ILLINOIS INSTITUTE OF TECHNOLOGY

Interprofessional Project 497-354
Developing Sustainable Production Support Systems

Sponsor: Quam-Nichols Company

Team:

Alan Beyer	- Industrial Technology
Robert Farmer	- Mechanical Engineering
Chi Moon	- Aerospace Engineering
Pablo Portilla	- Information Technology
Anish Ramanathan	- Physics
David Stuart	- Aerospace Engineering
Nick Taluzek	- Aerospace Engineering
Zaien Wasfi	- Electrical Engineering

IPRO TEAM CHARTER

Quam Nichols aims to enhance the level of manufacturing responsiveness to support the needs of its customers, which is critical to maintaining a competitive advantage. Quam-Nichols company offered the IPRO 354 team the challenge of assessing current production practices and investigating improvement options that could achieve reduced lead times and increased productivity.

Team Emphasis:

1. Powder Coating; **Process Improvement**
2. Speaker Assembly; **Process Automation**

IPRO TEAM DIVISION

Powder Coating (Team Members):

Alan Beyer
Anish Ramanathan
David Stuart
Nick Taluzek
Zaien Wasfi

Automation (Team Members):

Robert Farmer
Chi Moon
Pablo Portillo

PROCESS IMPROVEMENT STRATEGY

Using a statistical approach & Six Sigma methodology – ***DMAIC***

Define the objectives, process, and project goals

Measure key aspects of the current process and collect relevant data

Analyze the data to investigate and verify cause-and-effect relationships

Improve the process based upon data analysis

Control the process by reducing variation and eliminating defects

POWDER COATING TEAM OBJECTIVE

The team’s objective was to investigate and improve the black powder coating process used by Quam-Nichols Company. The aim was to investigate process alternatives and make suggestions for improvement.

The team sought to achieve success through the implementation of both ***Quantitative*** and ***Qualitative*** measures

