Improved Efficiency in the Investment Casting Process Utilizing Lean Manufacturing Principles

By

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Key Process Innovations

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key process™ innovations

FS PRECISION TECH

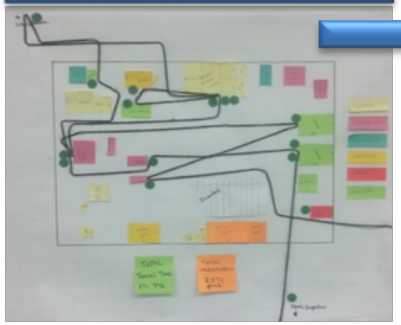
FS Precision Tech

- FS Precision manufactures precision investment castings for automotive, aerospace, and commercial applications
- Located in Los Angeles, CA
- World leader in titanium turbocharger castings
- Committed to process improvement

Continuous Improvement Journey

CELLULAR MANUFACTURING DEVELOPMENT PROCESS

CURRENT STATE PART TRAVEL

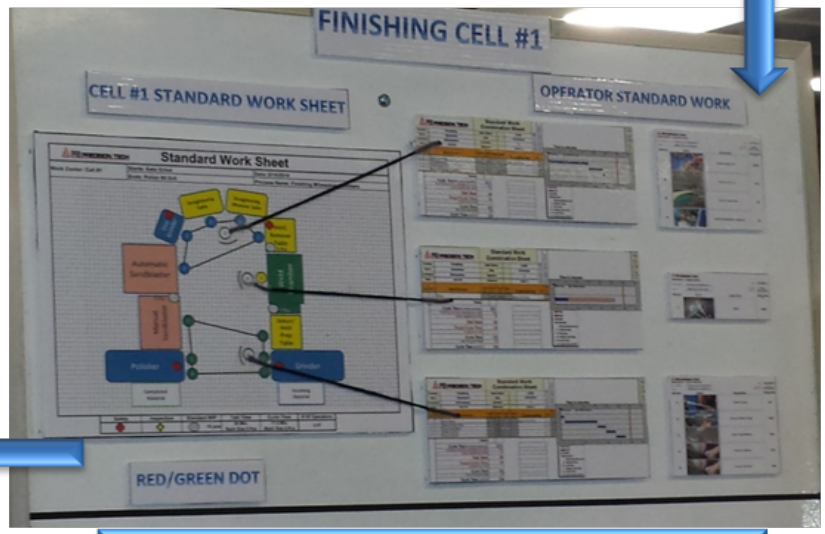


FUTURE STATE PART TRAVEL

FUTURE STATE CELL MOCK-UP

FUTURE STATE CELL DEVELOPMENT

FUTURE STATE CELL IMPLEMENTATION



FUTURE STATE CELL/OPERATOR STANDARD WORK

Common Vs. Special Cause

Common Cause

- Inherent to the Process
- Random
- Distributed about the average

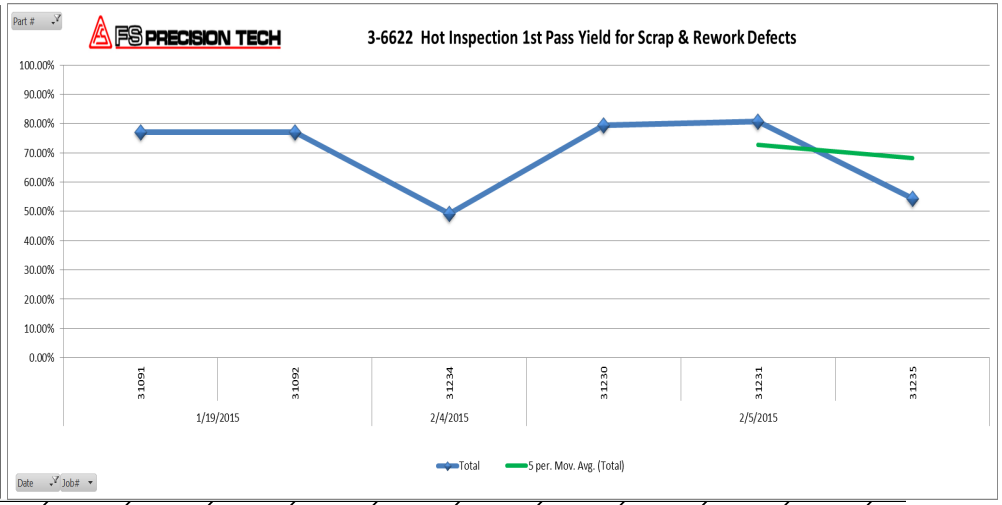
Special Cause

- Often called assignable
- Must be addressed in order for process to be considered stable

