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Casting Yields are improved through Automation and Process Control in the wax room

The purpose of my presentation today is to present real life cases of foundries who have implemented process control and automation in the wax room.

The foundries represent a cross section of our industry and their common objective was to reduce costs, improve quality, increase yields, and increase productivity.

- Wisconsin Precession Casting Corporation - A foundry specializing in short run high value castings.

- Dolphin Precision Investment Castings - An automated foundry designed with the flexibility of rapid change over several times a day and huge seasonal swings in market requirements.

- Pine Tree Castings - A foundry that uses an automated wax cell to produce assemblies ready for shelling.

- Invest Cast Inc. -A foundry in the commercial market which is competitively producing castings in short to medium runs.

First let me define Process Control and Automation.

Process control is a concept that states: If you control the variations in your process you will control the outcome of your process.

This is accomplished by:
- Knowing the variations in your process and how they affect your end product
- Monitoring key parameters that effect individual operations
- Having equipment capable of maintaining a consistent process

Automation is more than just mechanizing a manual process to reduce labor cost.

Automation is the adaptation of improvements to your existing processes so that you eliminate process variations and increase productivity by maximizing the use of automated equipment.

Implementation: This is what the four foundries did to achieve their objects.

WISCONSIN PRESISION CASTING CORPORATION

- Wisconsin Precession specializes in short run high value castings.

Management made a strategic decision to redesign its operation to be more efficient in low volume high value products. The goal was to turn around small quantity orders quickly and efficiently with each department producing 100% yields.

That's right 100% yields.

To achieve their goal they implemented Flow Manufacturing and a Process Control System.

The first department to implement Flow Manufacturing and Process Control was the wax room. The wax room was chosen because it was the first step in the process and its impact on the entire down stream operation is critical.

This was both a strategic and critical decision, as the wax room is not always looked upon as a critical step in achieving casting yields.

The review of the wax room showed:

- The process was not consistent.
- Procedures were based on memory.
- Each wax injector was considered unique and setup cards were specific to every wax injector
- No measurements were taken or monitored
- There was no accountability

IMPLEMENTATION

To bring the wax room process under control:

- A new wax was selected that was suitable for different products from large bulky parts to thin walled parts.

- Because wax temperature is the key process variable for making repeatable wax patterns Wisconsin made a decision to run every wax injector at the same wax temperature for all products.

- Controlling wax temperature in the process was more productive than adjusting the temperature to reduce cycle time. A constant wax temperature…
    - Reduces the variability in the injection process
    - Fewer adjustments were required during set up
    - Part change over problems was eliminated.
    - Reduces the wait time for wax temp to change
    - Promotes Flow Manufacturing.

- Supervisors can now visually monitor the process by observing if the wax temperatures on all injectors are set the same.

- Operators receive continuous training and are given the information that allows them to do their job.

- Each job has an order/process sheet that is followed and monitored through out the foundry process.

- The wax supplier must provide test results for each wax shipment and a batch-to-batch historical trend to see if the wax properties are drifting.

- Every wax pattern injected is counted and identified as either setup scrap or production scrap. Operators are accountable for scrap which is logged into Wisconsin's Guardian information system

- Limits are set for wax flow and wax pressure. Changes can be made only by a master technician or a supervisor.

- Wax temperature (actual wax temperature as it comes out of the nozzle, not from machine instrumentation) is measured two times per shift.

- Wax patterns and castings are measured on a weekly basis to ensure that the process is not drifting.

- Once a week process review meetings are held to identify and eliminate process problems.

INJECTOR TO INJECTOR PROCESS CONTROL

Due to production needs, it is not always possible to run the same job on the same wax injector. To maintain process control from one injector to another that did not have built in process control capability Wisconsin used MPI'S 20-20 graphing unit which gave them the capability to:

- Monitor process control from machine to machine
- View the injection process to facilitate good process decisions
- Move a wax die to multiple injectors and achieve the same quality results
- Calibrate the wax injectors

WHAT WISCONSIN PRECESSION LEARENED

As Wisconsin Precession found out implementing flow manufacturing and process control is not easy. It requires a cultural change and:

- A champion for Process Control. This individual has to continually be a driving force, reinforcing the company's goals.
- A good operating plan with defined expectations
- Trained personnel who are accountable for their actions
- Feedback with a lot of communication and patience
- An information system to document information about the process.
- Equipment capable of providing repeatability so the process can remain in control.
- Implementation will take time, you cannot rush a good thing
- A key issue was the willingness of employees to embrace change and accept accountability for their jobs.

WISCONSINS RESULTS WERE WORTH THE EFFORT

- Procedures made it possible for all operators to produce quality products with minimal scrap.
- Less setup time
- Improved dimensional accuracy in castings.
- Less pattern rework
- Less effort to supply quality castings and reduced customer returns.
- Lower cost to produce castings with higher quality in smaller quantities.
- **Scrap was reduced from 17% to 3%**
- **Sales increased 72% without adding employees**

MANAGEMENT COMMENTS

Achieving good process control requires high expectations. Don't settle for less.

