PPG Springdale Plant - Paint Filling Line Study

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The Team

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Problem Statement

PPG's light cell is not meeting its demand in the regularly scheduled 5 day work week.

Hypothesized Causes

- Long fill times
- Manual fill process
- Production planning
- Workforce scheduling
- Balance of filling with other steps
- Varying interpretations of SOP
- Adherence to procedure
- Poor data collection
- Old equipment
- Outdated Procedure

Categories of Variation

Man

Machine

Material

Method

Environment

Measurement

Environment

Man

- Long fill times
- Manual fill times
- Workforce scheduling
- Varying interpretation of SOP

Material

- Balance of filling with other steps

Method

- Long fill times
- Manual fill times
- Production scheduling
- Workforce scheduling
- Balance of filling with other steps
- Varying interpretation of SOP
- Poor data collection
- Old procedure
- Waiting on raw materials

Machine

- Long fill times
- Old equipment

Solution Channels

Automation

- Portfolio of recommended machines with quotes
- Updated CAD with proof of feasibility

Filling Model

- Model of filling process with analysis of varying resource amounts

Standardization

- Recommendations for modifications to the SOP

Data Gathering

From PPG

- Current CAD
- Current SOP
- 2019 Production Data

Collected Data

- Filling steps to generate process map
- Fill process time data
- Worker testimonials regarding procedure
- Automated machine information

Assumptions

Automation

- Statistics provided by machine vendors are accurate
- Cost of installation is consistent across alternatives

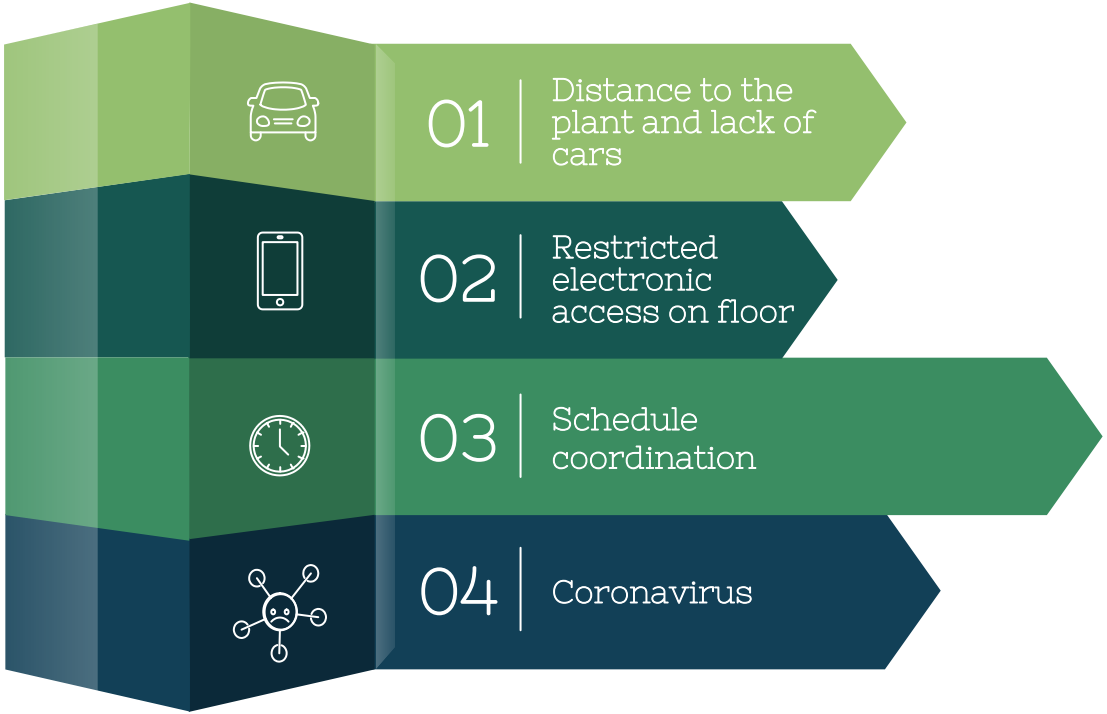
Resource Allocation

- Standard 8 hr day/3 shifts
- There is always an opportunity for a worker to fill