Situation Analysis

- 1st Pass Yield for all parts
  - Proxy part was 68% in early 2015

Date	Part #	Job#	Total QTY.	Total Defects	Total Scrap	Total Rework	1st Pass Yield
19-Jan	3-6622	31091	105	24	3	21	77%
19-Jan	3-6622	31092	113	26	7	19	77%
4-Feb	3-6622	31234	120	61	0	61	49%
5-Feb	3-6622	31230	112	23	0	23	79%
5-Feb	3-6622	31235	103	47	4	43	54%
5-Feb	3-6622	31231	119	23	1	22	81%



Non-Fill	Buckle	Broken Pattern	Wax Defect	Shell Inclusions	Orange Peel	Gas/Surface Porosity	Blade Root Porosity	BB's	Inclusion	Thru Porosity	Non-Fill	Buckle	Broken Pattern	Wax Defect	Shell Inclusions	Orange Peel	Gas/Surface Porosity	Blade Root Porosity	BB's	Inclusion on Blade	Thru
Defect Code	Defect Code	Defect Code	Defect Code	Defect Code	Defect Code	Defect Code	Defect Code	Defect Code	Defect Code	Defect Code	Defect Code	Defect Code	Defect Code	Defect Code	Defect Code	Defect Code	Defect Code	Defect Code	Defect Code	Defect Code	Defect Code
S-8	S-9	S-10	S-11	S-13	S-16	S-18	S-48	S-59	S-61	S-63	R-8	R-9	R-10	R-11	R-13	R-16	R-18	R-48	R-59	R-61	R-63
2						1														21	
2						3			2					1			12			5	
1		1															10			25	
1																	3			15	

Shell Room Situation

- Sources of special cause variation, including:
  - Intracoat dry time
  - Slurry mixing
  - Hand dip technique
  - Robot dip technique
  - Slurry health
  - Slurry rheology
- Process drifted over time
- No robust training system
- Part quality was causing increased rework and elevated scrap

Data Collection

- Time Observations
  - Conducted in all departments
  - For all major steps in the process

- Results were reviewed:
  - Time reflected in ERP System
  - Actual
  - Least Waste Way

