DEFECT PREVENTION IN PERMANENT MOLD CASTING THROUGH PROCESS CONTROL

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ARTICLE TAKEAWAYS:

- Defects are not free
- Processes for preventing defects
- Understanding all of the variables

The proverb, "An ounce of prevention is worth a pound of cure", applies to defects in the permanent mold casting industry. Defects, as defined by the foundry industry, are variances from a desired outcome.

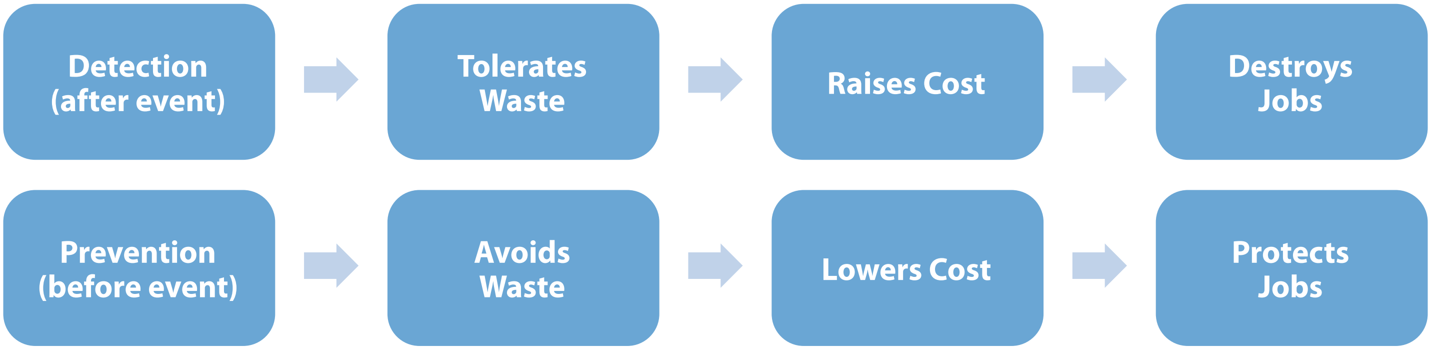
The cost of scrapping a casting is extremely high when compared to preventing the defect. Hence, it is better to take measures to prevent the defect as early as possible. The further down the manufacturing process, the more costly the defect becomes. **Automotive casting defects can be found in the following phases of the casting cycle:**

- In the dip well
- At the casting machine
- In the workcell
- After heat treatment
- During machining
- During assembly
- By the customer

As one can deduce, it is much less costly to detect a defect at the casting machine than for the customer to experience a failure. Defects are not free. When a defect occurs a person was paid to make it. Poor quality begets poor quality and lowers productivity throughout the process and if the defective casting goes to the customer it could lead to loss of the account or even the closing of the foundry. It is always better to prevent a defect rather than detect one. This principle can be expressed graphically:

Casting defects can be caused by:

- Inadequate training/lack of knowledge
- Poor communication
- Failure to document the problem/omission



- Varying from published casting procedures for the casting
- Accidental

A good method for preventing defects is to:

- Identify the defect/state the problem
- Get the facts
- Research for missing facts
- Test a trial solution
- Document and communicate the findings
- Develop a solution/take action
- Document and communicate the results

This process allows foundry engineers to use critical analysis to determine the cause and a solution for the defect. Defect prevention is not just the responsibility of the foundry engineer. Prevention activities should be planned into the responsibilities of each person in the casting process.

Identify the defect/state the problem – A correct, concise, complete statement of the defect/problem is mandatory for reducing the defect occurrence. For example, part number 123 has a consistent misrun in cavity two.

Get the facts – The facts or data should come from the job process documentation and production logs. Always ask Where? When? How? How often? Why? Who? Data acquisition software is the preferred method for getting the facts as it eliminates human error.

At minimum the following variables should be documented:

- Metal temperature
- Die temperature
- Die shut time
- Die open time
- Total cycle time
- Tilt speed
- Hydrogen level in metal
- Mold coating thickness
- Alloy composition
- Metal cleanliness

Research for missing facts – look for areas that are not in the production log or in the molders head. Quite often the machine operator knows what caused the defect.

Test a trial solution – many foundry engineers start the defect reduction process at this step and attempt to solve the problem without knowing the exact reason for the casting defect. Only change one casting parameter at a time. If the foundry engineer changes two or more parameters of the process and the defect is eliminated one cannot be sure which of the changes had the desired effect.

Restate the problem/Take action – Once you have done your research and tested a trial solution it is possible to restate the problem in a way that will lead to a solution. Some foundry engineers skip all the preceding steps and skip directly to take action. This can be very expensive. Making a change in a process is the last step in process control, not the first.

Remember, process control is an engineering discipline that deals with the mechanisms and algorithms for maintaining the output of the casting process within a desired range. The foundry engineer must communicate to the casting buyer what the capabilities of the permanent mold process are. They must both understand in advance what defects are acceptable and what justifies rejection.

Methodology for process control:

- Understand the process – before attempting to control the casting process the foundry engineer must understand the process and how it works.
- Identify operating parameters – once the process is understood, operating parameters (see list above) and other variables specific to the process must be identified for its control.
- Identify hazardous conditions – tilt pour permanent mold casting machines move in many axes and at extremely high pressure. A thorough risk assessment must be a part of the process design.
- Identify measurables (see list above)
- Identify points of measurement – once the measurables are identified, it is important to locate where they will be measured so that the system can be properly

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controlled. For example, where to place a thermocouple in a die so that it gives the relevant tool temperature.

- Select measurement methods – selecting the proper measuring device specific to the casting process will ensure that the system will be accurate, stable, and cost effective. Tilt pour casting machine signal types include:
  - Electric
  - Pneumatic
  - Hydraulic
  - Light
  - Radio waves
  - Ultrasonic
- Select control method – in order to control the casting parameters, selecting the proper control method is critical in controlling the casting process effectively.

  In the tilt pour process these method include:
  - On/off
  - Proportional
  - Integral
  - Derivative
- Select control system – most permanent mold casting cells utilize local control, but a distributive can be utilized.
- Set control limits – understanding the operating parameters gives the foundry engineers the ability to define the limits of the measurable parameters in the casting process.
- Define control logic – most tiltpour casting machines use some form of ladder logic and in some cases must communicate with other machine languages such as robots or CNC.
- Create redundancy – even the best control will have failures. It is important to design a redundancy system to avoid catastrophic failures or create an unsafe condition.
- Define a fail-safe – fail-safes allow the casting machine to return to a safe state after a control breakdown. In a tilt pour casting machine these include:
  - Spring to center hydraulic valves
  - Normally closed water and air valves
  - In line hydraulic velocity fuses
  - Motor protection
  - Lock out tag out
- Define lead/lag criteria – depending on the conditions within the casting work cell, there may be lag times associated with peripheral equipment such as ladlers, casting extraction devices, conveyors, and saws. Setting lead/lag times compensates for this effect and can reduce the possibility of creating a defect.
- Investigate effects of changes before/after – as noted above, investigating casting process changes in the control system, unforeseen problems can be identified and corrected before casting defects are created.
- Integrate and test with other systems - the proper integration of a casting process with the goal of eliminating defects in a work cell environment avoids conflicts between multiple systems with improved defect reduction, safety, cost and profitability.

The single best way to prevent defects is to keep the casting process in control. The benefits of controlling or automating the casting process are not only defect reduction, but it also increases worker safety.

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