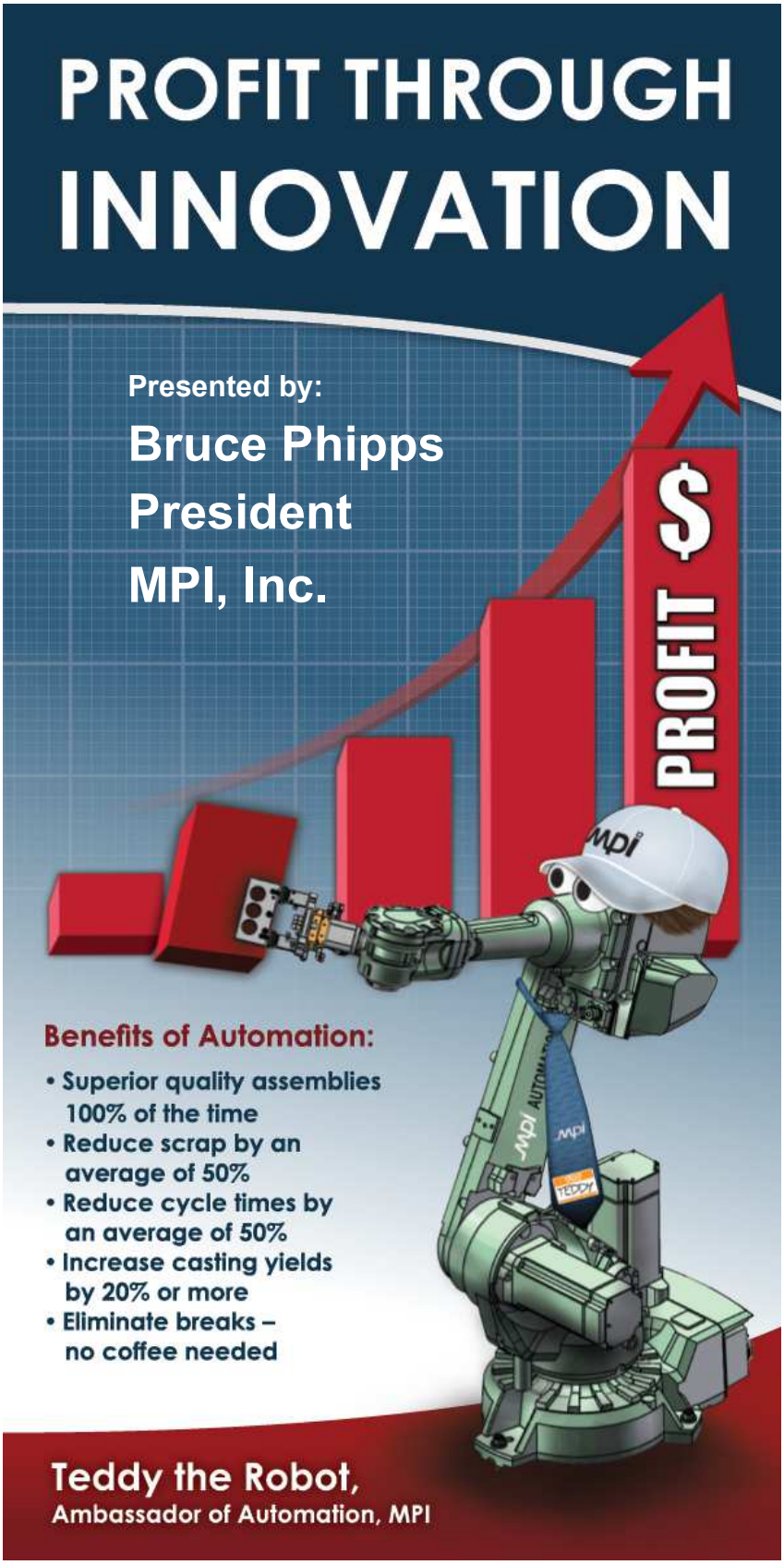
58th Technical Conference and Equipment Expo



Profit through Innovation

If I were to tell you we could increase your investment casting profits 100% you would most likely tell me I was nuts. Instead, how about I suggest to you that you could increase your castings per assembly by 20 percent or more? You may listen to that, because after all, who doesn't want to increase their casting to raw material ratio. How about decreasing your casting defect rate by as much as 50%? These are all achievable with the right innovation in technology. Combine these effects and you could see your profit per casting double. How can you possibly see these dramatic improvements?

The answer is automation.