Time Observation

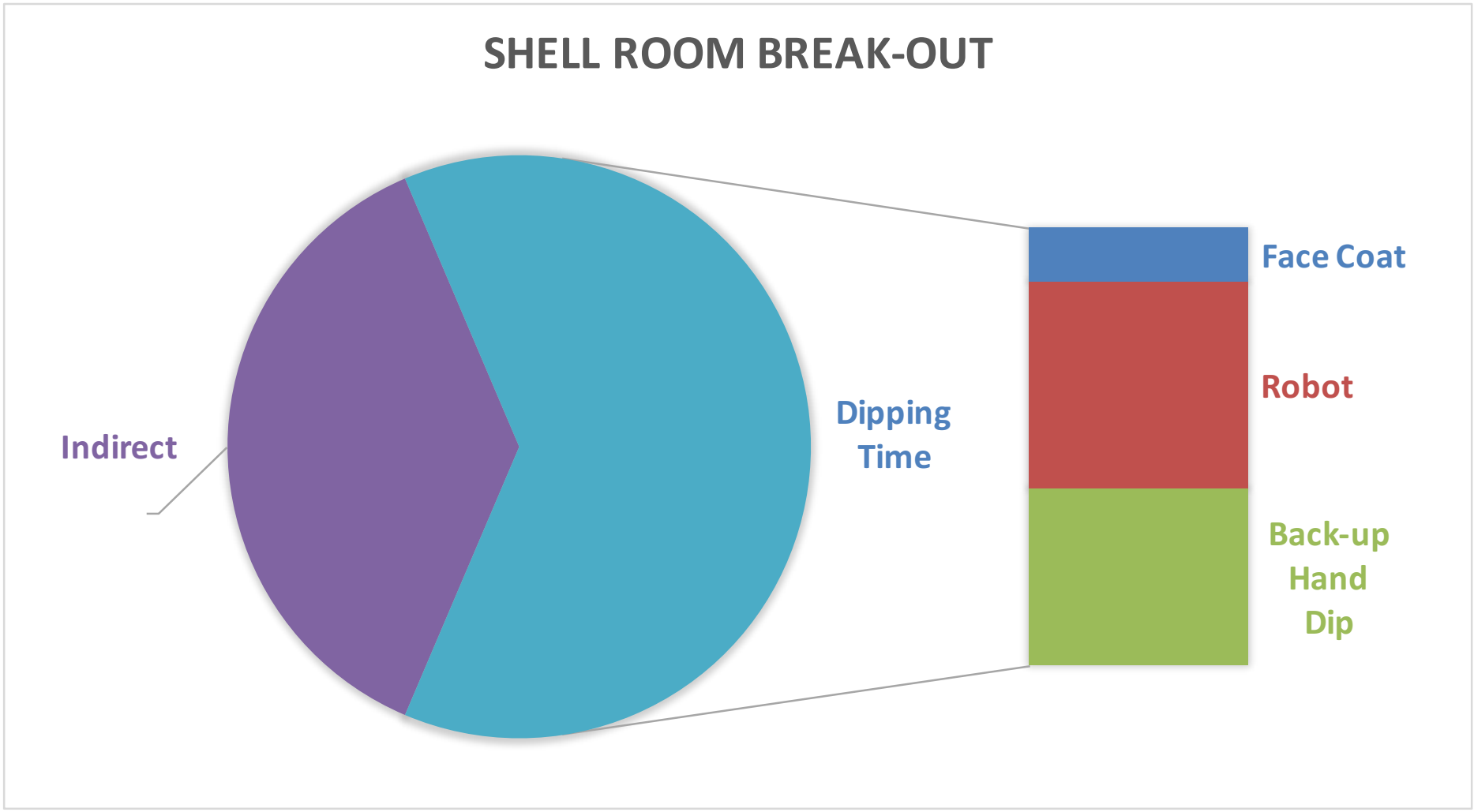
Taken From ERP system

Data from Time Observations

Actuals with Waste Time Removed

	Standard	**Actuals**	**Observation LWW /SW**
Operation	Standard CT (Min/Part)	Actual CT (Min/Part)	Observation LWW/SW CT (Min/Part)
WaxInj	4.615	3.945	3.052
WaxAssm	2.400	8.768	2.587
ShellOpr	**0.831**	**5.277**	**1.723**
Foundry	0.715	1.136	1.871
FClng	1.762	2.529	1.668
HotI	0.600	0.591	0.255
RawF	1.800	5.620	3.10
S-Weldng	1.200	0.822	1.90
FinFis	7.200	8.172	3.96
Final Inspection	0.000	0.000	0.56
TOTALS	21.123	36.859	20.676