Implementing Process Control through Flow Manufacturing is the path Wisconsin Precision is taking to achieve their goals of Zero scrap.

DOLPHIN PRECISION INVESTMENT CASTING

Dolphin produces golf club irons for Ping Golf Inc. and they are the only remaining major caster of golf club irons in the United States.

How was Dolphin able to prevent their products from going offshore to low cost producers?

They were able to prevent this by implementing Process Control and Automation.

Dolphin is an example of a company that under took a thorough review of its process and made changes to adapt the process to Automation.

One of the challenges that Dolphin faced was the cyclic nature of their business. Each year the requirement for golf clubs goes from a low of 3000 clubs per day to a high of 12,000 clubs per day.

Dolphins answer was to build a highly automated foundry that could turn capacity on and off to meet demand without hiring and training temporary personal to be skilled operators.

When Dolphin began their analysis for an automated foundry they first looked at casting cutoff due to its high labor content.

Management quickly realized that their manual process of pattern assembly could not provide the accuracy and consistency to support cost effective automatic casting cutoff.

To achieve the required accuracy and production rate Dolphin asked MPI for an automated pattern assembly solution.

Collaborating as a team MPI and Dolphin designed a system that:

- Automated Pattern assembly
- Increased the number of patterns per assembly
- Used one set of quick change tooling for their complete range of clubs
- Provided accuracy and consistency for automated of cut off

Dolphins Automated Foundry now consists of:

- Paste wax injection
- Automated Pattern Assembly
- Robotic dipping in shell room
- Manipulator for metal pouring
- Automation of casting cutoff

THE RESULTS ACHIEVED BY DOLPHIN ARE IMPRESSIVE

- Paste injection cut the pattern cycle time in half
- One operator runs two (2) MPI APAS (Automated Pattern Assemble Systems) producing 18 assemblies per hour as compared to one manual assembler producing 4 assemblies per hour. (Rev H) That's a **78%** reduction in labor cost and a 350% increase in productivity. (Rev H)
- APAS runs 24 hours per day during peak demand. Rapid change over of products 8-10 times per day
- All operations in the foundry are matched for the same flow using the pull concept.
- Scrap from inclusions associated with assembly went down to almost zero.
- Temporary personnel are now only used for unskilled tasks.
- Quality and training issues caused by hiring and then laying off personnel were eliminated

MANAGEMENT COMMENTS

Pete Poleon, the plant manager of Dolphin commented:

Dolphin is committed to Lean Manufacturing. The pull system of equal flow allows all departments to have the same flow with no inventory build.

The APAS is a key element in allowing this to happen.

- The APAS Human Machine Interface is user friendly, limits what the operator sees, and yet has a wealth of information in the background.

- The APAS learning curve is short and straightforward.

- The Internet connection to MPI provides for very little machine down time. For example when a thunderstorm shut down a machine MPI went on line to Dolphin and resolved the issue remotely.

- If something should happen to the golf business Pete feels confident that the APAS can easily change to other products due to the flexibility and ease of tooling design.

PINE TREE CASTINGS

Pine Tree Castings, a division of Sturm Ruger, has been implementing lean manufacturing throughout their operation.

This example shows us the productivity gains and reduced labor time achieved from implementing an Automated Wax Cell.

MANUAL PROCESS

The comparison of manual vs. an automated wax cell was accomplished by measuring the time it took for the existing process of three separate operations using three operators, as compared to an automated wax cell using one operator. To ensure a direct comparison, the same pattern die and wax were used. The assembly used for the comparison consisted of 40 patterns.

The existing process consisted of:

Operation 1
One operator ran a semi-automatic wax injector for patterns, inspected the patterns, placed the patterns in trays and trimmed off the runner.
Time: 10 minutes and 55 seconds.

Operation 2
A second operator made runners for this and other assemblies. Only the time to make runners for this assembly was included.
Time: 1 minute.

Operation 3
A third operator ran MPI's APAS which automatically welded the 40 patterns to the assembly.
Time: 6 minutes and 27 seconds.

The total labor time to make one assembly of 40 patterns was
18 minutes and 22 seconds.

AUTOMATED WAX CELL

Pine tree reevaluated the three operations and made the decision to replace the semiautomatic wax injector with a fully automatic wax injector. In doing so the injection time was now less than the pattern assembly time. This allowed them to move the three machines into a single cell operated by one person.

The automated wax cell consisted of:

- A fully automatic wax injector MPI 45-12 for injecting patterns
- An MPI 54-50 semiautomatic wax injector to inject runners

- An MPI 20-10 APAS to automatically assemble (weld) the patterns to the runner

The Automated Wax Cell allowed one operator to inject patterns and runners, trim, inspect and load the wax patterns directly into the APAS. . This same operator also removed the finished assemblies from the APAS and placed them for transfer to the shell room. Thus only one operator ran the entire wax cell.

