PROCESS CONTROL for Investment Casting

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Who’s ever been given a problem to solve?

1. Were you able to find the root cause?
2. Did you follow a process to solve it?
3. How long did it take?
4. Did the problem ever come back?
We’ve all seen this:
What could the problem be here?

- Flat Tire
- Out of Gas
- Car Accident
- Pulled Over
- Mechanical trouble
- Taking a phone call/texting
- Spilled food/drinks
- Upset Children

WE NEED MORE INFORMATION TO KNOW!
The 3P’s of Process Control

- The Purpose - to learn techniques and skills to apply in the context of the problem-solving process

- The Process – Tools will be introduced and applied through the simulation of a real-life problems

- The Payoff – You’ll understand the problem-solving process, and how the process control tools are applied.
What exactly is a process?

“A unique combination of tools, materials, methods and people engaged in producing a measurable output.”
The goal of Process Control is to identify and reduce sources of variation.
What exactly is Process Control then?

And why is it important?
Process Control is

Definition:

Activities involved in ensuring a process is predictable, stable, and consistently operating at the target level of performance with only normal (common cause) variation.

Source: Business Dictionary.com
A Controlled Process ensures:

1. Consistent, high quality products
2. Avoidance of costly mistakes
3. Easy detection if “out of control”
4. A safe working environment
5. Customer confidence
To control any process, we must first understand the problem solving method.
Process Control Problem Solving Phases

- Define
- Measure
- Analyze
- Improve
- Control
The DEFINE phase is simply about defining the problem. This is done with a well crafted problem statement.

“If I had an hour to solve a problem, I'd spend 55 minutes thinking about the problem and 5 minutes thinking about solutions.” — Albert Einstein
What Makes a Good Problem Statement?

A *good* problem statement will

1. Define the PROBLEM
2. Include a MEASUREMENT method for the problem
3. Define the customer REQUIREMENTS
4. Define the current CAPABILITY to produce to these requirements
5. Define the GOAL
6. Define WHEN it will be completed
7. Determine the WORTH of correcting the problem

Is this Project Worth Doing?
Process Control Problem Solving Phases

Define → Measure

Define → Analyze

Measure → Improve

Analyze → Improve

Improve → Control
In the MEASURE phase we are **measuring the problem**.

In this phase we need to learn everything we can about the problem. The problem is the **key output variable (KOV)** we are trying to improve.

- Where do you get the data?
- Is the output **objectively measurable**?
- Is the data used to measure the output reliable?
- Based on the data, what is a **realistic goal**?

Is our Problem Statement still valid?
Can you think of a time you made a decision based on bad data?

What was the outcome?

How could the outcome have been improved if the data used to make the decision was “better”? 

![Diagram of expectation vs. reality]
Process Control Problem Solving Phases

1. Define
2. Measure
3. Analyze
4. Improve
5. Control
In the ANALYZE phase the focus is on identifying all potential **Key Input Variables (KIV)**.

**What is an Input Variable?**

Any *input* to an operation that could *vary*.

A *key* input variable has *direct or indirect effect on* the Key Output.

There are many input variables but only a few have an effect on the Output.

**Do KIVs meet our selection criteria?**
How do we determine all Input Variables?

With the use of:

1. A detailed **Process Flow Diagram** for the area of interest

2. A list of **hypotheses** for the cause of the issue

3. Using a structure brainstorming session, fill the funnel with potential High Level Causes

4. Narrow down the list of Variables using a **Cause and Effect** matrix
A **Process Flow Diagram** is a visual representation of the steps in a process. It uses standardized shapes that represent different types of operations.

```
Inject wax pattern

Inspect wax pattern

Good?

Yes

Pattern cooling

No

Yields, defects

Scrap
```
A Cause and Effect diagram, also known as a fishbone or Ishikawa diagram, is used to reveal the reasons behind a problem.

This diagram is used in brainstorming sessions to help identify all of the likely causes of the problem (effect).
Process Control Problem Solving Phases

- Define
- Measure
- Analyze
- Improve
- Control
Problem Solving Phases – Improve

Now that we have a list of Key Input Variables, we need to determine which impact our Key Output Variables.

This is done by:

- Conducting screening tests to determine the relationship of the most promising input variables to the Key Output
  - Single or Multi-Factor testing

- Conduct optimization testing to discover the ideal settings for each Key Input
  - High and Low testing conditions

Is the Process Capable of Meeting Project Goals?
You’ve Solved the Problem!

So now you’re done, right?!?

WRONG!!!!
Process Control Problem Solving Phases

Define → Measure

Define → Analyze

Measure → Improve

Analyze → Improve

Improve → Control
Problem Solving Phases – Control

In the CONTROL phase we establish methods to **sustain the gains**.

An effective control system focuses on two aspects:

1. **Prevent** the problem from occurring.
2. **Detect** when a problem has occurred.
Types of CONTROL methods include:

1. Process Documentation
2. Monitoring
3. Reaction Plans
4. Training
1. Process Documentation

What documents are used to establish process consistency?

- Generic Instructions
- Part Specific Instructions
- Calibration and Maintenance
- Standard Work
- Checklists
2. Monitoring

Monitoring systems will detect when the Key Input Variables are out of control

• Alarming
• Audits
• Control Charts, Run Charts
3. Reaction Plans

A reaction plan is a *predefined* procedure for reacting to an outcome. It can be simple or complicated. Examples include:

1. Adjusting slurry viscosity
2. Troubleshooting bubbles in wax patterns
3. Quarantining parts

Reaction plans can be very effective when included in a control chart or a decision diagram!
3. Reaction Plan Example

Viscosity Run Chart

Zahn #5 Viscosity in Seconds; 11.5 to 13 seconds

Adjust the viscosity to the middle of the range (12.2 seconds)

<table>
<thead>
<tr>
<th>Viscosity (seconds)</th>
<th>Pounds of water</th>
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<tbody>
<tr>
<td>13.5</td>
<td>17</td>
</tr>
<tr>
<td>13.4</td>
<td>16</td>
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<td>15</td>
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<td>13.2</td>
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<tr>
<td>12.4</td>
<td></td>
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<td>12.3</td>
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</table>

If the slurry viscosity measures 12.7 seconds, The chart tells them to add 9 pounds of water.

Because this reading is within specification, do you think all operators would add water unless we told them to?
4. Training

An effective training system **must**

1. Quickly and effectively train associates in new tasks or skills

2. Prevent quality and safety issues

3. Provide a path for associate development

4. Provide training status for each associate
4. Training

The best training methods include the use of:

• Job Instructions
• Operator Evaluation Forms
• Qualification Matrices
## 4. Training – Qualification Matrix

### Training order

<table>
<thead>
<tr>
<th>Employees</th>
<th>Name</th>
<th>Robot Helper</th>
<th>Vacuum Dip Operator</th>
<th>Handline Operator</th>
<th>Robot Operator</th>
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</table>
Summary

The use of process controls help with...

- Reducing scrap & rework
- Improving production predictability
- Developing skills and knowledge of everyone
- Serving our customer
- Making more money!
Goal:
To teach students to apply process control tools in an investment casting foundry in order to solve a problem and prevent it from reoccurring

- Learn how to reduce variability in your foundry
- Hands-on experience applying process control tools
- Identify process areas which cause variation
“Many times the main difference between mediocre and world class manufacturing is effective and meaningful Process Control”