LOUDSPEAKER 8” BASKET

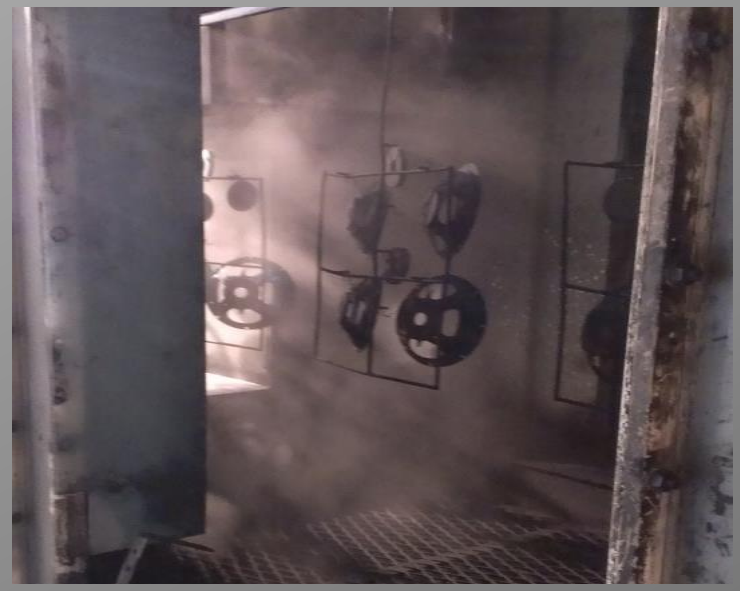
POWDER COATING PROCESS

STEP 1

HANGING PARTS

STEP 2

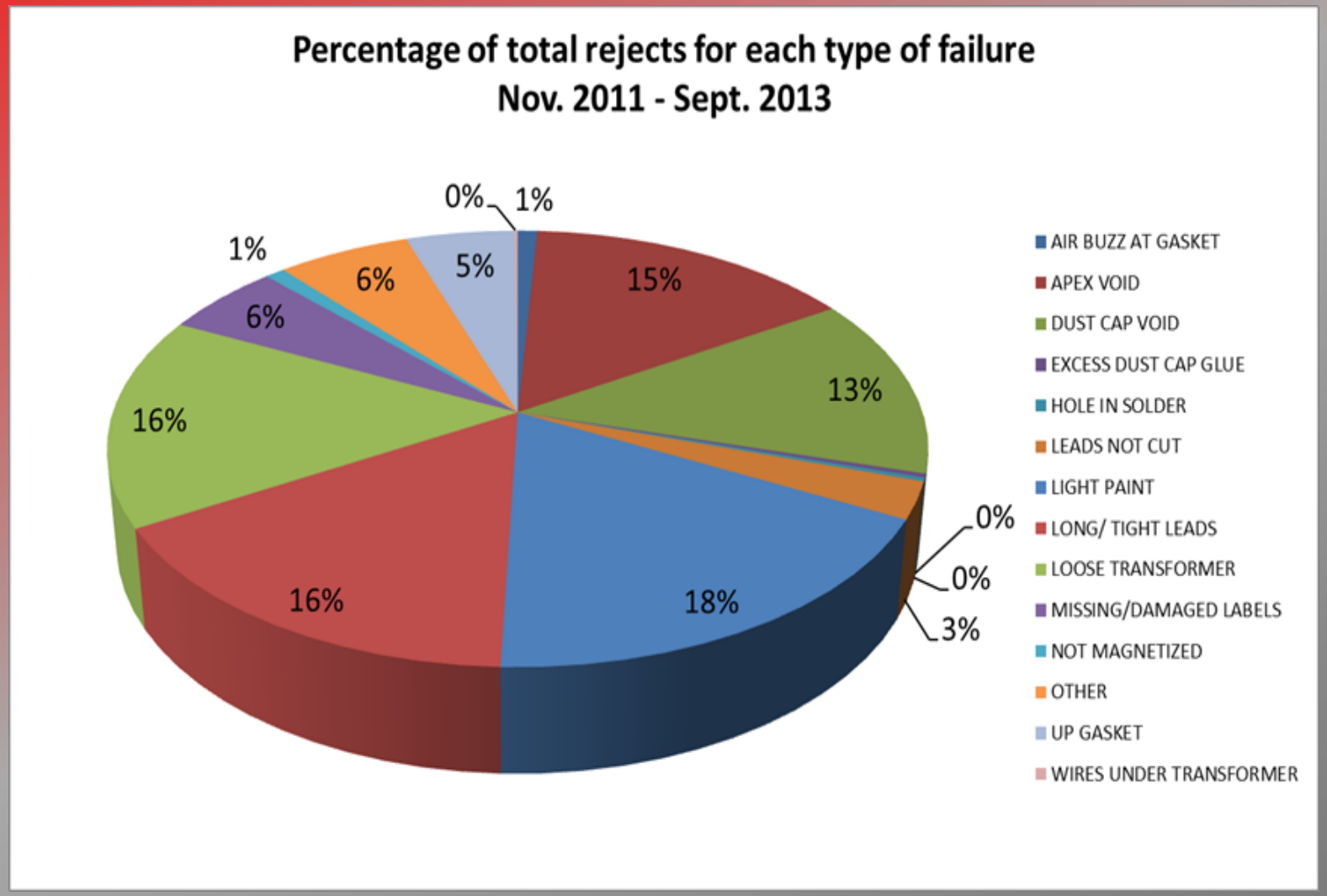
WASHING PARTS



STEP 3

POWDER COATING

IDENTIFYING THE PROBLEM



18% percent of total rejects is attributed to light paint.

Light paint is the largest contributor to total rejects.

Light paint < ~.5 mil

PROBLEM: UNDERCOATING

Acoustic Effect:

Above 1 mil Coating

Reduces Quality of Speaker

Visual Effect:

Incomplete Coverage

(Rejected Part)

POWDER COATING PROJECT GOALS

To minimize number of defects by

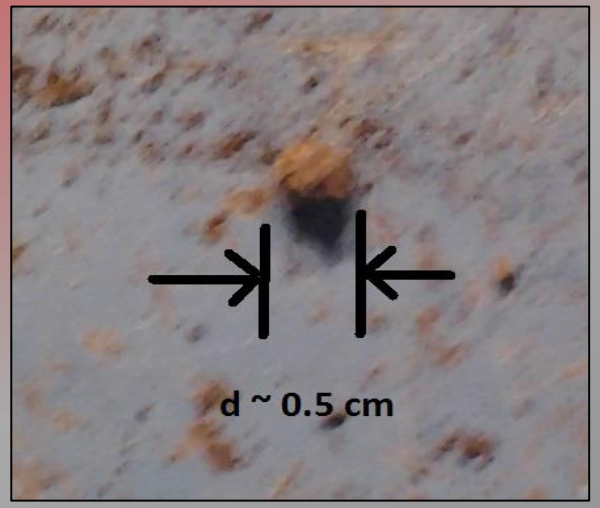
- Consistent line operation
- Optimizing rack design