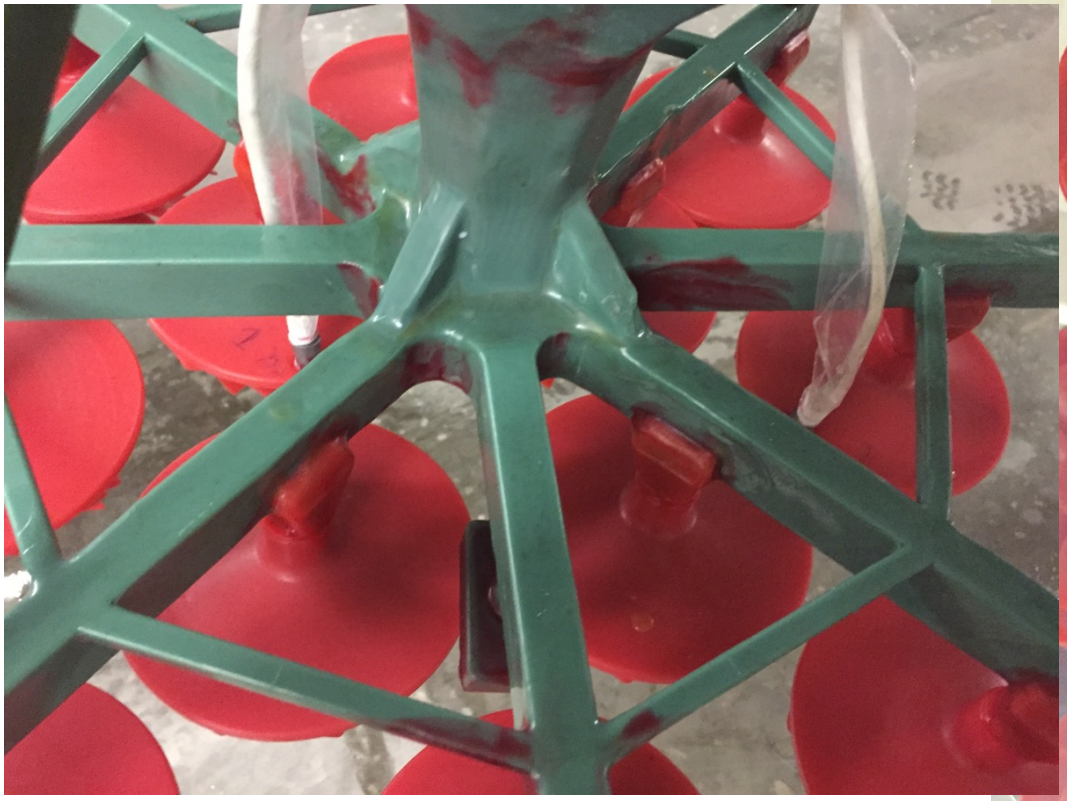
Current State Capability Analysis

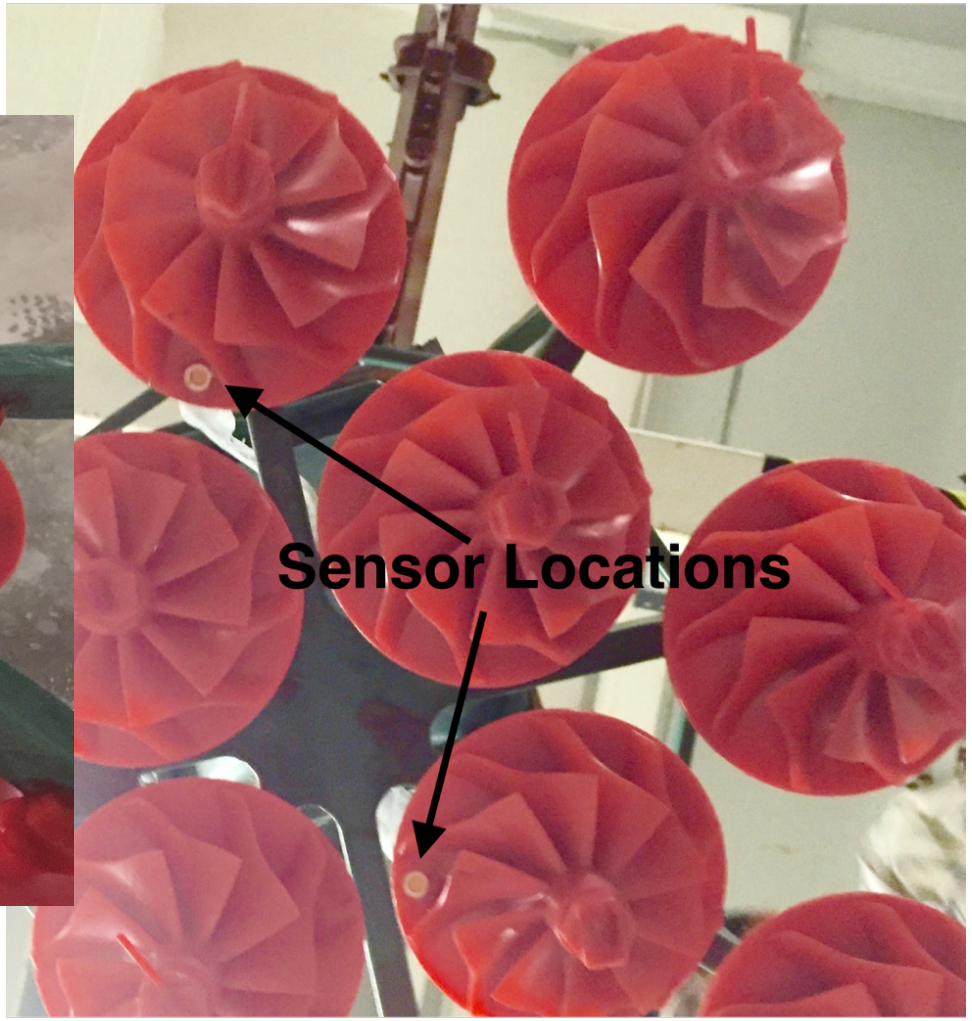


Mold Drying

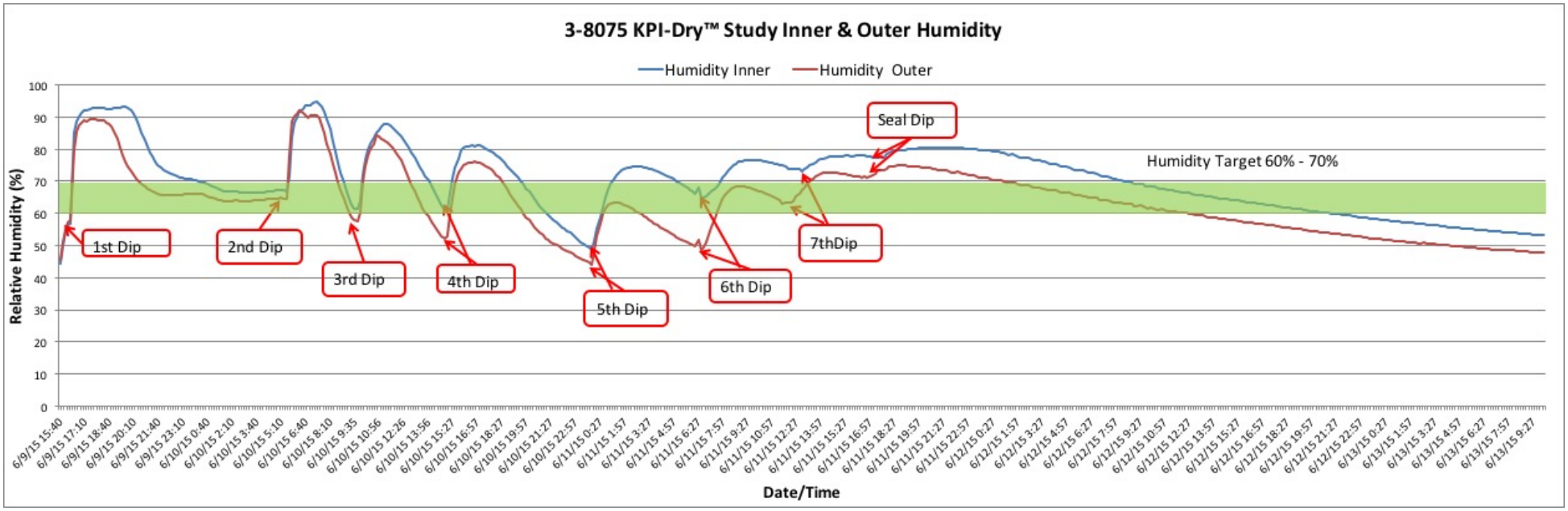
- Variations in:
  - Shell room environment
  - Intracoat dry time
- Impact to Casting Quality Unknown
- Used KPI-Dry™ to measure mold dryness

Mold Drying Set-Up





Mold Drying Results



Learnings:

- Variations in dry times could have detrimental impact on casting quality
- Mold RH is a critical process input

Operator Variability

- Variability Between:
  - Operators
  - Procedure and Operators
  - Procedure and Best Practices
  - Best practices and Operators
- Source of special cause variation

Addressing Operator Variability

- KPI was teamed up with knowledgeable employee
- Combined aspects of procedure, current process and industry best practices
- Captured on Video
- Procedures matched videos
- Videos, procedures and standard work are reviewed by FSPT technical team

1. **Purpose**

   The purpose of this pro
   slurries.

