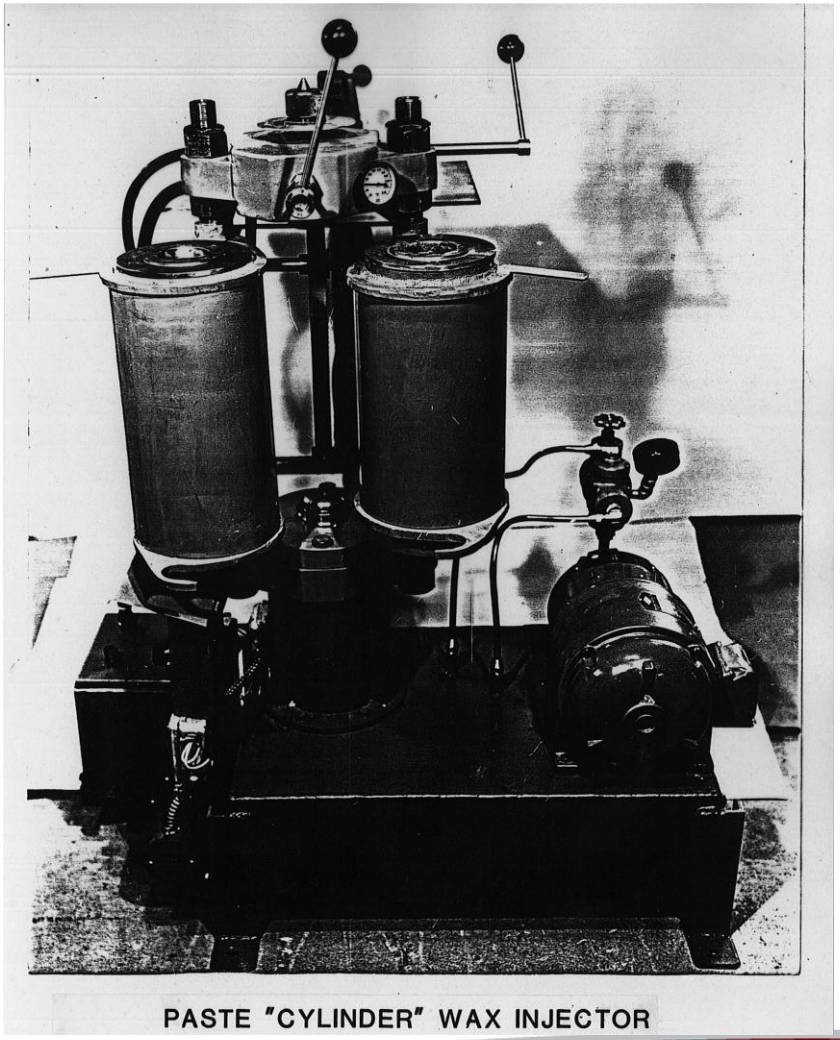
Digital Technology in the Wax Room

EICF Hungry
Digital Technology for Quality Assurance
24th – 25th September 2012

Bruce Phipps
President, MPI, Inc.

MPI Total Automation

Digital Technology in the Wax Room



PASTE "CYLINDER" WAX INJECTOR

- Trip down Memory Lane

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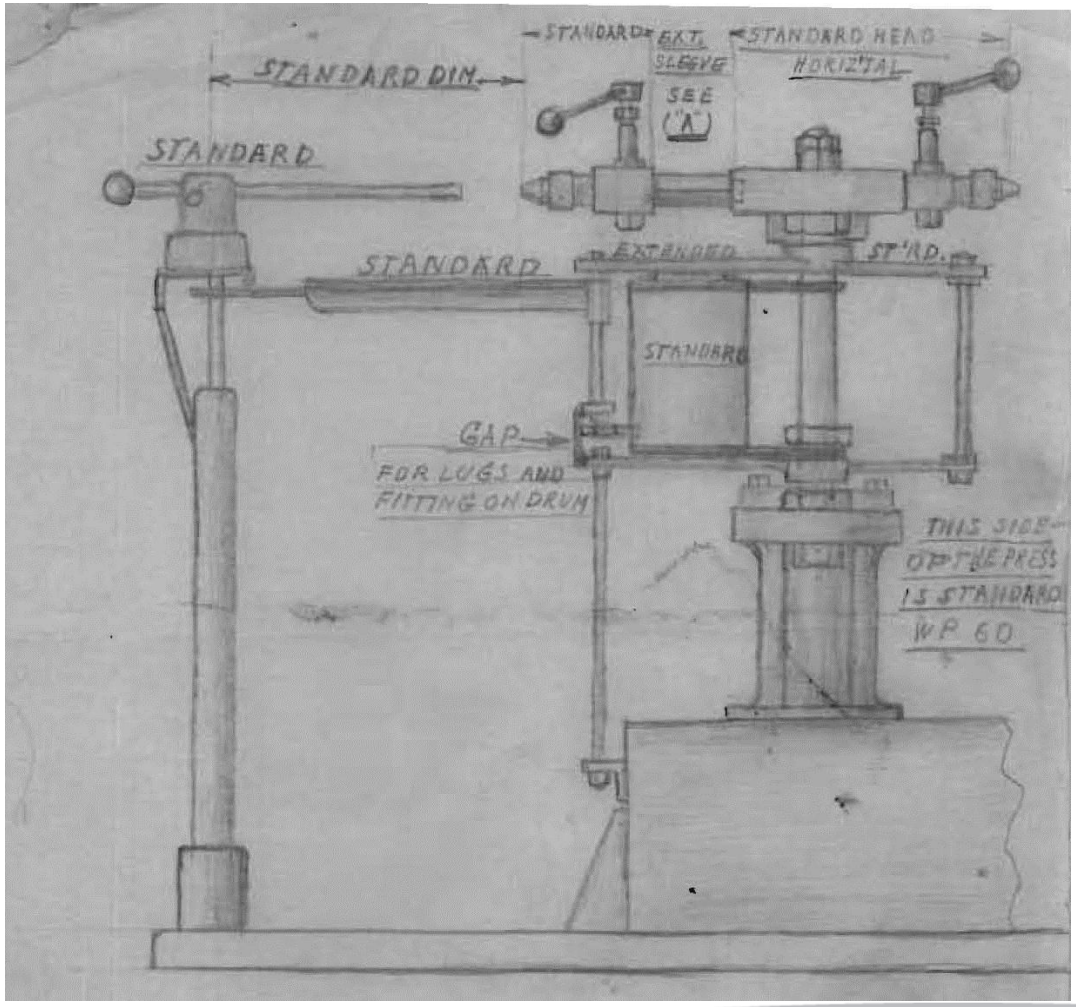

- Trip down Memory Lane
- 40 years ago controls were minimal

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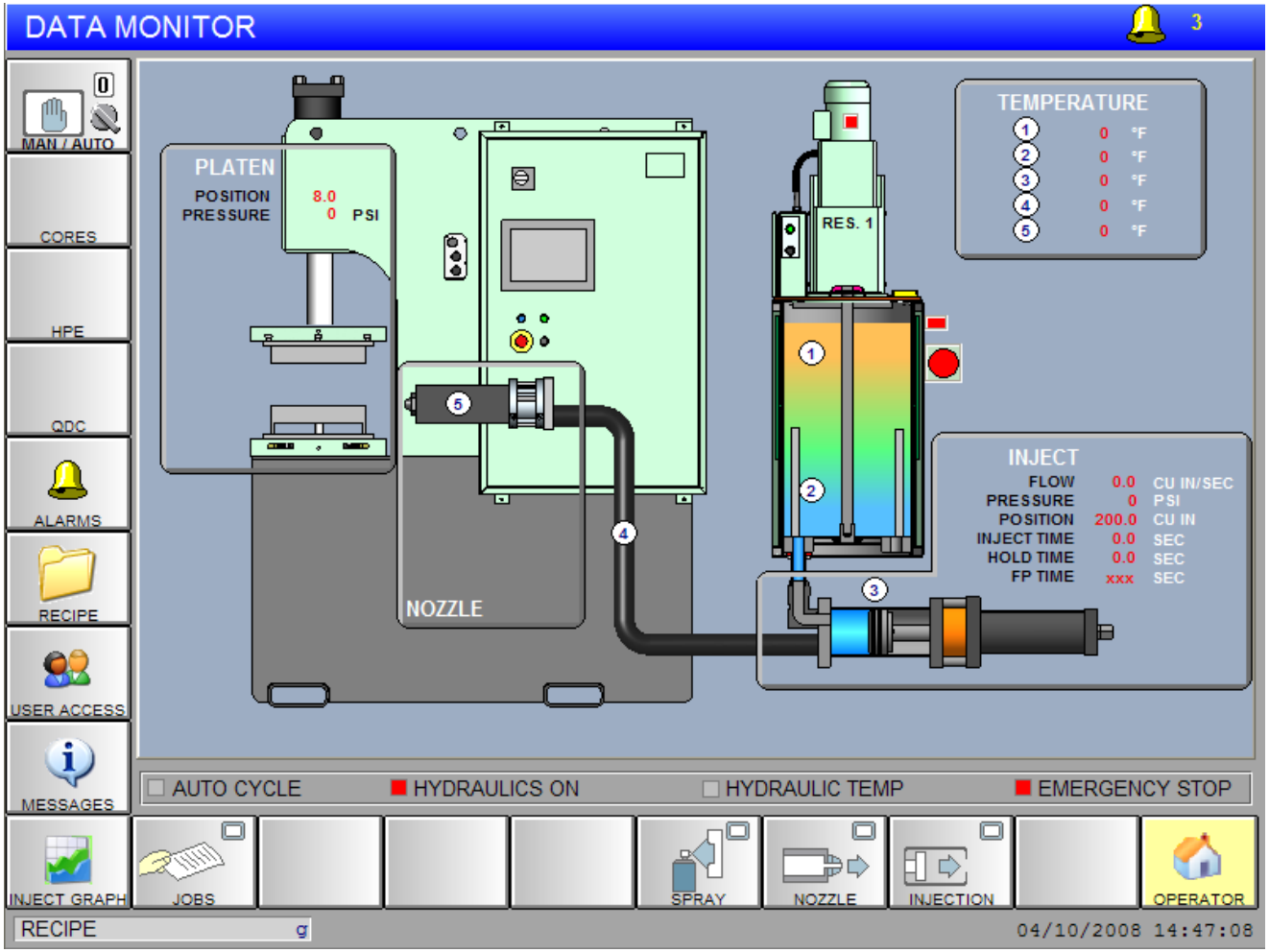