- Total labor time to produce an assembly was 6 min. and 27 sec.
- The reduction in labor time for one assembly was from 18 minutes. 22 seconds to 6 minutes 27 seconds
- That's a reduction in labor of **65%**
- Or to look at it another way an increase in operator productivity of **185**%
- Two operators were freed up for other tasks.

WHAT DID WE LEARN FROM THIS EXAMPLE?

- The wax cell could be run by one operator vs. three for the manual process

- An automatic 45-12 injector produced more patterns than an operator running a semi automatic injector.

- The automated production of wax patterns and runners was matched to the automated cycle time of the APAS.

- The equipment used was capable of maintaining continuous production and consistent quality.

MANAGEMENT COMMENTS

INVEST CAST Inc.

Invest Cast is a commercial foundry which produces a wide variety of parts.

Their philosophy is to embrace technology which will enhance the bottom line.

Invest Cast saw that they could increase their productivity and casting yields if they could reduce pattern assembly time, improve the assemblies weld quality and increase the number of patterns per assembly.

To achieve this goal would require:

- Process Control of the wax welding process
- Reduction of the spacing between patterns on the runners
- Equipment that could automate and control the wax welding process

Invest Cast made a strategic decision to adapt its process for automation using the MPI APAS as a vehicle to achieve their goals. Invest Cast was very open and took a fresh look at how an assembly could be made to achieve the maximum throughput for the entire foundry operation from the wax room through cutoff and finishing.

- Working as a team Invest Cast and MPI designed "Foundry Friendly" wax assemblies. These are assemblies that are both operator and process friendly encompassing the entire foundry operation. In most cases this meant more patterns per assembly. But in some cases it actually resulted in fewer patterns per assembly in order to reap the benefits of an assembly that was more "Foundry Friendly".
- In either case all the assemblies have pattern spacing too close for manual assembly and too close for other types of automated pattern assembly equipment.

WHAT DID AUTOMATION AND PROCESS CONTROL DO FOR INVEST CAST?

Following are examples of increased productivity from Automated Pattern Assembly as compared to manual assembly.

Part Number 1:	
Manual assembly	175 patterns per hour
APAS	300 patterns per hour
Percent increase	71%

Part Number 2:	
Manual assembly	45 patterns per hour
APAS	110 patterns per hour
Percent increase	144%

Part number 3:	
Manual assembly	230 patterns per hour
APAS	320 patterns per hour
Percent increase	39%

Part number 4:	
Manual assembly	220 patterns per hour
APAS	450 patterns per hour
Percent increase	105%

Part number 5:	
Manual assembly	170 patterns per hour
APAS	325 patterns per hour
Percent increase	91%

Part number 6:	
Manual assembly	210 patterns per hour
APAS	250 patterns per hour
Percent increase	19%

As I stated above, for a part to be "Foundry Friendly" it does not necessarily mean that it always has more parts per assembly. Part number 2 for example went from 36 parts per assembly using the manual process to only 16 parts per assembly using APAS. Yet the number of patterns assembled per hour was increased by 144% and the assembly flowed through the foundry easier resulting in higher casting yields.

Part number 4 on the other hand was loosing money when assembled manually with 60 patterns per assembly. When converted to a "Foundry Friendly" assembly using APAS they were able to assemble 76 patterns per assembly, 104% more parts were assembled per hour and the castings are now running through the foundry with a positive profit margin.

MANAGEMENT COMMENTS

Automation of the wax pattern assembly process not only reduced our labor cost and increased our yields it also allowed us to save jobs that were previously not profitable.

DOWN STREAM OPERATIONS

These four companies have shown clear examples of how they were able to make gains through the implementation of process control and automation. These gains did not stop in the wax room. The gains multiply as the assemblies move through the foundry.

Let's look at how the gains in the wax room have impacted other down stream operations.

For example, when using the APAS one of our customers increased the number of patterns per assembly from 40 to 48 without changing the runner size.

This resulted in:

- 20% gain in the number of patterns per assembly
- 20% more patterns dipped in the shell room
- 20% more parts per metal pour
- 20% more parts cut off from each assembly
- A 20% increase in casting throughput.

In addition to these increases

- No additional metal was poured to make the runner, only the metal needed for the 8 additional castings
- Less metal in the runner means less metal to re-melt or reprocess

Weld quality is 100% repeatable which means:

- No inclusions from poor welds
- No Rework from pour welds
- No pattern damage from manual assembly

Automation and process control will produce more castings with less labor cost and no increase in manufacturing overhead (except for depreciation of new equipment). This means increased gross margins and the ability to be price competitive.

REV H

CONCULSIONS

- Process Control must start in the wax room.
- Adapting your process to fully realize all of the benefits of process control and automation equipment is worth the cost and effort for the long term gains.
- A wax room under control can result in wax room and downstream gains of:
  Labor cost reductions in wax room of 25%-80%
  Productivity gains of 100%-300%
  Casting yield gains of 20%
- Process control is an essential component for manufacturing concepts whether it's Flow, Lean, Flex, Cell or Automation.
- Equipment must be capable of process control.
- Process Control and Automation will give foundries the tools they need to succeed in a an ever more competitive market