2. **Scope**

   This procedure is estab
   measuring the slurry vi

3. **Safety/PPE**
   Safety glasses are requi

4. **Procedure**

4.1. Inspect Zahn Cup [*See*
4.2. Submerge cup into the
4.3. Do not immerse cup th
beginning test. If neces
to the surface, prior to
4.4. Dip cup upstream of th
same location every tir
is completely submerg
4.5. Simultaneously start th
4.6. Watch the stream unde
cup. [*See Figure 4*]
4.7. If at any time the slurr
4.8. Repeat 4.4-4.7, record
recorded, add the three
the average of the 3 re
AVERAGE. Then calc
largest of the 3 reading
reading.
4.9. Make adjustments to t
Red zone.
4.10. Follow Instructions o

F

Figure 2: Loca

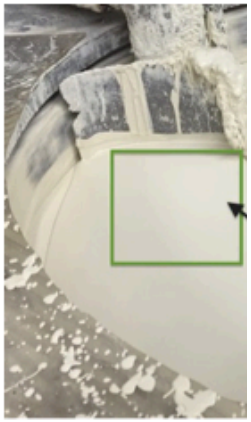


Figure 3: Properly submerged cup vs Improperly submerged cup

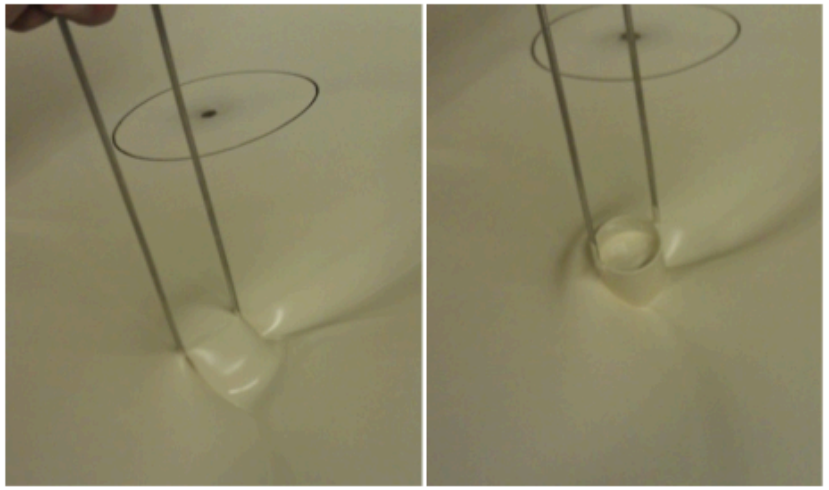


Figure 4 – Breaking Point of the stream

Video

Slurry Viscosity Procedure
Reference P10-030

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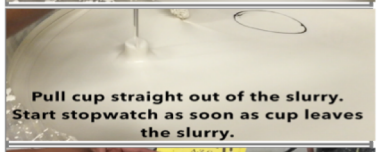
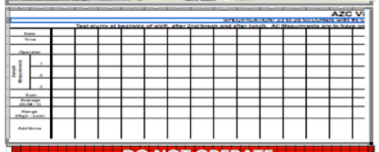
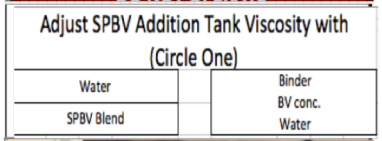
Standard Operations

Standard Work

Date: 5/11/15

Area / Machine: Shell Department | Procedure: P10-030

Product: Viscosity Readings and Charting | Frequency: 3 x per shift: Beginning, after 1st break, after lunch

Element	Photo	Description
1		Select correct viscosity cup to be used for testing. This can be verified by checking the Slurry Tank Viscosity Chart. Inspect viscosity cup to ensure it is clean.
2		Submerge the cup into the slurry and dump the contents. Do not immerse cup through pooling liquids or floating debris. Remove material before beginning test.
3		Take viscosity readings on the upstream side of the plow inside the shadow of the plow.
4		Pull cup straight out of the slurry. Start Stopwatch as soon as cup leaves the slurry.
5		Watch stream under cup and stop the stopwatch when the stream breaks 1" beneath cup.
6		Take 3 readings and record on viscosity chart (F09-009). Calculate SUM, AVERAGE AND RANGE.
7		Fill in box in the column which corresponds to the AVERAGE reading. Follow instructions on chart to determine if adjustments are necessary.
8		If liquid adjustments are necessary, follow instructions on Slip on top of Viscosity Chart.
9		Rinse the Viscosity cup in the Storage container and make sure it is clean before returning it to its original location.
10	Record All Additions	Viscosity must be recorded before and after adjustments. Any additions to the Tank must be recorded on the Viscosity Chart.