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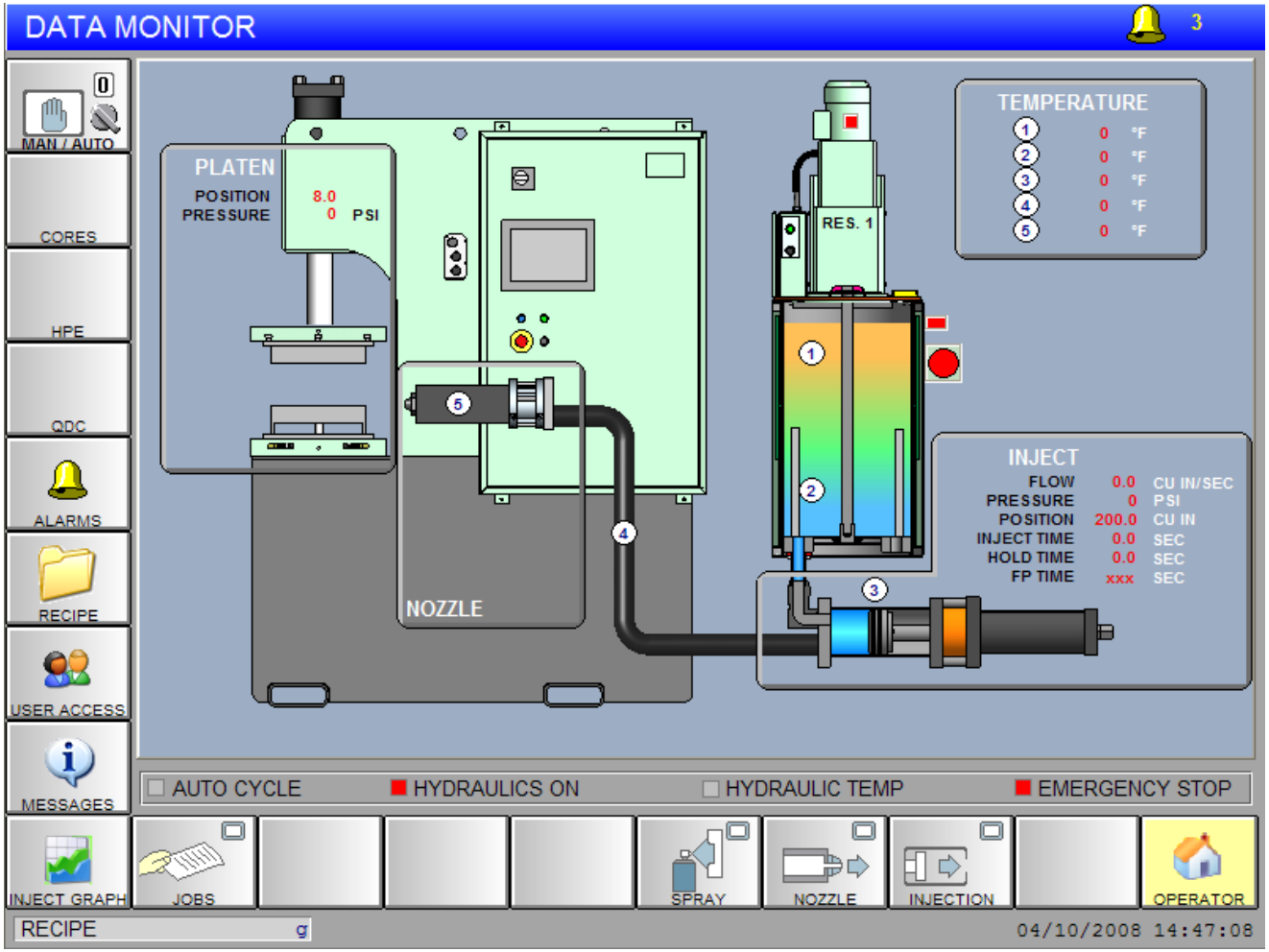

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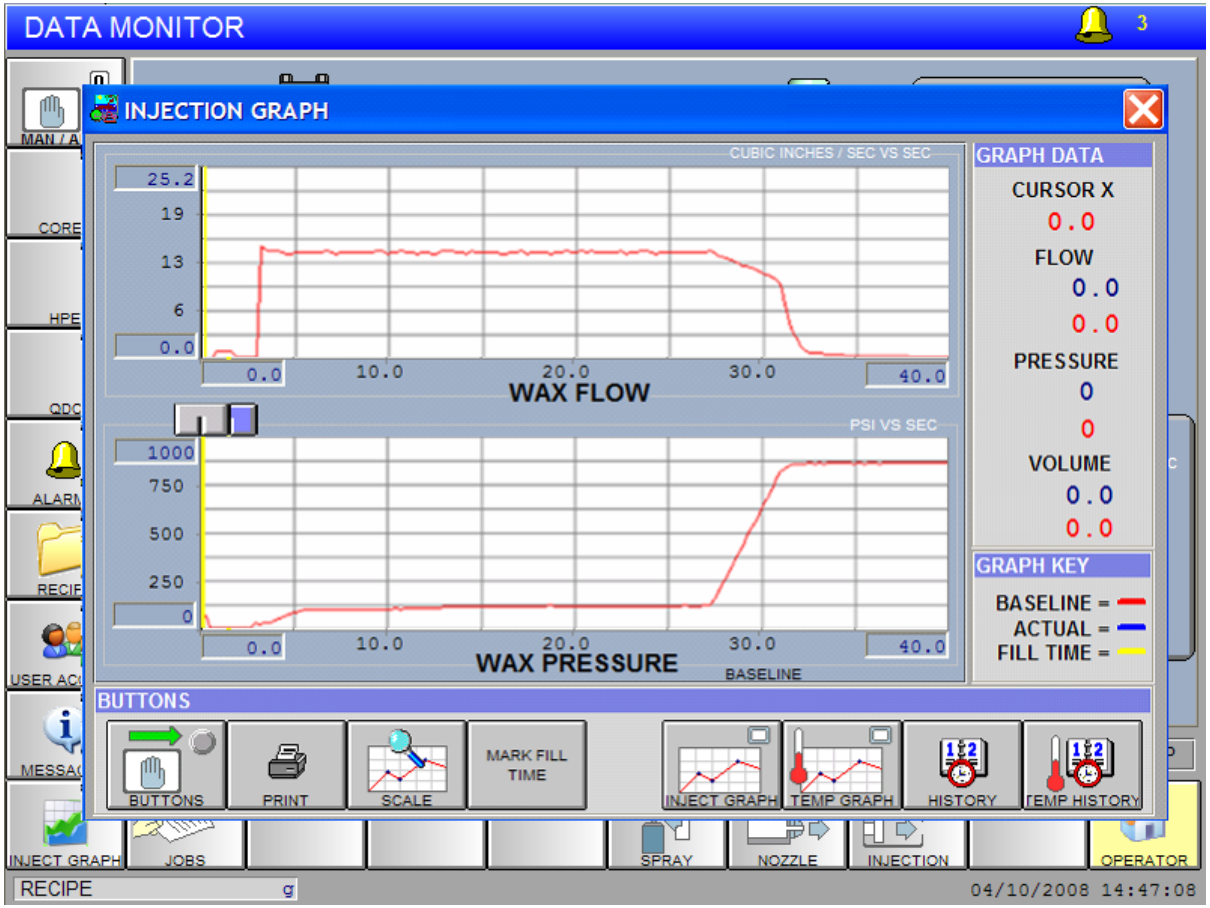

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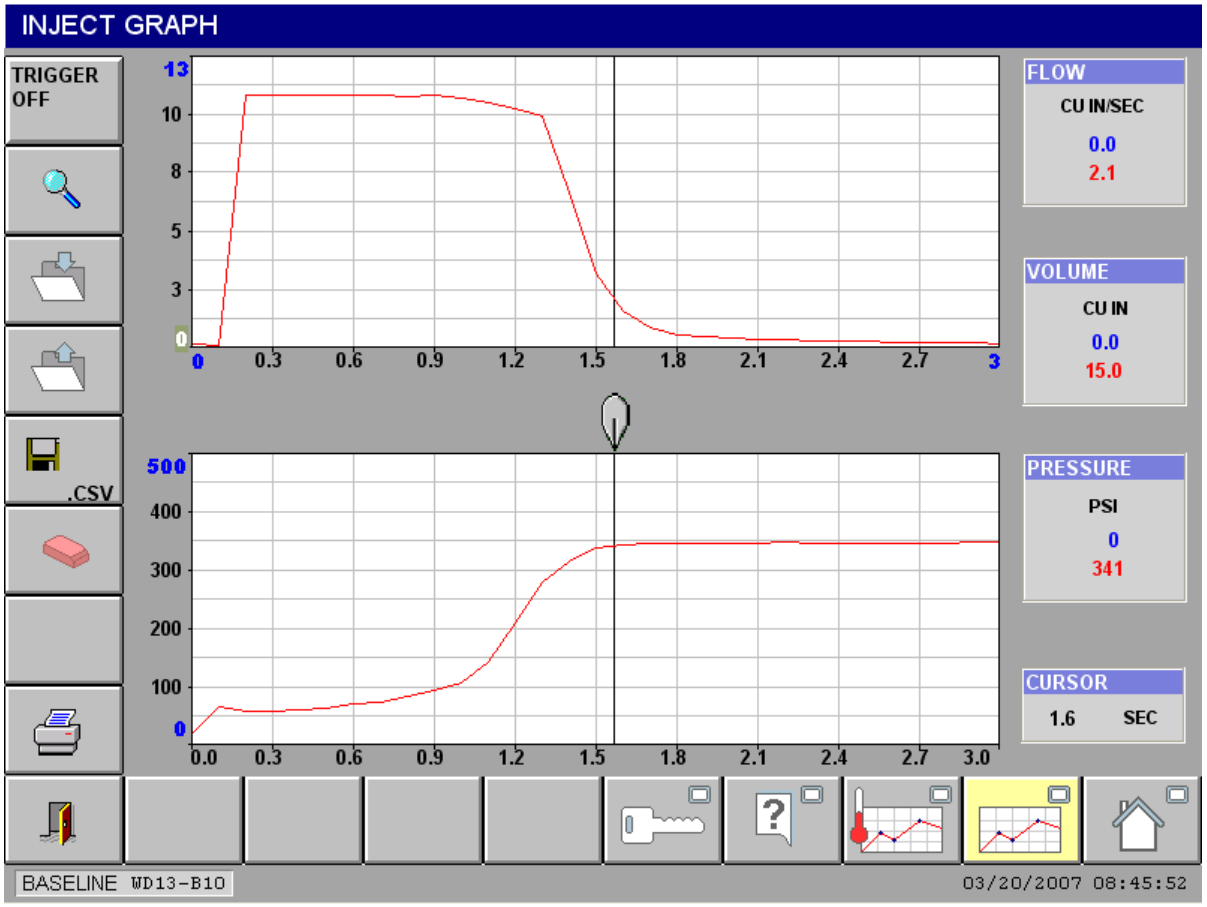