> I recently read a good article on the subject of automation. Drew Greenblatt, the President of Marlin Steel Wire Products, LLC, a Baltimore based manufacturer of fabricated wire products speaks about his facility and the decision to automate. He believes that automation is critical to pursue, it is intrinsic to improving the livelihoods of employees and ensuring the survival of your business. After investing $2.5M in robots for his small factory Mr. Greenblatt points out that he now employs 25 people, compared to 18 when he purchased the company. According to Mr. Greenblatt "without automation we would have gone from 18 to zero". He boasts that they have "had six years of record revenue growth, record profit and record cash flow. And this has been due to a couple of things, but high on the list is automation". Drew talks about having a person work doing hand-bending of wire at a rate of 300 bends an hour. With four robots, he still has one person – now running the robots - and now gets 20,000 bends per hour.
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> March, 2011, *Automation World,* (pg 11-14)

We all know how automation has changed our world. The question becomes can we see the same results in our world? Why have we automated some processes in investment

casting, but not the wax room? This paper will discuss the benefits of automating the wax room, and how to approach assessing your processes for automation.

Why Automate?

We know the trend of our industry is for high cost, lower production run castings. We believe that automation is reserved for a world of high volume long production runs. As such we wonder if there is value in automating, will the automated equipment be flexible enough to respond to our changing needs. I believe, Mr. Greenblatt would pose a different question, can we afford to not automate our processes. Many successful organizations have demonstrated in order to be competitive, to maximize your human capital; you must take advantage of automation. The answer to the question of why automate is pretty straight forward, to make more money by being more competitive. Low volume castings can be automated and show the same type of ROI that high volume castings produce. This requires automation equipment that adapts to your needs and can do so with minimal down time.

What are the Direct Benefits of Automation in the Wax Room?

The benefits of automation in the wax room are many and can be summed up as: Higher Casting Yields at Reduced Operating Expense, which net a significantly greater profit per casting. The increased yields come from three main areas; increased patterns per assembly, less defects and less variation in both patterns and assemblies. More and more of our customers are sharing data with us that show that a high percentage of casting to casting variation is coming from the handling of the wax patterns by the operator. By replacing the operator with a robot the defects and variations are reduced and the number of patterns per assembly can be optimized. How can we do this effectively?

Automation Experience:

We have some great stories to tell from successful automation projects covering:

1. Automated Injection
2. Automated Assembly of DS and Single Crystal Assemblies
3. Automated Pattern Assembly

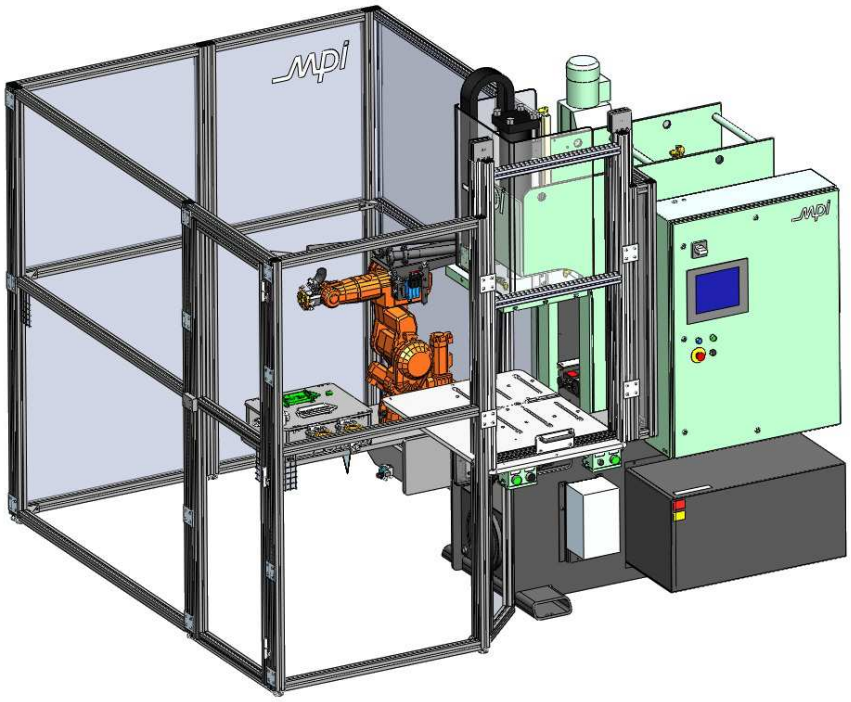
Interestingly enough this all represents technology no one wants to share. The ICI tries very hard to have speakers who will share foundry success stories and supply you with real hard facts of what they did and the gains they achieved. This was the goal of this paper. However, I can't tell you who all the players are. And why can't I? Let's put you in their situation. If you had a competitive edge in the production of your products would you want your competition to know how you are doing it? Would you want to reveal your latest technology? Would you want your competitor taking advantage of the real gains in productivity and reap the same rewards in profitability? Clearly the answer is no, so bear with me while I tell you the success of automation without the ability to tell you who is winning.