Slurry Integrity

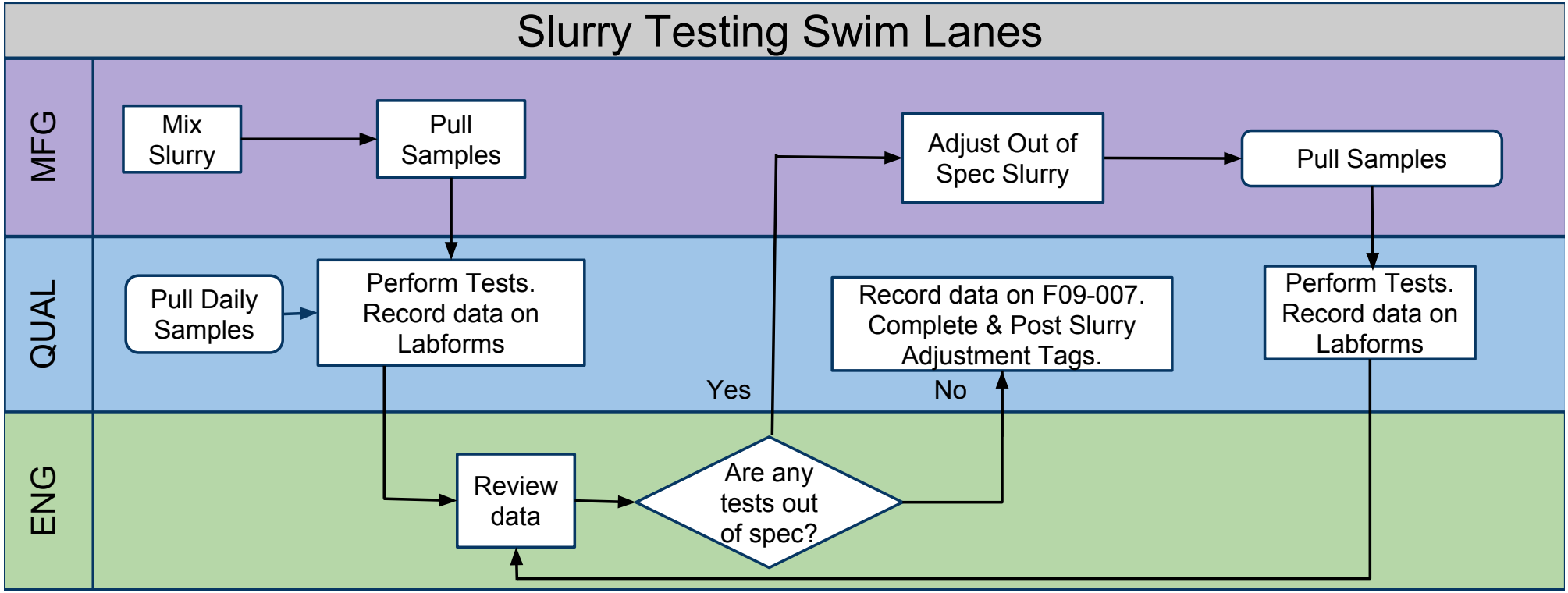
- Slurry testing was labor intensive, however…
- Tests were not sufficient to detect issues prior to impacting casting quality
- Confusion over roles and responsibilities if slurry was out of range

Slurry Testing Matrix

	TEST METHOD	RESPONSIBLE DEPARTMENT	PRIME	PRIME Pre-Wet	INT	INT Pre-Wet	BACK-UP	BACK-UP Pre-Wet
VISCOSITY	P10-030	SHELL	X		X		X	
PLATE WEIGHT	S09-104	SHELL	X					
TEMPERATURE	S09-104	SHELL	X					
pH	P10-010	LAB			X	X	X	X
SPECIFIC GRAVITY/%SiO2	P10-009	LAB	X	X	X	X	X	X
BUBBLE TEST	P10-033	LAB			X			
SUPERNATE (BEFORE)		LAB			X			
SUPERNATE (AFTER)		LAB			X			
% POLYMER	P10-006	LAB					X	X
BACTERIA DIP SLIDES	P10-031	LAB			X	X	X	X
LABFORM			39B	39C	37A	37B	31A	