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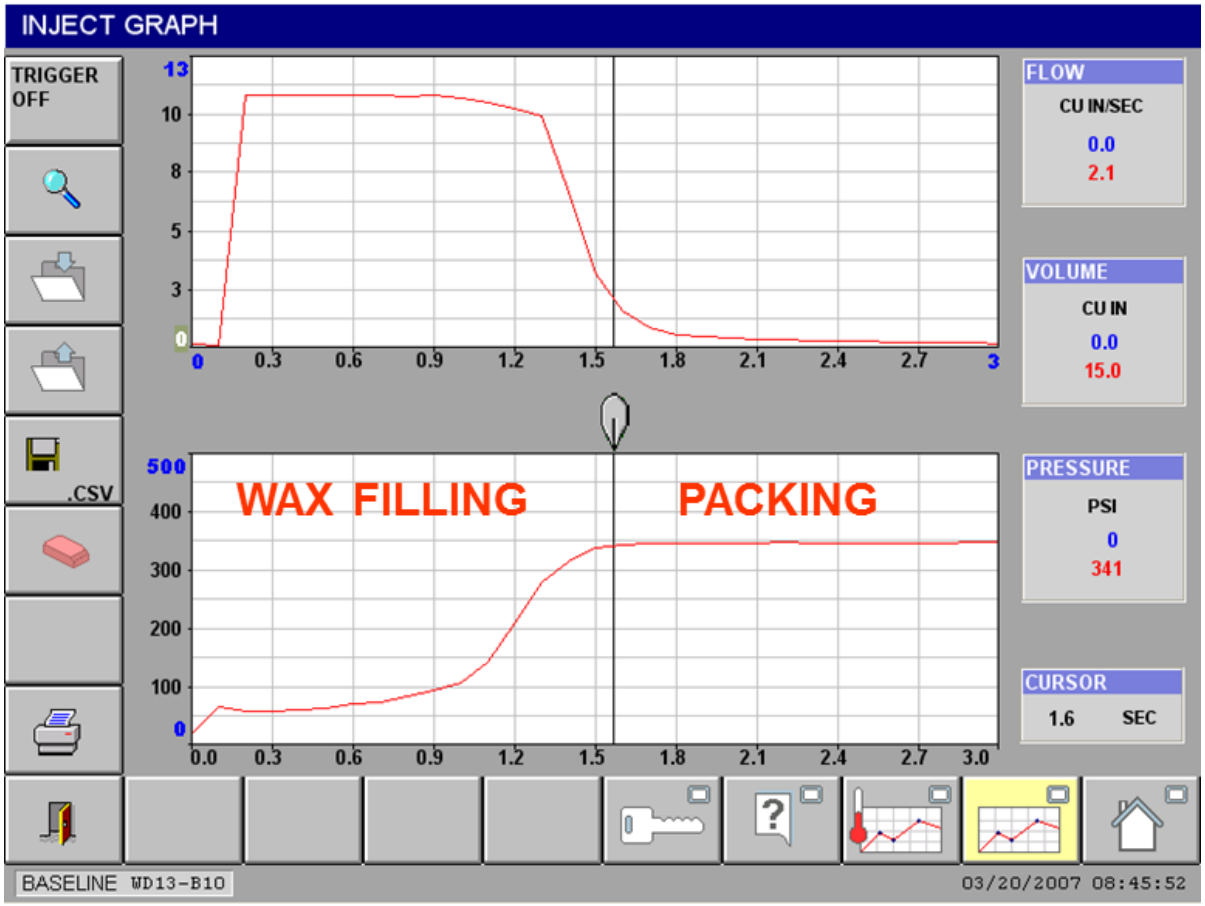

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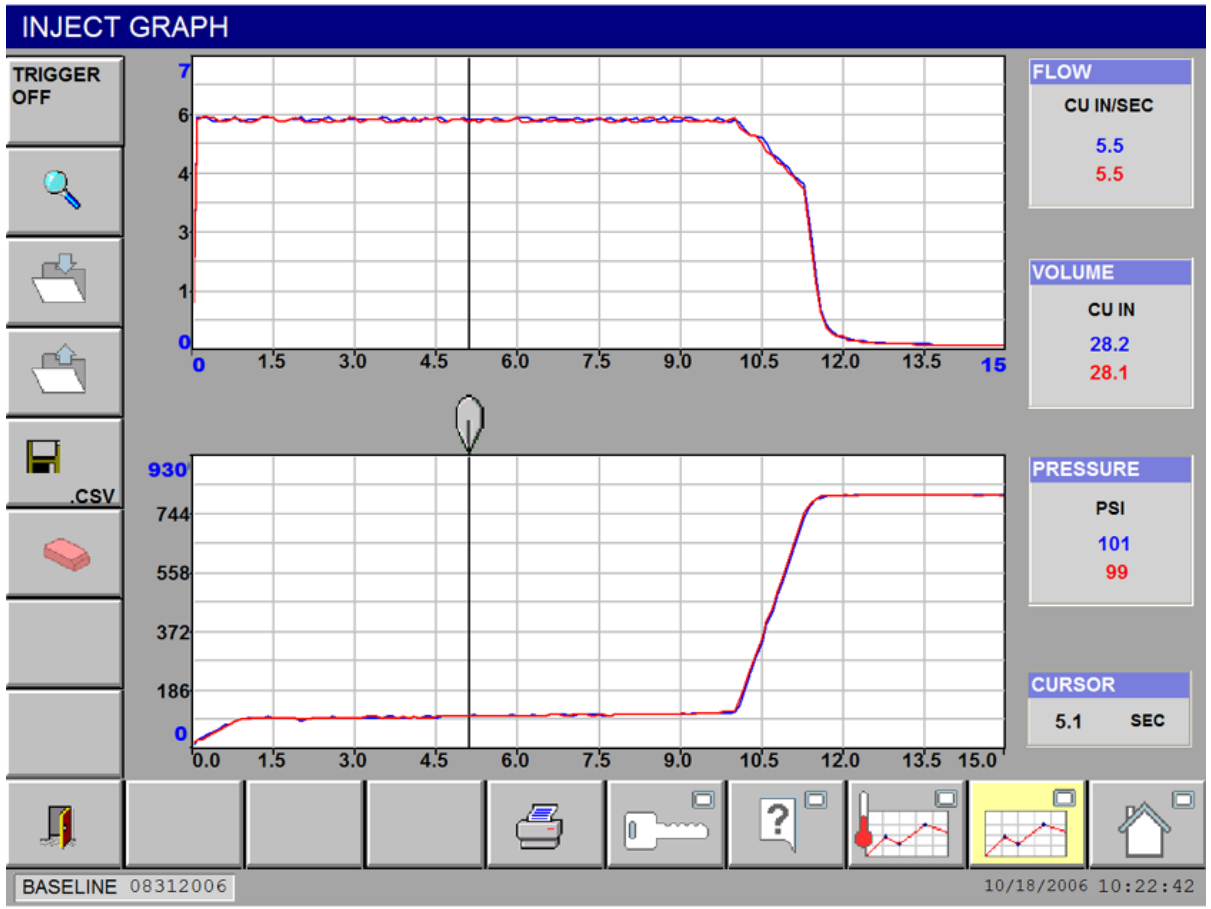