Example #1

Automating a Wax Injection Machine

MPI is presently working on some projects that integrate a robot to an injection machine creating a fully automated injection cell. Due to the sensitivity of these projects there is presently little data that we can share. This being said it has been recorded by several of our customers that the manual handling of the wax pattern creates pattern to pattern variation. Depending on the pattern geometry, this variation can be the cause for as much as 50% of the metal scrap. By automating the injection process, including secondary operations to the patterns, much of this variation can be eliminated.

By marrying a semi-automatic injection machine to a 6 axis robot and creating a fully automated cell gives us the ability to perform the following tasks.



1. The robot picks up a combination air knife/die lubrication nozzle assembly and precisely manipulates the nozzle assembly to:
    a. Clean the die of any foreign material, flash etc., using the air knife
    b. Lubricates the die with mold release with more accuracy and repeatability than is possible by a human
    c. The robot picks up a ceramic core and manipulates the core for inspection
    d. Reads the bar code on the core and records the core to a particular injection
    e. The robot accurately places the core into the die
2. The injection press closes the die and starts an injection cycle
3. While the pattern is being injected the robot
    a. Removes the previous pattern from the setter and trims the injection runner from the pattern
    b. Places the pattern into a tray on a conveyor
4. The injection press opens
5. The robot removes the pattern from the die and places the pattern in a setter for cooling; the setter maintains the patterns critical dimensions while reducing the injection cycle time.
6. The entire cycle repeats until the tray is full

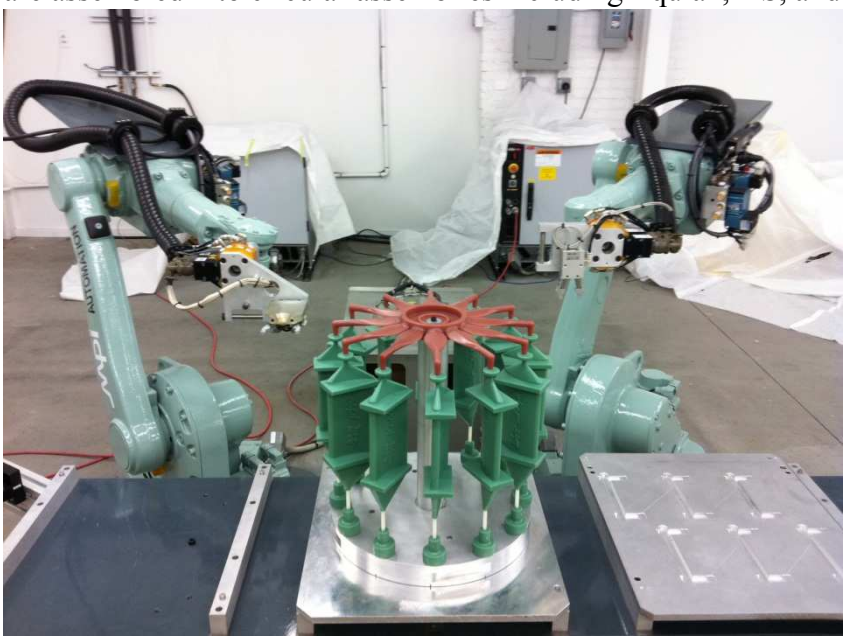
7. Once the tray is full the conveyor transports the tray out of the cell
8. An empty tray is moved into the load position
9. Enough trays are loaded into the cell so that there is no need for human intervention for several hours of production.
10. The cycle repeats until you tell it to stop.

Our customers have seen huge productivity gains from the automated cells as compared to an operator controlled injection machine. These gains include:

1. Twice as many patterns from an injector when run automatically as the same machine run with an operator.
2. The patterns that are produced automatically had yields that are 10 to 50% higher than the same die run with an operator, why?
    a. Reduced pattern defects from improved die spray coverage
    b. Reduced pattern distortion from improper manual handling of the patterns
    c. Uniform pattern trimming, minimal variation
    d. The cell runs more hours, no coffee brakes
    e. Higher casting yields because of reduced pattern defects.