To achieve consistent **1 mil** coating thickness by

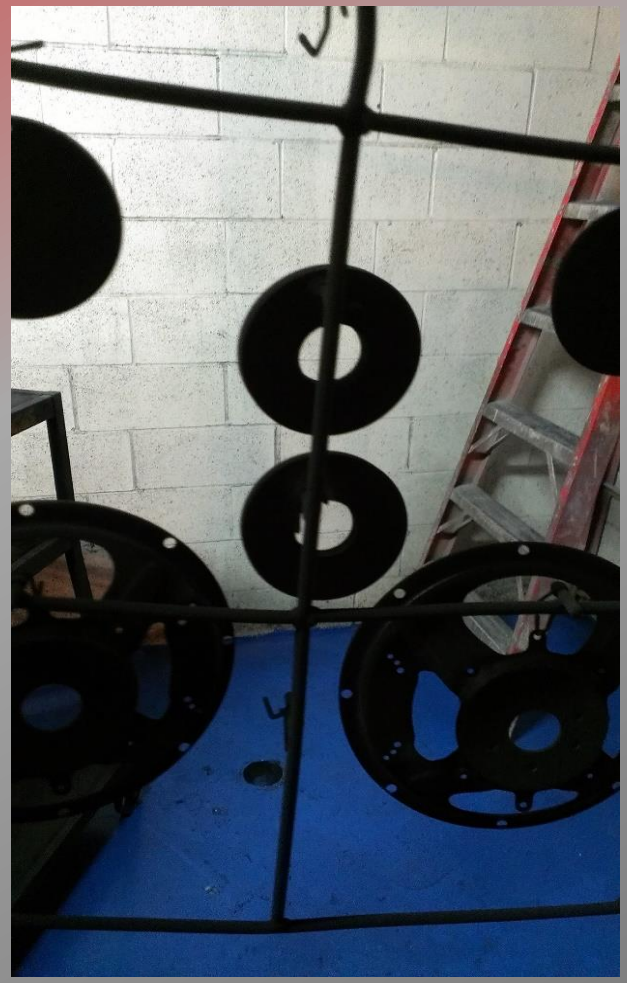
- Adjusting booth settings
- Considering room humidity and temperature

OBSERVATIONS: CLOGGED NOZZLE

- Dispersed Debris (visual and performance effect)
- Inhibits Proper Air Flow (causes undercoating)
- Causes the line to stop