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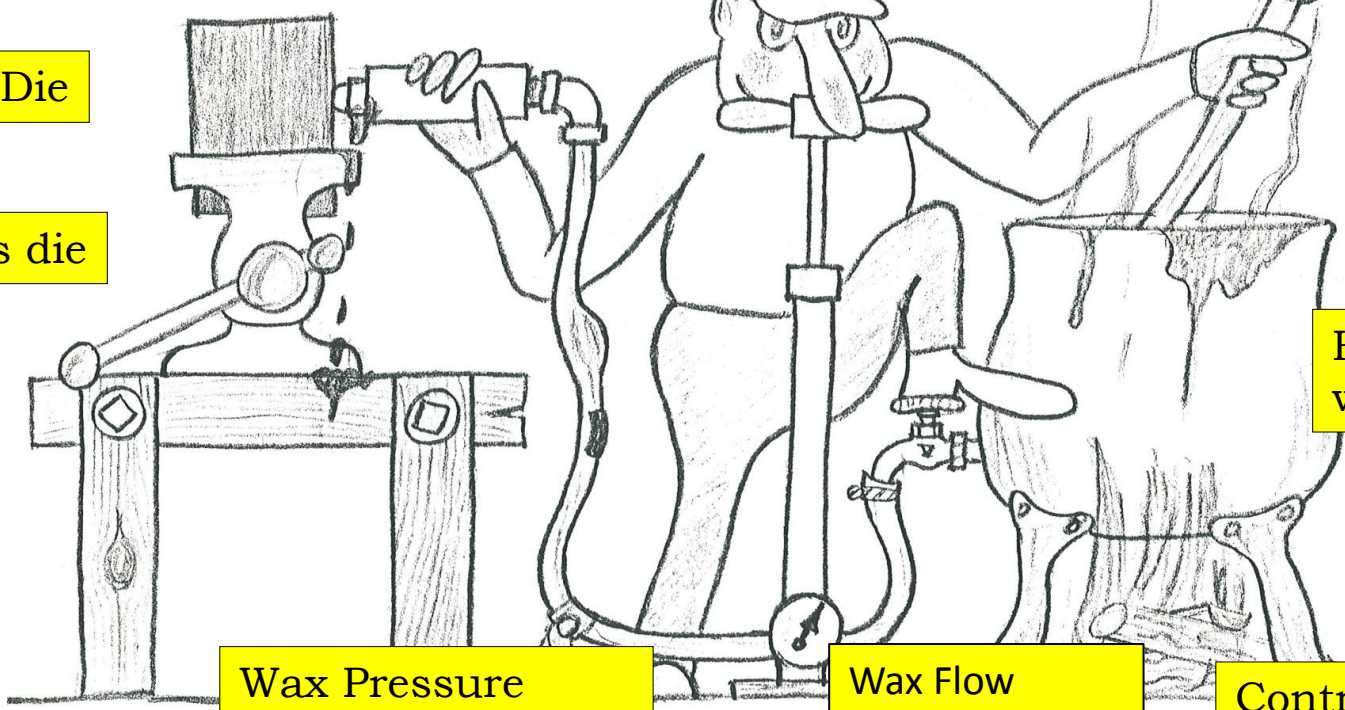
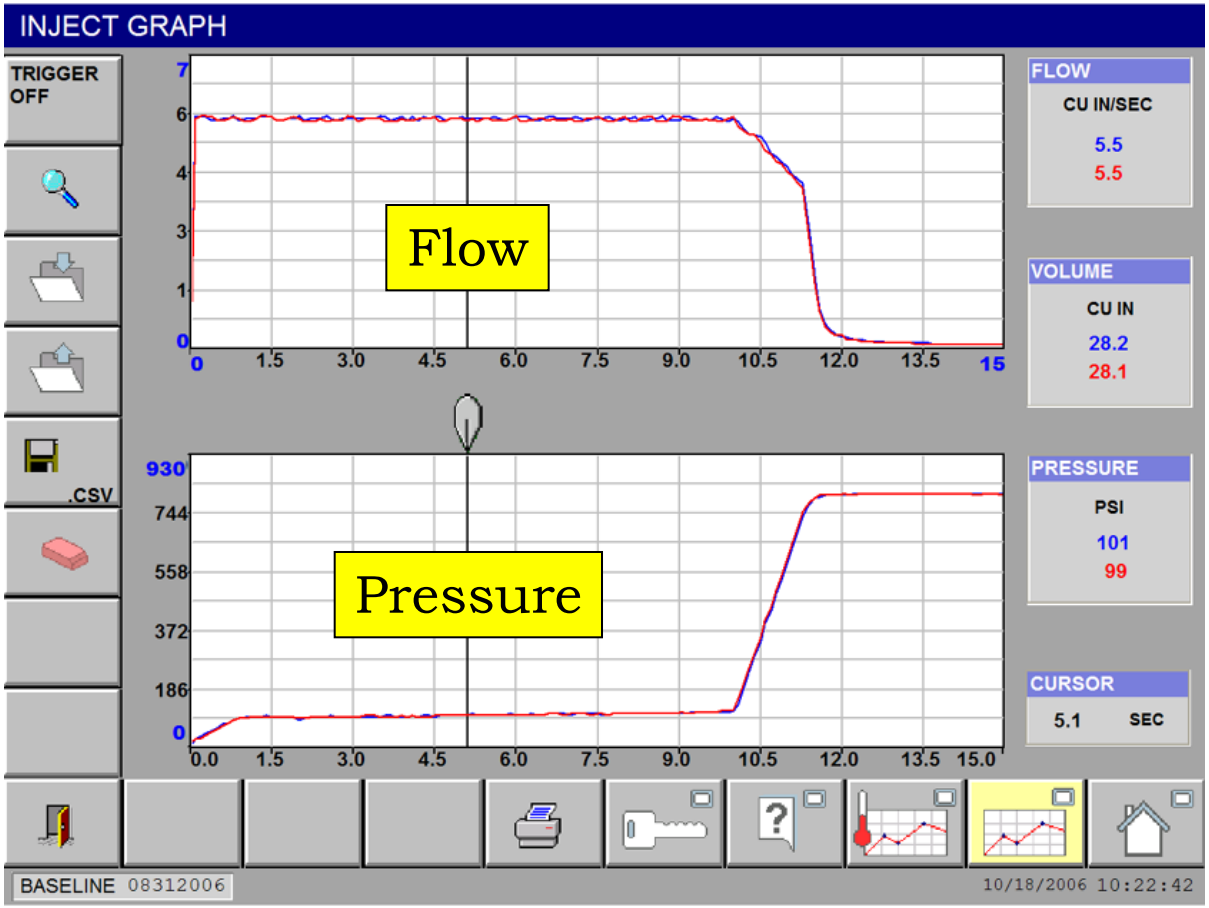
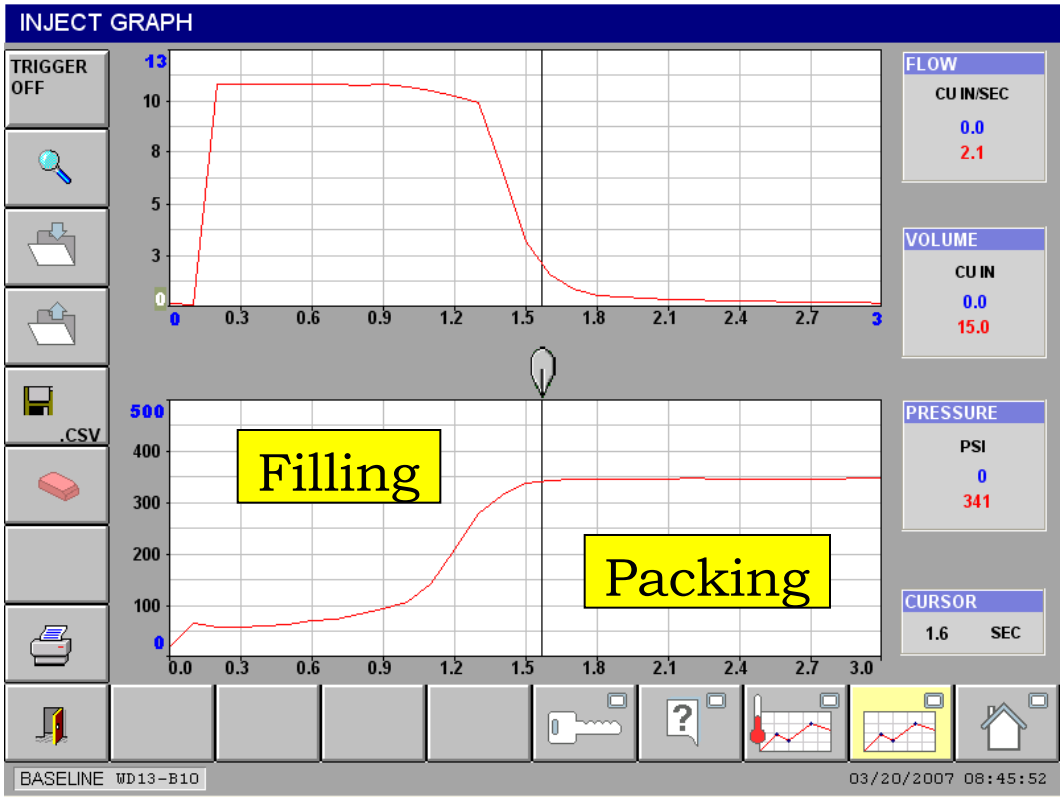


Digital Technology in the Wax Room

Die Filling - Real Time Graphing



Die Filling – Real Time Graphing



Flow rate drops when die is filled

Pressure increases when die is filled

FILLING

Flow control phase

PACKING

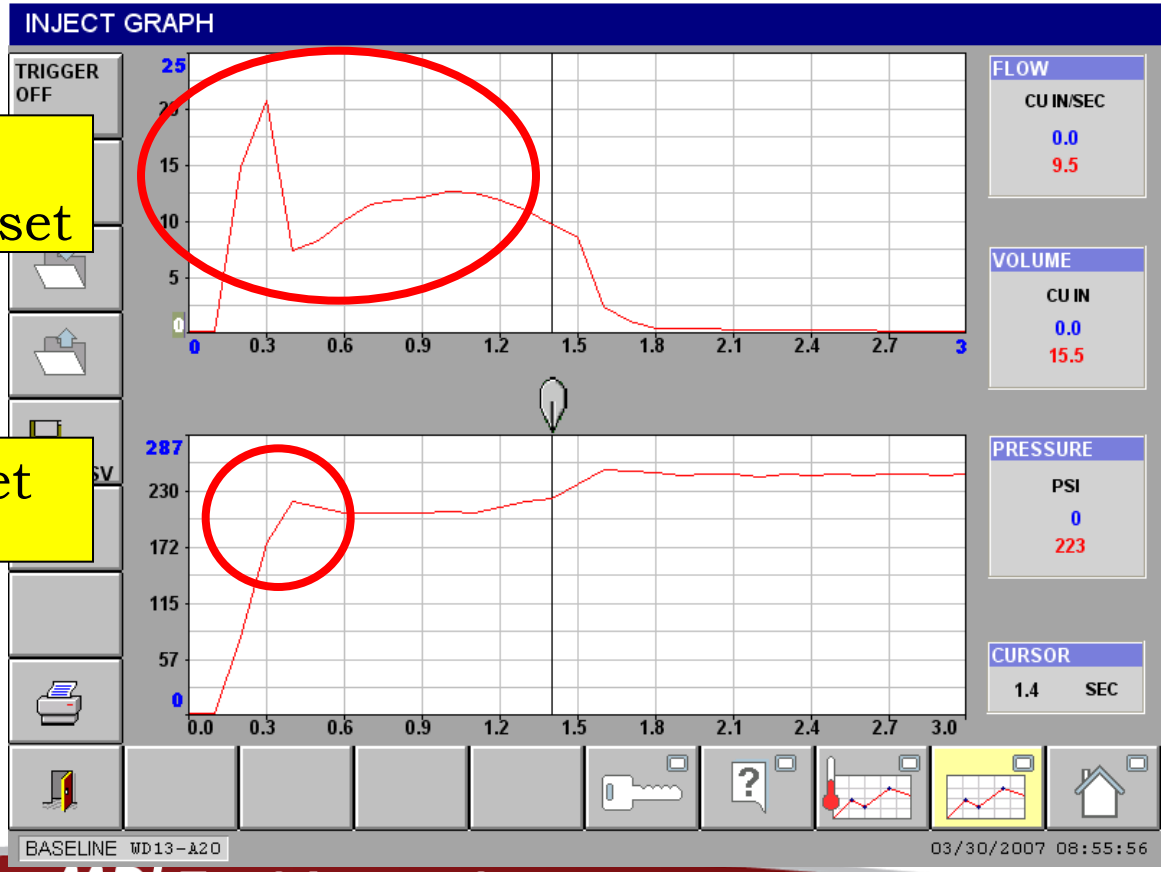
Pressure control phase

Die Filling – Real Time Graphing

Poorly Controlled Injection Cycle

Flow is unsteady
Flow does not match preset

Pressure is close to preset during fill



MPI Total Automation

- FLOW SET POINT = 20 CU IN / SEC

Automation, Why and How

Why Automate?

But, there is another key area to consider:

Automation, Why and How

Why Automate?

But, there is another key area to consider:
Reducing Process Variability

Automation, Why and How

The Problem is Variability

Why Automate?