Standardization

- Every worker has reviewed the SOP
- Every worker has been trained through shadowing

Limitations and Barriers



Time Studies & Observations

- Quantitative
  - Time distribution
  - Large variation in times

Time Studies & Observations

- Qualitative
  - Variation between workers
  - Long breaks
  - Lack of adherence to SOP

Handling the Data

- Grouped Data in different ways and assessed using ANOVA
- Once groups were determined, distributions were fit using ARENA

Assumptions - Model

- Standard 8 hr day/3 shifts
- There is always an opportunity to fill
- Workers take two 15-minute breaks, a 30 minute lunch, start each shift with a 15-minute production meeting and end with a 15-minute clean-up
- Each worker performs all tasks associated with filling one pallet and is thus “seized” by the order at the start of the process
- Every worker has reviewed the SOP and has been trained accordingly

Discrete Event Simulation Model: an Overview

- Models the filling process at the light cell
- Tracks the production of drums, totes, and pails during a shift
- Based off of limited collected data: can only use it in specific ways

Discrete Event Simulation Model: Verification

- Coded using the R Package Simmer
- Verified using Excel

Capacity and Schedule

```
#Allow Capacity to Change
capacity = .7 #CHANGE THIS to change capacity

standard <- c(0,15,135,15,105,30,90,15,60,15,0)
wCapacity <- c(standard[1],standard[2],capacity*standard[3],standard[4],capacity*standard[5],standard[6],capacity*sta
ndard[7],standard[8], capacity*standard[9],standard[10],standard[11])
SumWCapacity <- vector(mode = "numeric", length = 10)
SumWCapacity[1] = 0
for (i in 2:11){
  SumWCapacity[i]= SumWCapacity[i-1]+wCapacity[i]
}
SumWCapacity[11] = SumWCapacity[10]+sum(standard[c(3,5,7,9)])*(1-capacity)
```

Set the Environment

```
# Schedule inputs
ScheduleInMinutes <- SumWCapacity[2:11]
ScheduleInSeconds <- 60*ScheduleInMinutes
ResourceDuringShift <- c(NumWorkers,0,NumWorkers,0,NumWorkers,0,NumWorkers,0,0,0)
LengthOfShift = 8*60*60 #Eight hours/shift, 60 minutes/hour, 60 seconds/minute

## A single shift schedule
ShiftSchedule <- schedule(
  ScheduleInSeconds,
  ResourceDuringShift,
  period = LengthOfShift)

# RunTime inputs
ShiftsRun = 15 #CHANGE THIS to change number of shifts run
RunTimeSeconds = LengthOfShift*ShiftsRun

# Fill Rate of Pump
CurrentFillRate = function() 394 + rexp(n = 1, rate = 1/220)
AutomatedSystemFillRateDrum = function() 5*60 #make sure this is in seconds!!
AutomatedSystemFillRateTote = function() 5*60 #make sure this is in seconds!!
  #CHANGE THIS to match the system
FillRateToUseDrum = AutomatedSystemFillRateDrum
FillRateToUseTote = AutomatedSystemFillRateTote
#CHANGE THIS to tell model either CurrentFillRate or AutomatedSystemFillRate
```

Integrate Collected Data

```r
## Distributions
EmptyPalletTransportDist <- function() rtri(n = 1, min = 7.5, max = 62.5, mode = 18.4)

PrepDist <- function(){
  m <- runif(n = 1, min = 0, max = 1)
  if (m<=.5){ #Stickers during fill 50% of time
    PrepTime <- rnorm(n = 1, mean = 71.7, sd = 31.4)
    return(PrepTime)
  }else{ #Stickers during prep 50% of time
    PrepTime <- rnorm(n = 1, mean = 326, sd = 60.2)
    return(PrepTime)
  }
}

PrepNoStickers <- function() rnorm(n = 1, mean = 71.7, sd = 31.4)

DrumPumpDist <- FillRateToUseDrum

TotePumpDist <- FillRateToUseTote

CloseDist <- function() 28 + rexp(n = 1, rate = 1/85.7)

FullPalletTransportDist <- function() runif(n = 1, min = 27.5, max = 72.5)

TransitionDist <- function() rtri(n = 1, min = 5, max = 130, mode = 15.4)

QueueDist <- function() 9 + rweibull(n = 1, shape = 251, scale = 0.557)
```