OBSERVATIONS: RACK DESIGN



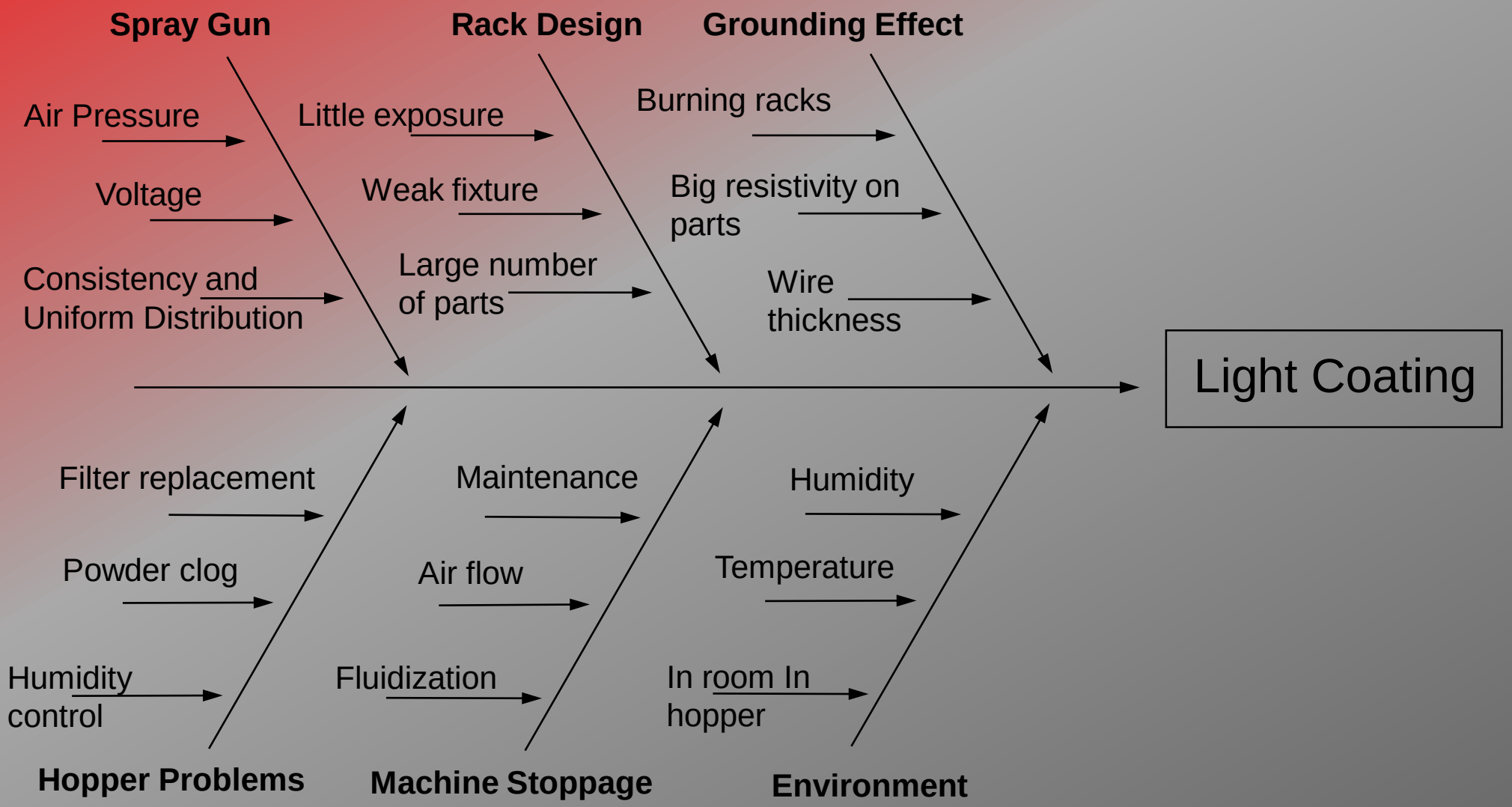
- Causes interference with parts
- Reduces exposure to cloud

MAIN LINE REJECTS DATA – PART SIZES

Part Size Category	Total Produced	Percentage of Total Production	Light Paint Failure Totals	Light Paint Percentage of Part Size Production	Light Paint Percentage Failures of Total Production
8	584089	66.7%	6744	1.155%	0.770%
4	30223	3.5%	31	0.103%	0.004%
3.5	2017	0.2%	1	0.050%	0.000%
3	34215	3.9%	203	0.593%	0.023%
2.5	155524	17.8%	673	0.433%	0.077%

- Data from Main Line Rejects Excel, Nov. 2011 to Sept. 2013
- 8 inch speakers have the highest rate of light paint failures
- 0.77% of all parts produced fail because of light paint on 8 inch sized assemblies.

CAUSE AND EFFECT



EXPERIMENTATION: EFFECT OF RACK DESIGN

Purpose

To determine the effect of changing rack design on coating thickness

Results

Average of 6 baskets:

Baseline	0.95 mils
Hanger	1.80 mils

Conclusion

Higher coverage

No contact damage

T-RACK DESIGN

Experiment average of 8 parts:
1.1 mils

Meets goals

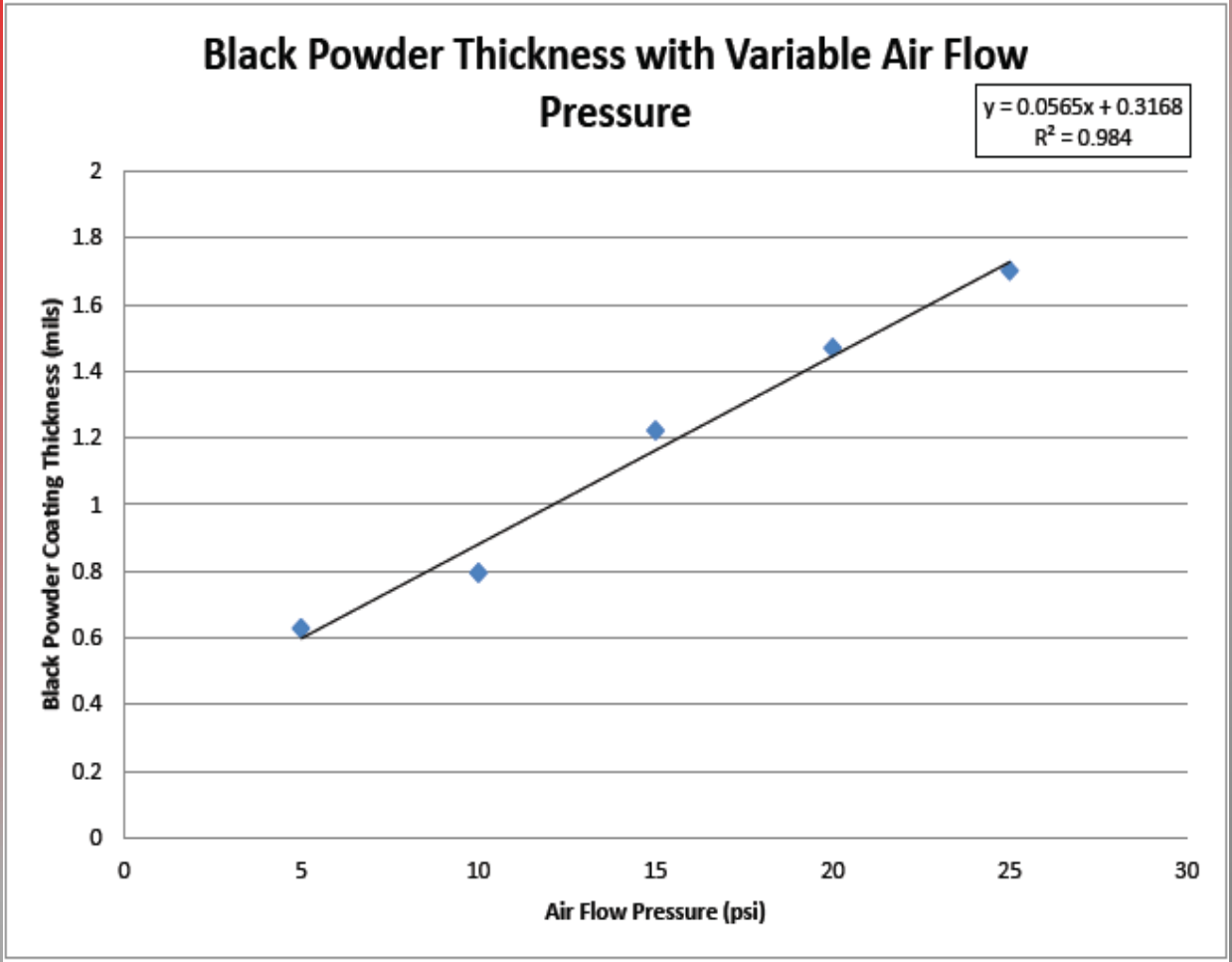
- Maximum exposure to cloud
- No rack-part interference

Accommodates all 6 parts

- 2 baskets (different sizes)
- 2 T-Yokes
- 2 magnets

Available in storage but may need customization for 8” baskets

EXPERIMENT:
AIR FLOW PRESSURE



Purpose

To investigate correlation of gun air pressure with coating thickness.