Automation = Repeatability!

- Pattern to Pattern Repeatability
- Assembly to Assembly Repeatability
- Casting to Casting Repeatability

Customer Results

INCREASED YIELDS + DECREASED SCRAP = INCREASED PROFITS

How to Automate?

Not so easy

How to Automate?

Requires a Holistic Approach

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Include Key Personal from all Departments

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Many Defects are not Readily Apparent

How to Automate?

Requires a Holistic Approach

Include Key Personal from all Departments

Many Defects are not Readily Apparent

Design your assembly for the highest yields

The Approach - Considerations

Optimize the pattern assembly to include:

The Approach - Considerations

Optimize the pattern assembly to include:

- A design for highest metal pour ratio

The Approach - Considerations

Optimize the pattern assembly to include:

- A design for highest metal pour ratio
- Design for optimum metal flow

The Approach - Considerations

Optimize the pattern assembly to include:

- A design for highest metal pour ratio
- Design for optimum metal flow
- Design for optimum metallurgical properties

The Approach - Considerations

Optimize the pattern assembly to include:

- Design for part cut off

The Approach - Considerations

Optimize the pattern assembly to include:

- Design for part cut off
- Design for de-wax

The Approach - Considerations

Optimize the pattern assembly to include:

- Design for part cut off
- Design for de-wax
- Design for Shelling

The Approach - Considerations

Now concentrate on the wax room:

- Automation requires Standardization
- Use a future oriented vantage point
- Get out of the past
- Change is painful but rewarding

Where do you start?

Understanding your motivation

- Work closely with your Integrator
- Have a well defined plan
- Reduce the amount of variables

Where do you start?

Understanding your motivation

You need to clearly define the following:

What do you want to automate?

- The injection of wax patterns
- The injection of wax runners
- The assembly of wax patterns to your runners
- Transportation of the various components
- All the above

Where do you start?

Understanding your motivation

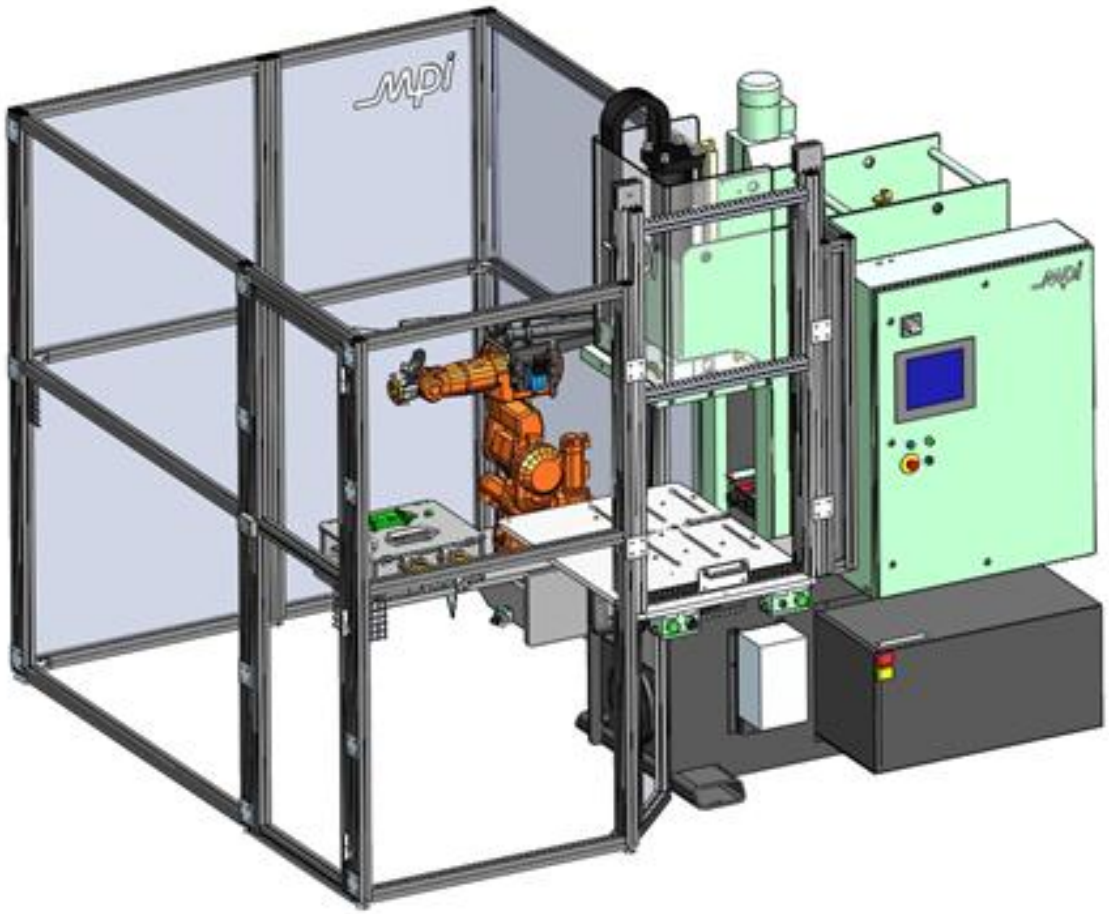
Why do you want to automate?

- Reduce labor
- Reduce pattern to pattern variability
- Reduce pattern warpage
- Reduce pattern drop off in the shelling operation
- Reduce metal inclusions due to inconsistent welds

Specifications for Automation

- Wax Pattern Specifications:
  - Provide solid model files wax patterns
  - The pattern gate is a critical part of the pattern
- Wax Runner Specifications:
  - You will need to provide solid models of the wax runners
  - Include any steel inserts, pouring cups, and any special requirements or secondary operations
- Wax Properties:
  - Wax Manufacturer's Part #
  - Viscosity Curve

Wax Injection Automation



Wax Injection Automation

Note: Wax Patterns and Wax Runners are ***both*** critical patterns

Customer needs to define what is critical on the patterns e.g.:

- Where the pattern can be gripped without doing damage
- The amount of witness that is allowed on the pattern Are there secondary operations required if so what are they:
  - X-ray
  - Pinning cores
  - Inspection
  - Pattern Cleaning and Trimming

Wax Injection Automation

Automated wax injection tools (dies/molds):

- High quality automated tools with no flash on the pattern.
- Standardized mounting with accurate location
- Automated Core Pulls
- Automated pattern ejection
- Water cooling passages
- This applies to runner injection as well

Wax Injection Automation

Wax Injection Automation

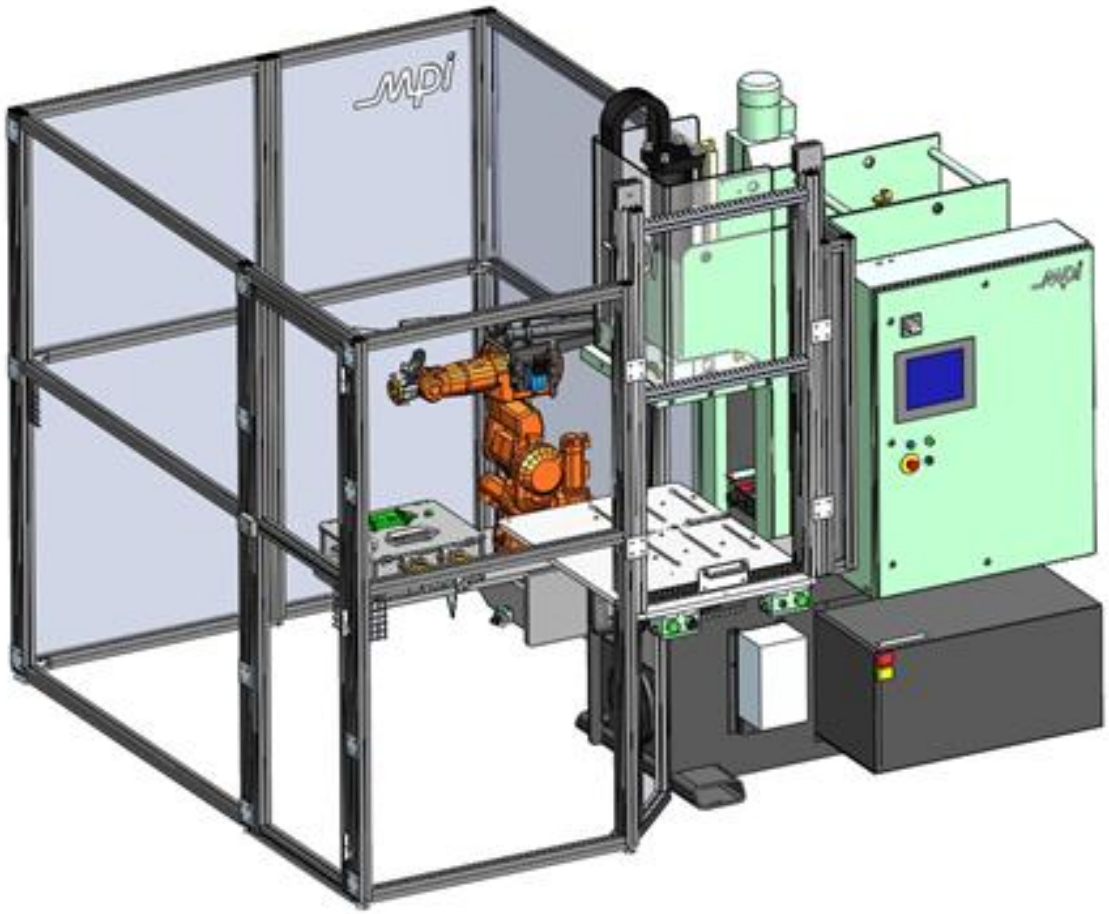
Need a clearly defined operation:

- Tool clean off
- Tool lubrication
- Pattern removal
- Injection runner removal
  - Defined witness on pattern
  - Where to deposit the runner

Wax Injection Automation

- Pattern setter:
  - All setters need to have common mounting
  - The setter needs to be automated
- Pattern transport out of the cell needs to be defined
  - What is the next operation and where?
  - How is it transported to the next operation?
    - Tray
    - Conveyor
    - Tray on a Conveyor

Automated Injection, 6 Axis Robot



Automated Injection, 6 Axis Robot

Customer Results

- Double the number of patterns injected per day
- Pattern yields increased 10 to 20%
  - Reduced pattern distortion
  - Reduced pattern defects
  - Uniform pattern trimming, minimal variation
- Higher casting yields

Customer Results

INCREASED YIELDS + DECREASED SCRAP = INCREASED PROFITS

Automated Pattern Assembly

Automated Pattern Assembly

When automating pattern assembly select a family of parts that will fit a single runner design. The automated pattern assembly process requires:

- Tooling to hold the wax patterns
- Tooling to hold the wax runners
- Tooling to weld the pattern to the runner

The end of arm tooling cost can be reduced with a family of parts because of commonality.