Build Worker Paths

```
## Drum trajectory- Combined into one seize so that we can see number of pallets as output
drum <- trajectory("drum_trajectory")%>%
  seize("worker",1) %>%
  timeout(function(){
  EPT <- EmptyPalletTransportDist()
  Prep <- PrepDist()
  Pump <- DrumPumpDist()
  Close <- CloseDist()
  FPT <- FullPalletTransportDist()
  Transition <- TransitionDist()
  Queue <- QueueDist()

  Total = EPT + Prep + Pump + Close + FPT + Transition + Queue

  return(Total)
})%>%
  release("worker",1)
```

Initiate the Simulation

```
## Initiate Simulation- arrival of different containors is designed to follow proportions of containors for 2019, assumed poisson arrival to
Env <- simmer("PPGLightCell") %>%
  add_resource("worker", capacity = ShiftSchedule) %>%
  add_generator("pail", pail, function() rpois(n = 250, lambda = 1.8))%>%
  add_generator("drum", drum, function() rpois(n = 250, lambda = 0.0743))%>%
  add_generator("tote", tote, function() rpois(n = 250, lambda = 0.147))

Env %>% run(until = RunTimeSeconds)

ThroughPut <- Env %>% get_mon_arrivals()

##End of Simulation
```

Discrete Event Simulation to Predict Improvement

- Take the base model and manipulate it to show model the process with proposed changes
- We can give % increase in throughput

Assumptions - Automation

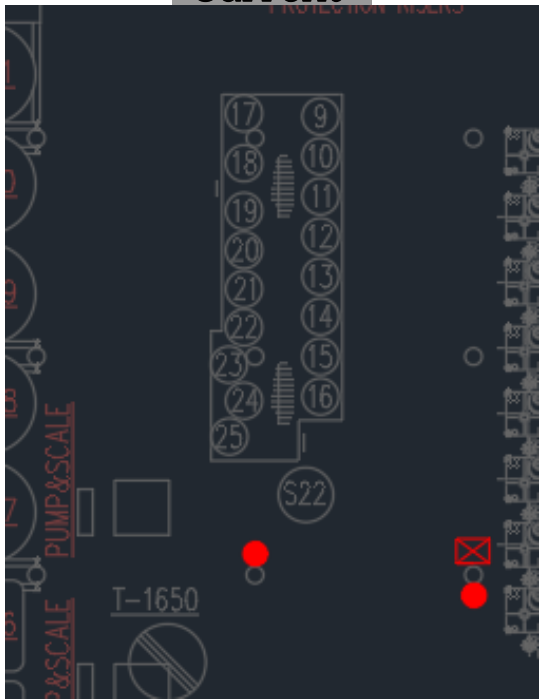
- Statistics provided by machine vendors are accurate
- Cost of installation is consistent across alternatives
- Difference in company delivery time is negligible
- Estimates received before pandemic still hold

CAD Layout

- Two recommendations
- Removal of add cell
- Removal of fill station
- Movement of pallet storage

CAD Layout

Current



Proposed

Machines Pros and Cons

- 10 machines compared
- Ranked machines
  - Highest priorities from PPG
- Same information for all machines

Paint Machines

- Ideal-Pak
  - PT-IF
  - PT-IF/PT-BF Auto

- Specialty Equipment
  - ADF-5540
  - Palletized Drum and IBC Filler

Cost Analysis

Machine:	ADF-5540	Palletized Drum & Tote Filler	PT-IF	PT-IF/PT-BF Auto
Drum Fill Rate	48 / hr	50 / hr	60 / hr	60 / hr
Estimated Cost of Machine	$425,000	$95,000	$90,000	$120,000
Predicted Improvement	28.60%	31.69%	44.79%	64.79%

Implementation Plan

Short term

- New SOP

Long term

- New device
- Change layout
- New SOP

Implementation Plan

In-house

- Piping adaptations
- Removal of scale
- Removal of add cell
- Dock door

Outsourced

- Delivery of machine
- Installation of machine
- Calibration

Final Deliverables

- Formal report
- Portfolio of recommendations
- CAD file with automated system
- Process map
- Model code, user guide, and time study data
- Formally documented assumptions

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Questions?