Example #2

Aerospace Blades which are assembled into circular assemblies including Equiax, DS, and Single Crystal



We are working with several customers in the industry to automate the assembly of turbine blades. Their goal is to retain or regain their leadership position by reducing costs and

improving profits. They are investing in their future and these companies are real innovators. The process I will take you through will show how we are partnering with our customers and the steps we are taking to achieve their goals. Because of the proprietary nature of the projects and their sensitivity, we have combined them all into one group. The video you are seeing is showing the assembly of patterns that are generic and have been made by MPI for demonstration purposes. These are not real turbine blades but they do show the actual automated welds.

Our customers all have a common approach, to automate an assembly and eliminate the variability that comes from manual assembly. It has been proven over and over again that variation in the wax assembly creates metal scrap.

Today turbine blade assemblies are as unique as the engineers who designed the assemblies. The challenge is how do we automate such a variety of assemblies? It all starts with a close partnering with our customers and working together toward a common goal.

What are the steps that we are taking to achieve this goal?

1. There are a lot of wax parts that make up the assembly that were previously extrusions. These extrusions due to their very nature are extremely variable on their own; now add the human element of forming the extrusions into a final shape and you have variation added to variation. We work with the customer to eliminate the extrusions and replace them with injected patterns. In doing this we are able to maintain part to part uniformity.
2. Many patterns which were previously manually assembled into a subassembly from patterns, extrusions or a combination of both are redesigned into a single injected subassembly. This approach eliminates manual assembly while reducing the amount of patterns that need to be welded into the final assembly.
3. Wax parts which were previously welded on vertical planes where wax dripping was a problem have been redesigned for horizontal welds allowing for automated

drip free fusion welds with 100% penetration. This horizontal weld can be done two different ways by:

   a. The part can be redesigned so that the weld is in a horizontal plane or
   b. The entire assembly can be manipulated using two axes of movement so each weld can be positioned for an optimal horizontal drip free weld.

4. The turbine blade wax patterns which require a grain selector are assembled through the injection process as a single pattern. This eliminates the manual assembly of the grain selector to the pattern.
5. All of the uniform subassemblies can now be welded automatically and very accurately into the final assembly using two 6 axis robots working in tandem. One robot does the wax melting and the other robot does the pattern manipulation and together they perform a 100% fusion wax weld.

The gains that are able to be achieved by automating the assembly are:

1. Extremely uniform and repeatable assemblies offering improvements in:
   a. Increased strength of the wax assembly
   b. A more uniform shell coverage due to accurate spacing
   c. Improved thermal gradient of the final shell
   d. Improved metallurgical properties
2. Decreased cycle times
3. Reduced labor costs
4. Higher casting yields

This is an example of current ongoing work to automate Equiax, DS and Single Crystal Assemblies. We do not have specific casting yield improvement numbers that we can share with you at this time but the results are significant and the work with our customers continues.

Example #3

Avalon Precision Casting

Outsourced Automated Pattern and Assembly Production

Avalon is a job shop foundry specializing in commercial and aerospace hardware components. Avalon is certified to ISO 9001:2008 ANAB Accredited and is also PED certified to EN 764-5, Article 4.2.

I want to thank Avalon for allowing us share their name, and specifics.

Management at Avalon has wanted to embrace automated pattern assembly for some time but was reluctant to make the required capital investment. Their biggest concern was a lack of factual data to substantiate the potential ROI. Avalon worked directly with MPI to develop a program where MPI provides complete assemblies, which are ready for the shell room from MPI's automated pattern assembly division. This solution allowed Avalon to get into automation without making the investment in automation equipment. MPI and Avalon have worked closely together to select the correct parts to be automated and establish families of parts that utilize common tooling. MPI now injects the runners and patterns needed, and then completes the assembly process using MPI's Automation equipment. The shell ready assemblies are then delivered to Avalon. Avalon's goal in this endeavor no doubt includes increasing the profitability of their operation. According to Mel Kman, the company owner and President, "I want cost savings while improving quality". He also sees the foundry of the future being run with fewer manual laborers; Mel feels that a fully automated foundry would significantly reduce the cost of doing business.

The results are assemblies with more patterns per assembly, higher metal yields and increase casting yields.

Mel provided the following information to be shared with the industry:

1. We have automated several different assemblies with patterns per mold increasing between 15% and 28% depending on the assembly.
2. Metal yield has increased between 23% and 31%, again depending on assembly.
3. Overall yield has improved 0.8% over an already low scrap rate.
4. There was a pleasant and much unexpected surprise. The tighter pattern spacing available with the automated process caused bridging of the shelling material between the parts. This bridging allows for less shelling material per assembly. Another net savings! Mel stated "What was the one finger rule now is the one finger nail rule." Mel is now a believer. This had no impact on the metallurgical properties of the parts.
5. Mel pointed out that since the assemblies were being shipped into Avalon in a large batch quantity it defeated the goal of lean. In spite of the change, Avalon was soon able to integrate the large group of molds seamlessly into the daily production flow.
6. Previously the runners were made by gravity pour into an open top die; now that they are injected they have a smooth surface finish, virtually eliminating the potential for inclusions in the castings.