Automated Pattern Assembly

Each family will have a defined commonality and grouped by:

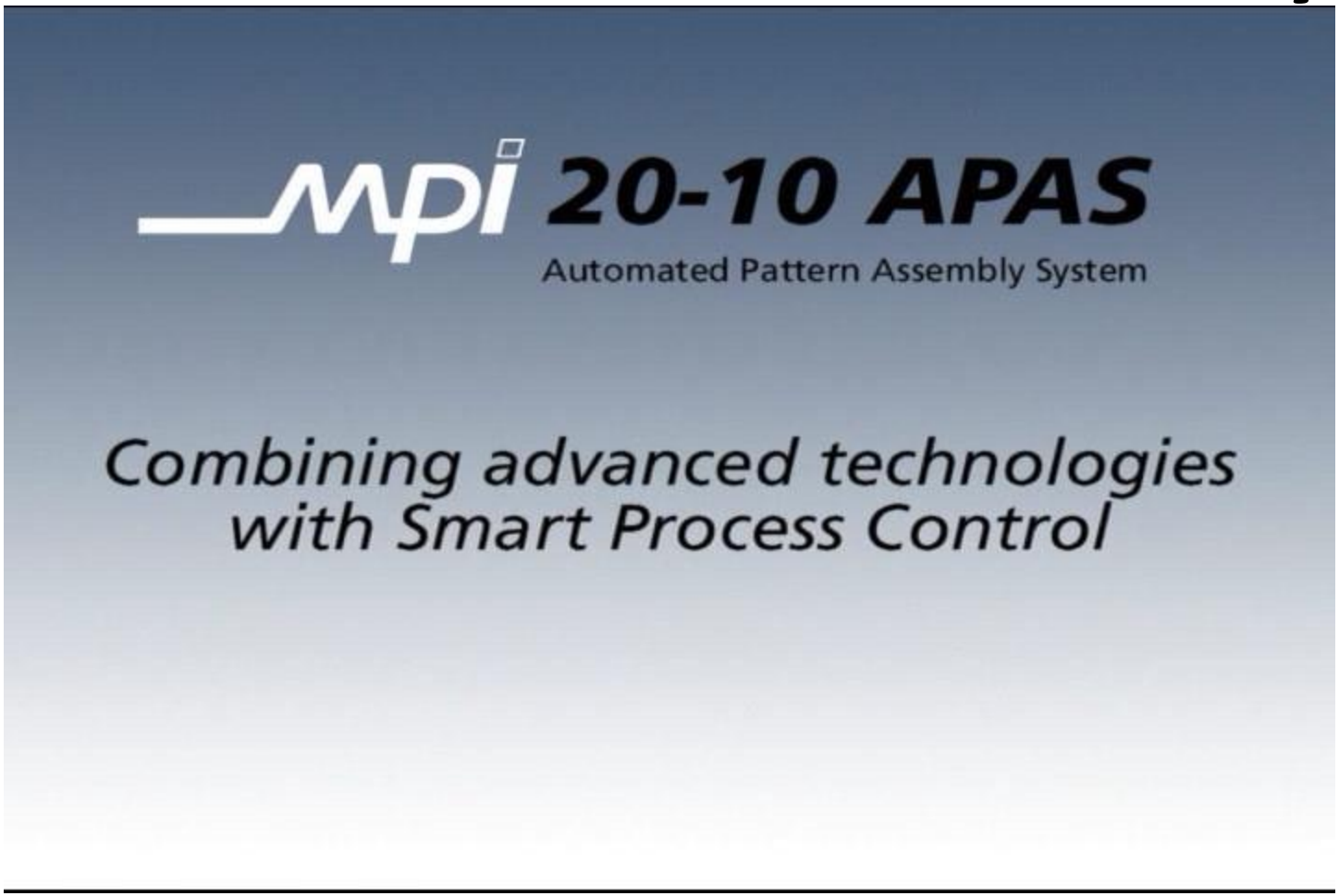
- Patterns of a similar size
- Patterns of a similar shape
- Patterns with a common gate
- Patterns mounted on the same runner
- Spacing of the patterns on the runner
- The angle of pattern to the runner bar
- The type of mechanism that is used to hold the patterns during the assembly process, e.g. grippers or vacuum

Automated Pattern Assembly

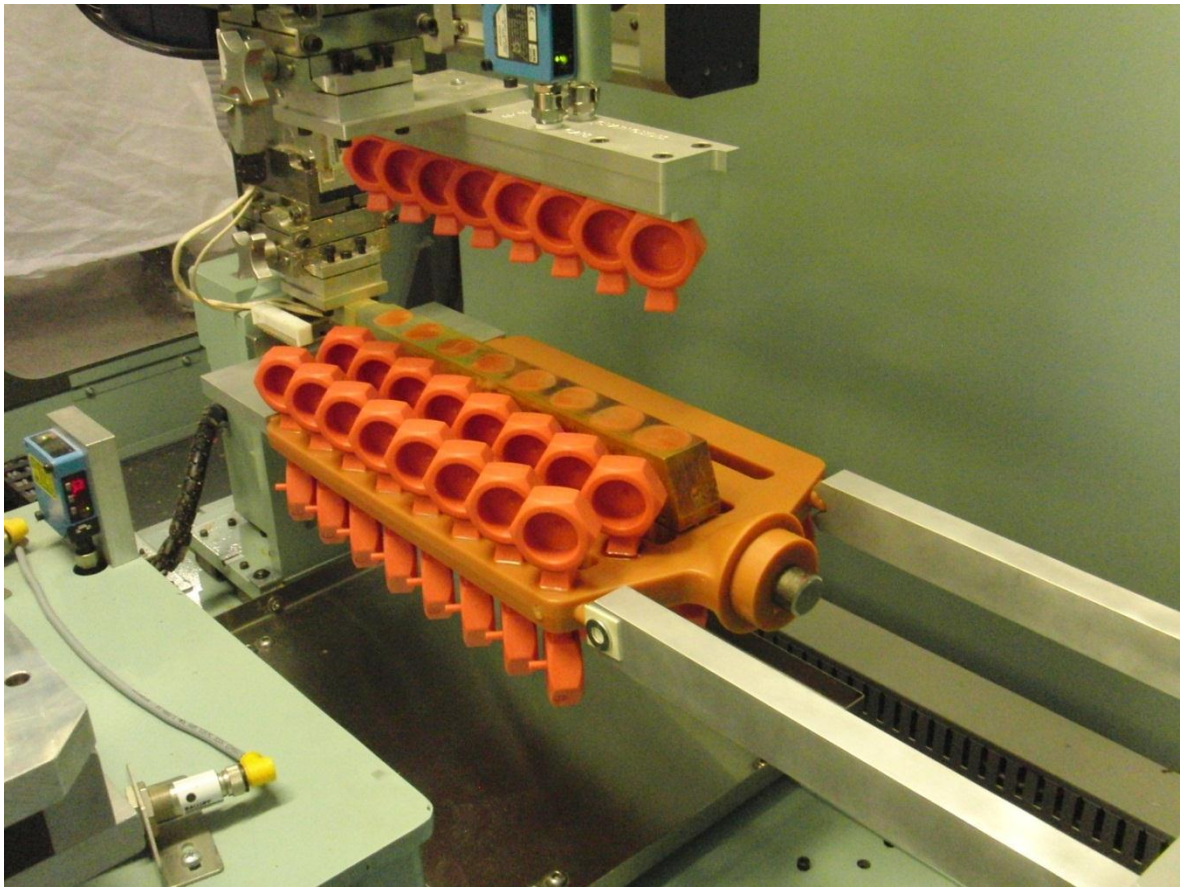
The design process requires :

- Photos of the assembly
- Internal pattern assembly documentation
- Solid model files of the complete assembly including:
  - Steel insert
  - Pouring cup
  - Any secondary or unique features

Automated Pattern Assembly



Outsourced Automated Pattern and Assembly



Outsourced Automated Pattern and Assembly

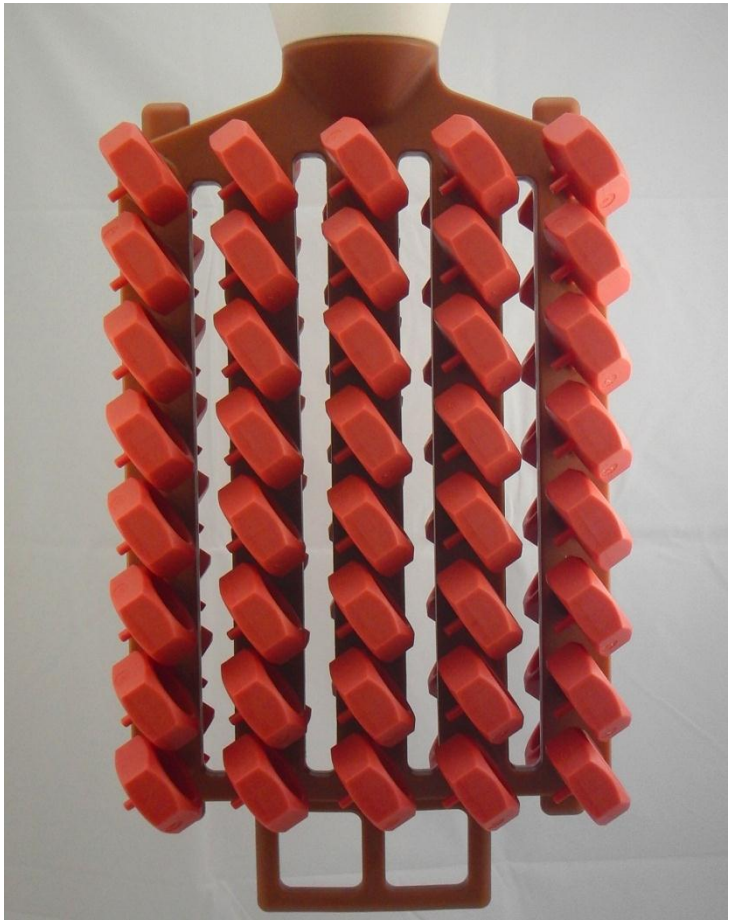
Unexpected benefit:

*"What **was** the **one finger rule** **now** is the **one finger nail rule**."*