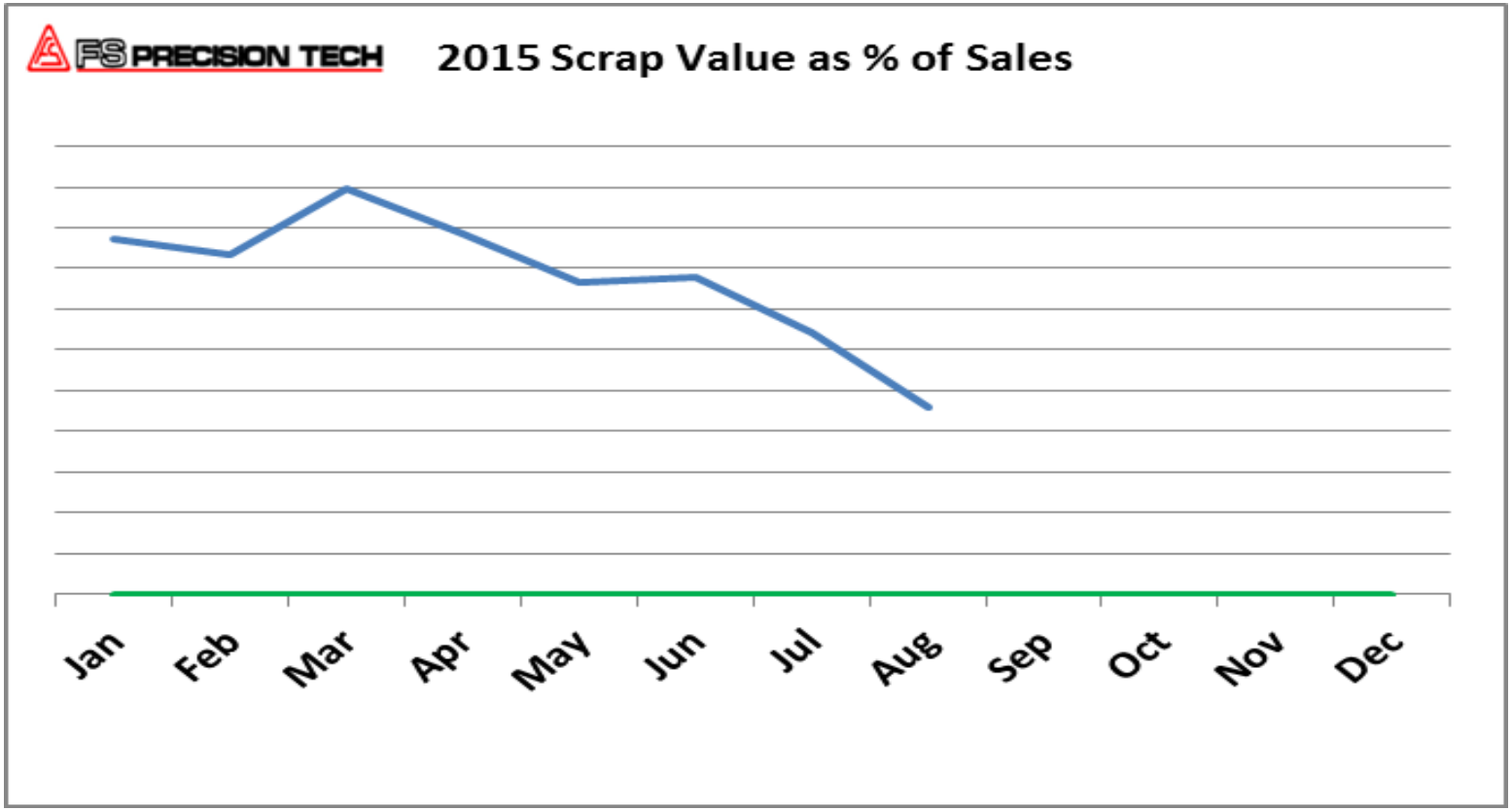
3x/Shift	1/shift	Daily	2x/Week

Slurry Testing Swim Lanes



Outcomes

- Standardized Process
- Trained Operators



Lessons Learned

- Take the time to collect data
- Understand plant culture
- Gather tribal knowledge

Conclusion

- Lean Manufacturing principles can be used in the investment casting process
- Investing in a training program is key to sustaining the improvements

Thank You!

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