Again I want to thank Avalon for making this information available to the industry.

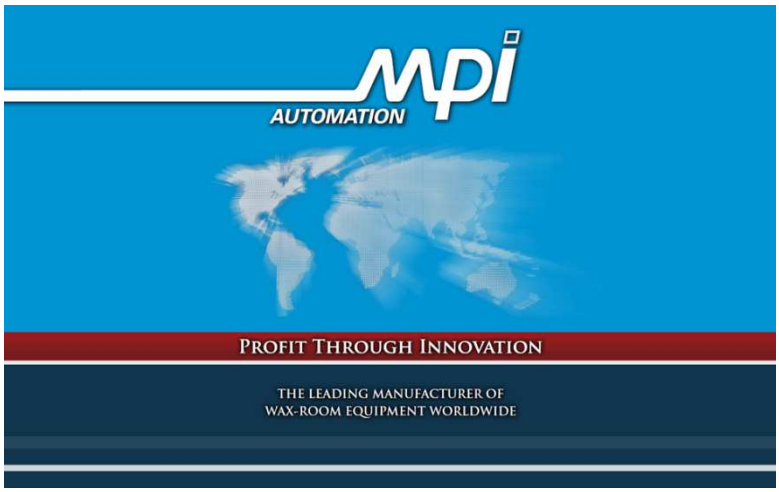
Conclusion

We have looked at automation in general and discussed the value automation brings to the manufacturing process. We know that automation has and will continue to be a valuable tool in many industries. Drew Greenblatt shared his success story in *Automation World*. This still leaves room for doubt about the value of automation or the ROI associated with automation in your wax room. The balance of this paper hopefully leaves little doubt in your mind that automation in your wax room is the right thing to do and now is the time to invest.

Automation will allow your organization to gain from:

1. Decreased Defects
2. Higher Casting Yields
3. Reduced Operating Expense
4. All netting a Significantly Greater Profit Per Casting

The leaders illustrated in the three case studies are on the path to long term business success. My hope is that you will embrace automation and the process control that comes with automation. I will leave you with some thoughts on how to go about justifying and ultimately implementing automation.



How can you approach Automation in your wax room?

Be selective in what you automate - all processes should be considered for automation, but not all processes should be automated.

1. Look at your total foundry operation and measure your casting scrap rate. Cliff Fisher of Wisconsin Precision Casting did a great article in the July and August issues of INCAST Magazine showing how they implemented its business software system which is now the foundation for the operation of the company. They now know what is happening in each operation and use the information for continuous improvement. Remember if you do not measure it you cannot improve it.

2. Analyze your scrap rate, where is your scrap coming from. What is the real root cause of your largest scrap contributors?
    a. If your scrap is coming from inclusions for instance, you want to look at pattern assembly and weld quality.
    b. If scrap is coming from cut off you may still want to look at pattern assembly, but it may be from warped inconsistent runners which are causing the defects.
    c. Perhaps you have scrap from castings that do not meet physical dimensional requirements. Look at the wax patterns to see if there is a handling issue.

3. Understand the ROI associated with each automation effort
    a. Scrap Reduction
        - Determine the cost of the scrap
        - Determine the impact of automation on the process – how much will it reduce or eliminate the scrap?
        - Calculate the savings generated through scrap reduction

b. Increased casting to metal ratio
    - Automation allows wax patterns to be placed on the runners more tightly
    - Work with a wax room automation supplier to determine the patterns (castings) per assembly that can be achieved. MPI has proven solutions that increased this ratio by 20% and more.
    - Determine the value of the reduced metal cost per casting.
c. Labor reduction
    - Determine the number of labor hours reduced through automation
d. Other ROI items – determine the value associated with:
    - Customer satisfaction – quality and delivery improvements
    - Safety – cleaner work areas with fewer, more highly skilled workforce

4. Be selective in how you automate - one process at a time using a phased in approach or all at once.
    a. Automation efforts do not require you to tackle the problem all at once. If your capital improvements budget limits the ability to automate your entire casting process, determine where you can get the most bang for the buck.
    b. To determine which area to automate first look to the ROI associated with each process step - where in your process is the most variation, what is the root cause of most significant defects and how can you increase yields?

5. Partner with a proven innovator in Wax Room Automation!