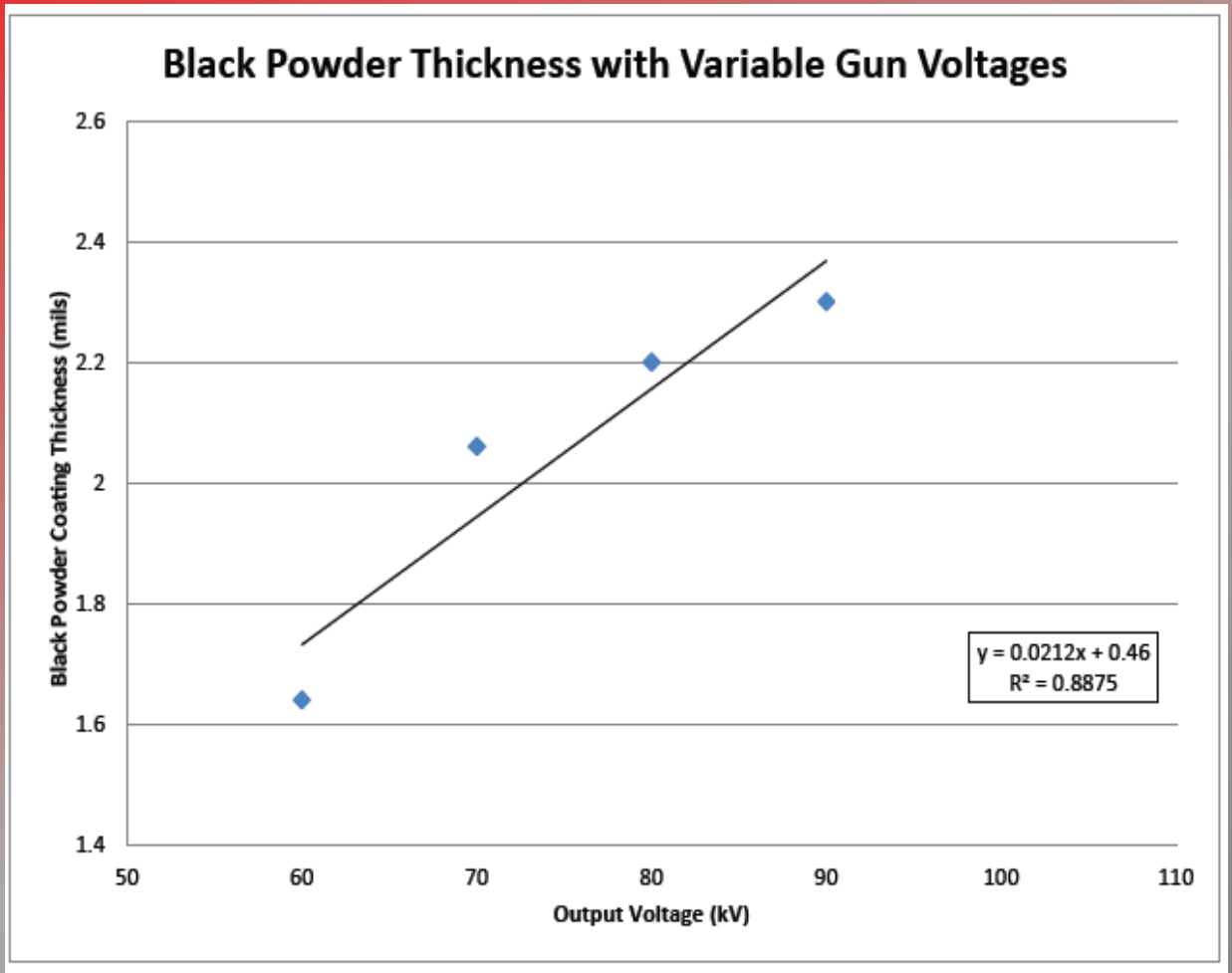
Procedure

- 100 baskets total
- +5 psi after each 20 parts
- 77kV and 22psi atomizing pressure held constant

Conclusion

- 0.0565 mil/psi Relationship

EXPERIMENT: GUN VOLTAGE



Purpose

To investigate correlation of gun voltage with coating thickness.