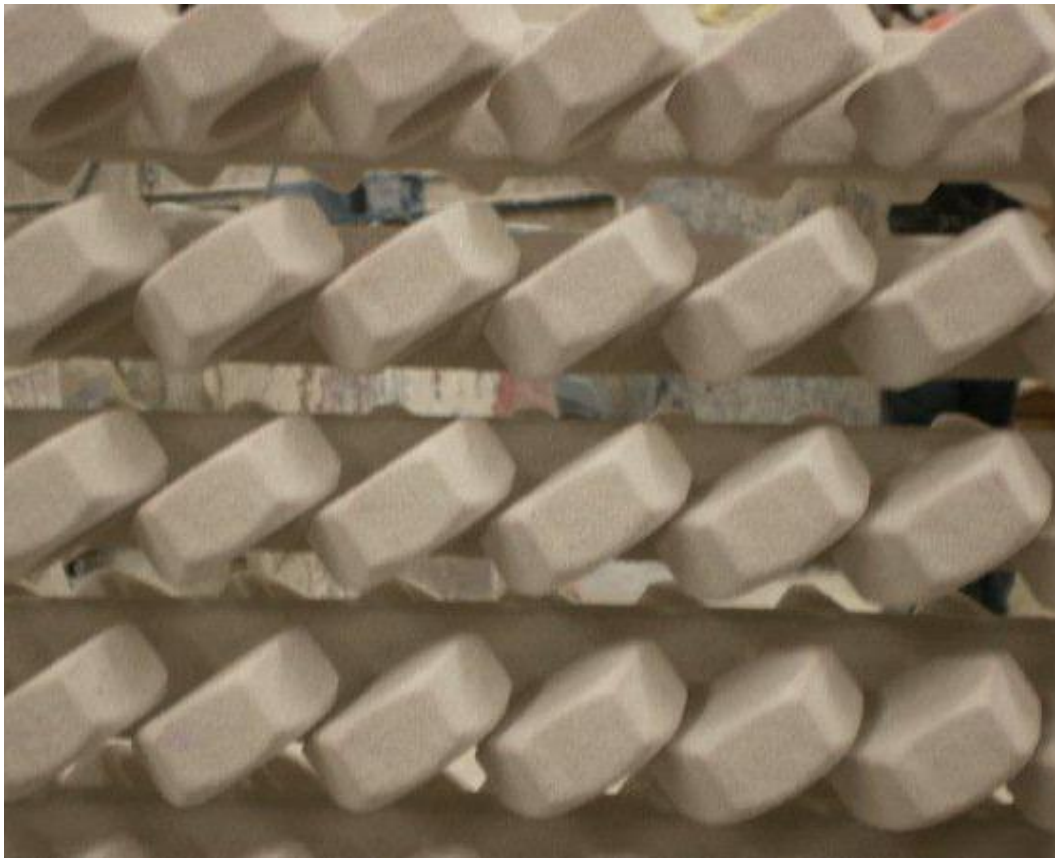
Mel Kman

President

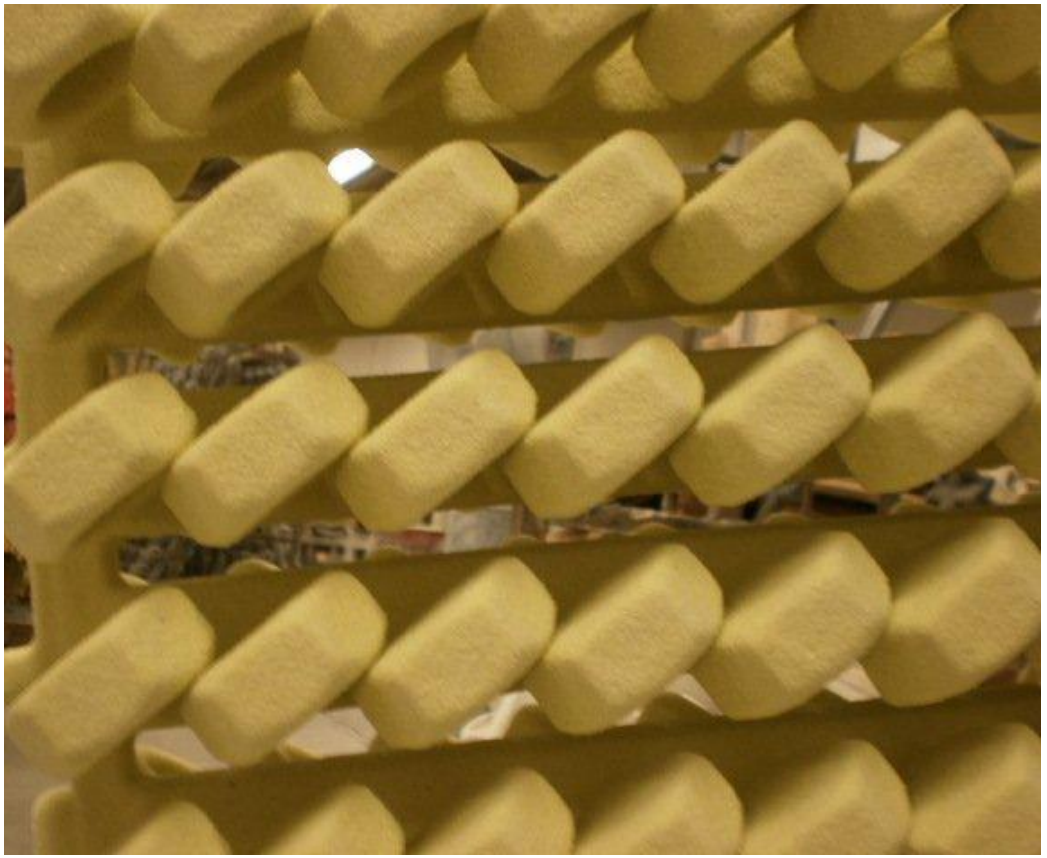
Avalon Precision Casting



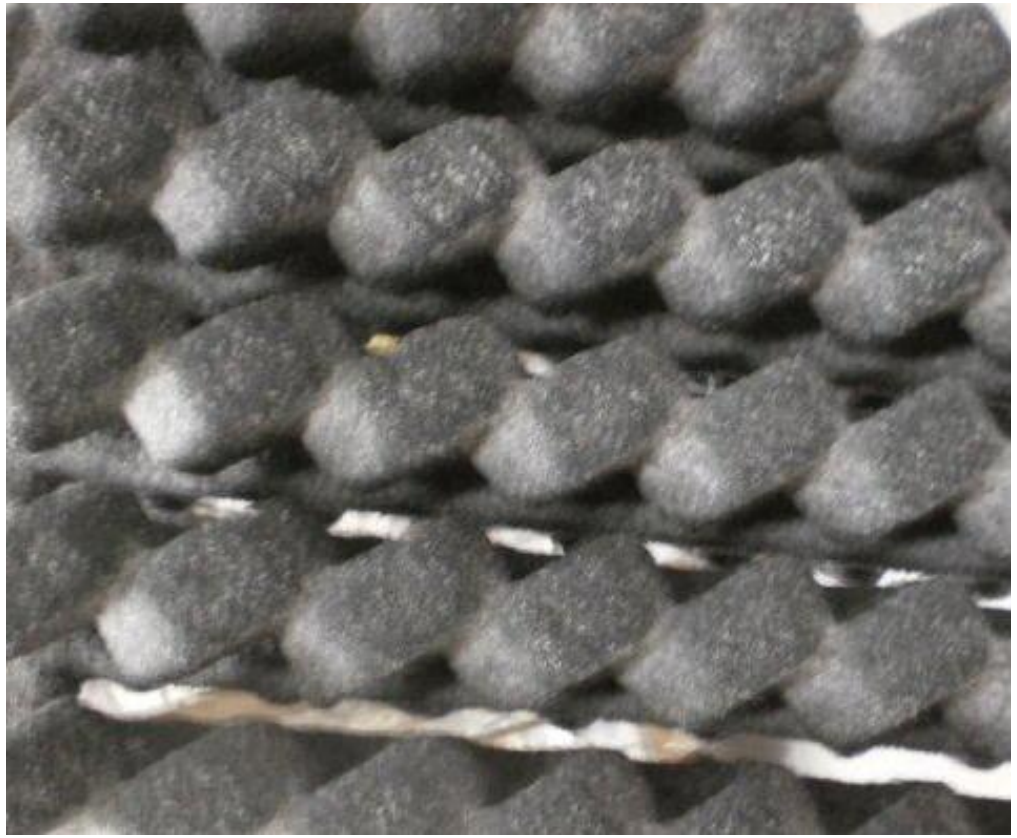
Outsourced Automated Pattern and Assembly
1st Coat



