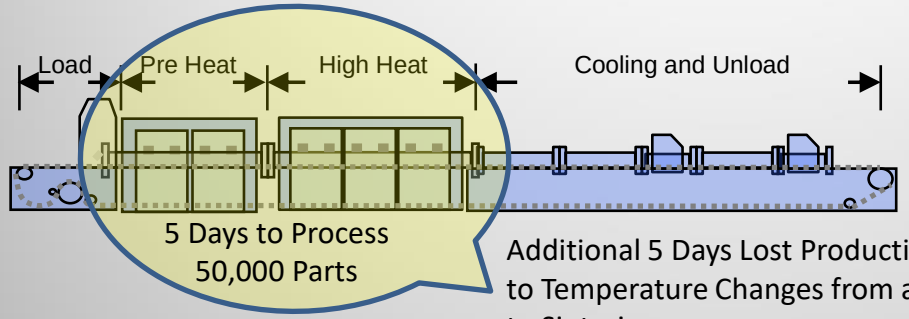
New Process – 3P



Electrically Heated with Elements Above and Below the Muffle



Processing with Conventional Equipment

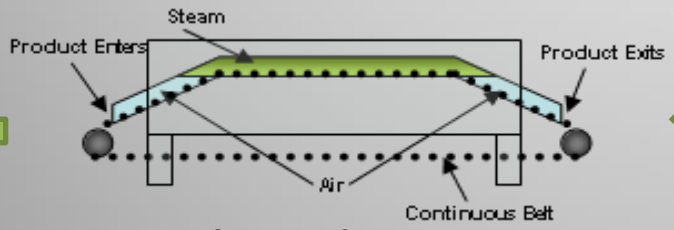


Additional 5 Days Lost Production Due to Temperature Changes from and back to Sintering

Unload Parts

Truck Parts to Steam Treater

Load Parts



3 Days to Steam
50,000 Parts

Unload Parts

Truck Parts Back

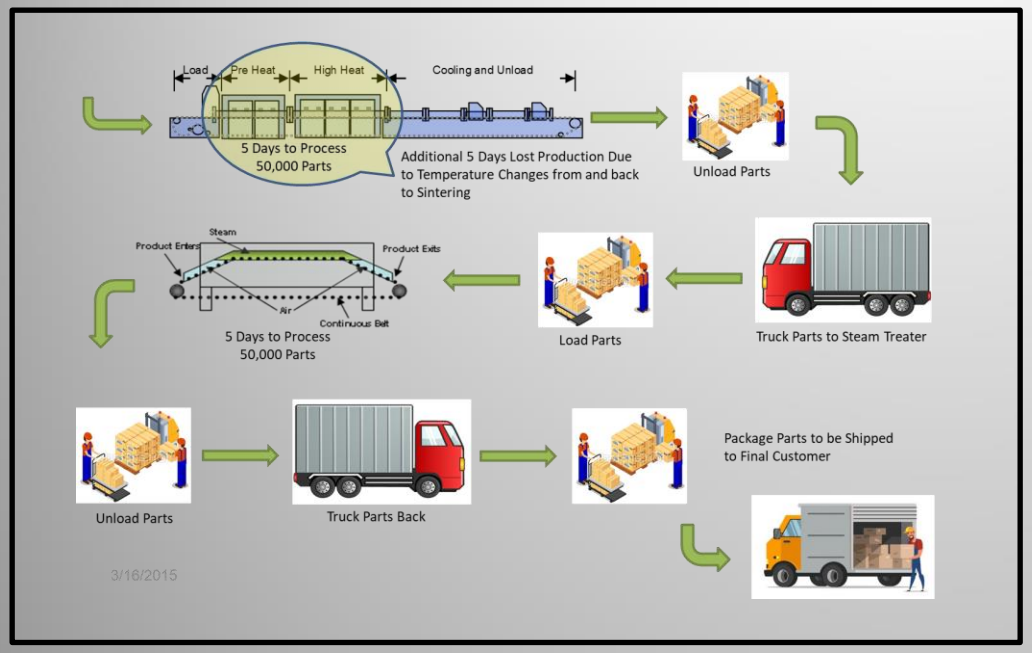
Package Parts to be Shipped to Final Customer

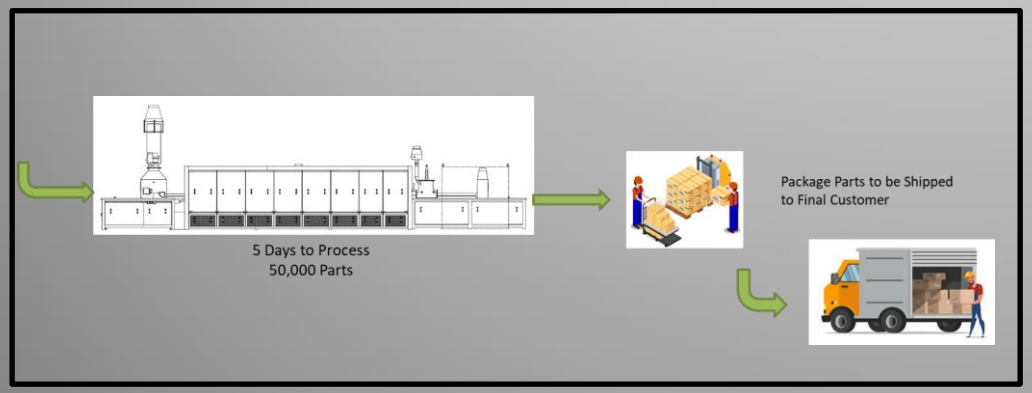
Processing with New Process

3 Days to Process
50,000 Parts

Package Parts to be Shipped
to Final Customer

New Process Savings





- Single Pass Saves
  - 5 days of lost production due to temperature adjustment
  - 2 to 3 handling steps
  - Potential trucking cost
  - 2 to 3 weeks processing time
  - Atmosphere and Heating Cost due to Furnace Conditioning
  - Faster Rate Saves 2 Days of Production

New Process Savings!

- The Average Sintering Furnace Produces at a Rate of ~$2,000.00 / Hour
- 7 Days of Lost Production due to Temperature Adjustment in Conventional Processing

- New Process has the Potential to Save ~$340,000.00 / Change-Over
  - Does NOT Include:
    - Additional Handling Costs
    - Trucking Costs
    - Out-Sourced Steam Treating Costs or Heating Costs to Re-Heat Parts to Steaming Temperature
    - Lost Atmosphere and Heat Costs associated with Furnace Running Empty during changes

ABBOTT FURNACE
LEAD WITH TECHNOLOGY. SUCCEED WITH SERVICE.

Thank You