Procedure

- 80 baskets total
- +10 kV after each 20 parts
- 2 guns used day of experiment

Conclusion

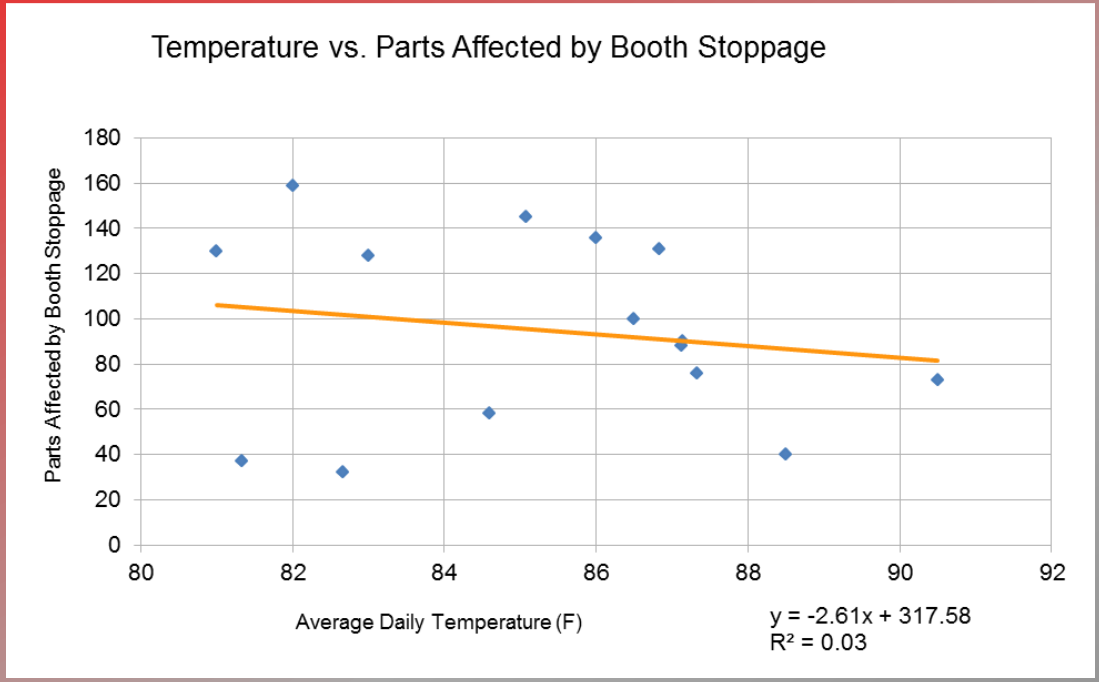
0.0202 mil/kV Relationship

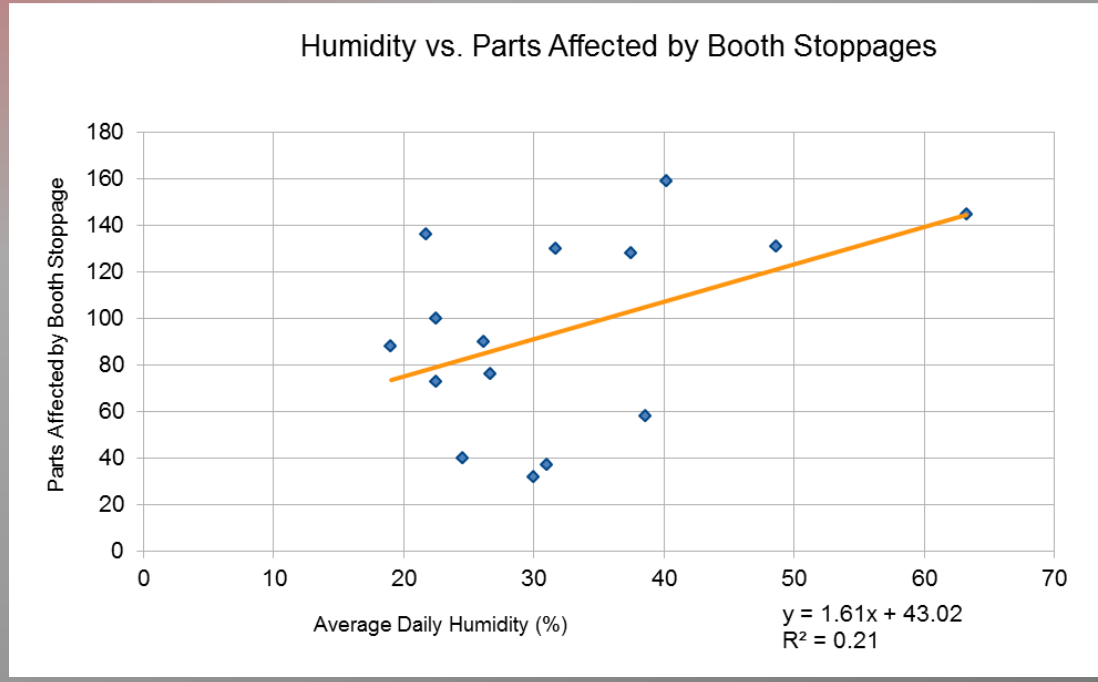
DATA COLLECTION: PROCEDURE

- Current QC procedure is to measure thickness of 10 baskets & t-yokes once a day, and alert the Line Supervisor if noncompliant thickness
  - Apparent gaps allowing systematically overcoated (>2mil) production on certain instances
  - Not frequent enough to ensure consistent thickness being met through day

- Booth data sheets created to quantify booth stoppage, reported by Line Supervisor
  - Previously unmeasured aspect hindering production
  - Provided useful data for study impact of temperature & humidity