Outsourced Automated Pattern and Assembly
2nd Coat



Outsourced Automated Pattern and Assembly
3rd Coat



Outsourced Automated Pattern and Assembly
4th Coat

Outsourced Automated Pattern and Assembly
5th Coat

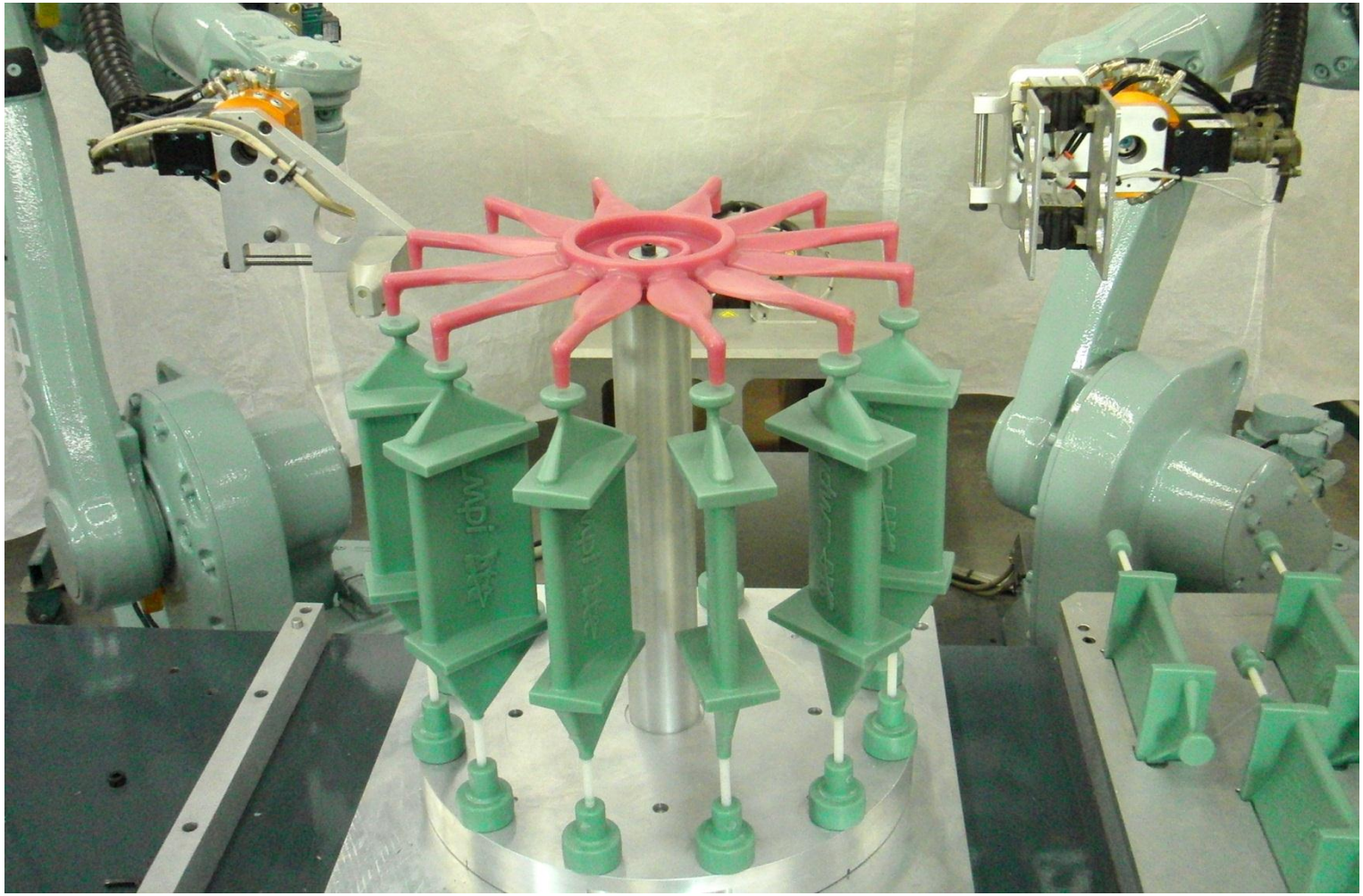
Outsourced Automated Pattern and Assembly
5th Coat with Seal Coat

Customer Results

INCREASED YIELDS + DECREASED SCRAP = INCREASED PROFITS

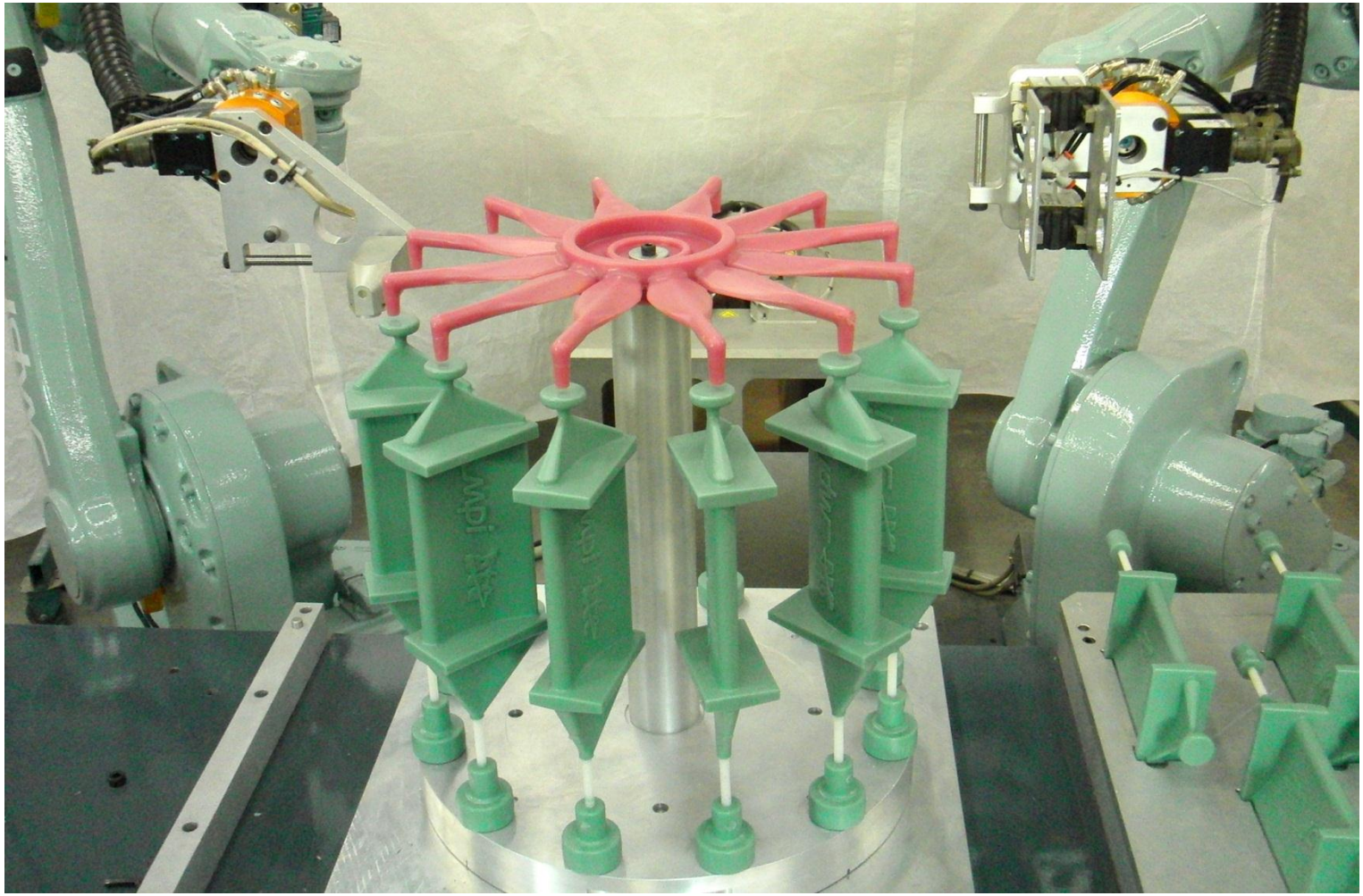
Automated Pattern Assembly of Single Crystal Turbine Blades

Robotic Assembly - Automation

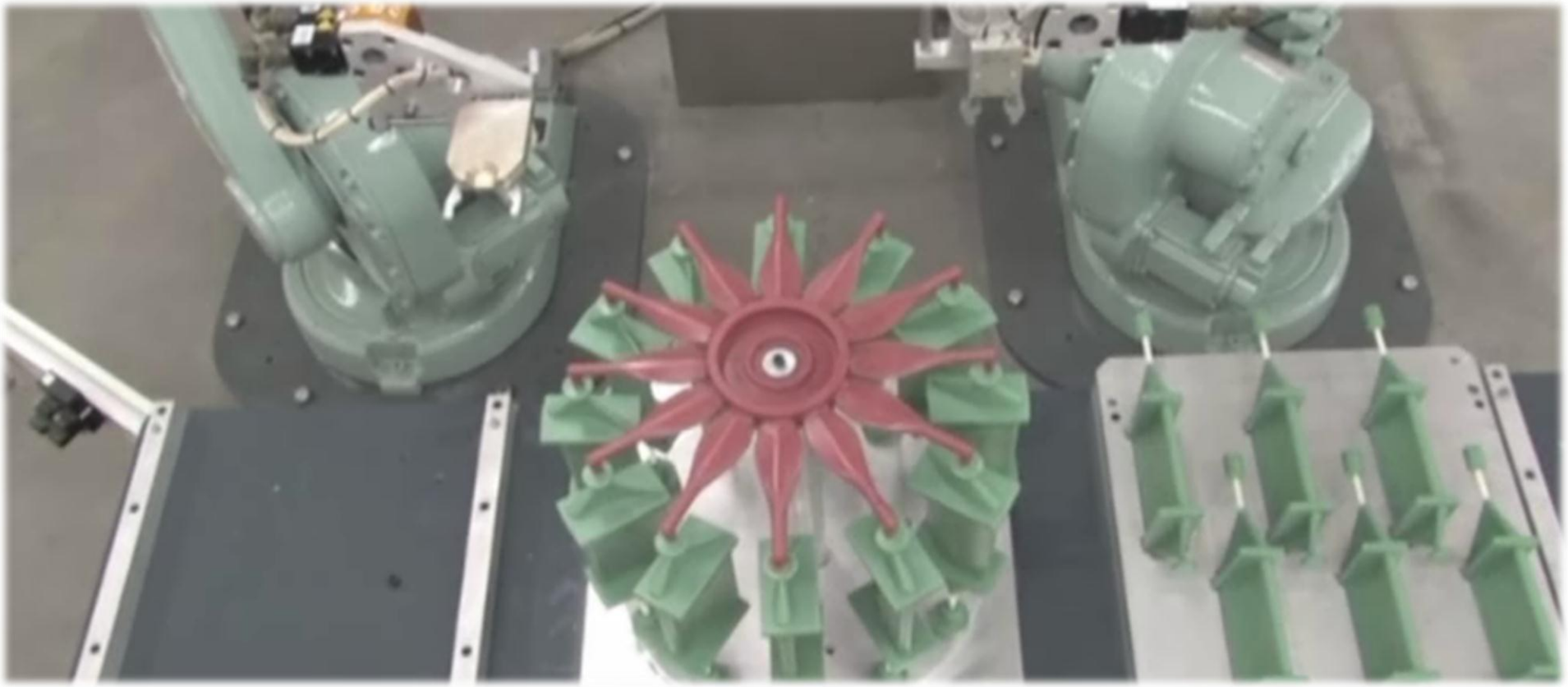


Robotic Assembly - Automation

Robotic Assembly - Automation



Robotic Assembly - Automation



Automated Assembly of DS and Single Crystal Turbine Blades

Results:

- Extremely uniform, repeatable and stronger assemblies
- A more uniform shell coverage due to accurate spacing
- Improved thermal gradient and metallurgical properties
- Decreased cycle times with reduced labor
- Higher casting yields

Customer Results

INCREASED YIELDS + DECREASED SCRAP = INCREASED PROFITS

Summary

- Automation is a clear means to reach many of the critical goals you set for your business.
- Automating your wax room will have a significant positive impact to your bottom line.
- Once you have made the commitment to automation you will begin to see more automation possibilities and they will be easier to implement so…

Why not automate?

Questions?