DATA COLLECTION: HUMIDITY AND TEMPERATURE





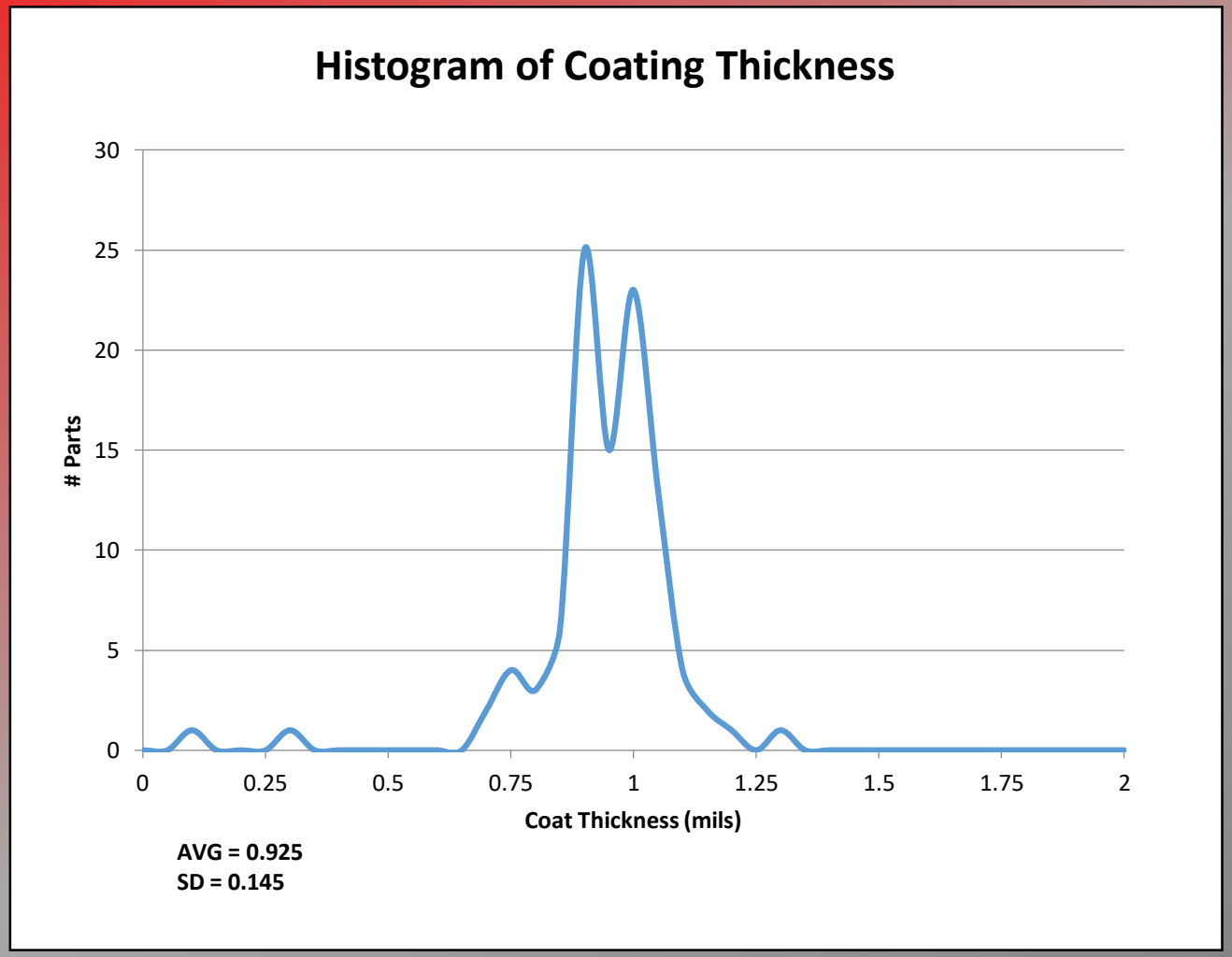
- Initially believed humidity strongly affected booth stoppage
- Data shows no correlation between temperature or humidity and booth performance

MAINTENANCE OBSERVATIONS – IMPROVED PERFORMANCE

	Daily Booth Stops	Daily Parts Defective	Average Temperature (°F)	Average Humidity (%)
Pre - Maintenance	8.00	123.2	84.6	47.6
Post - Maintenance	4.18	84.5	85.5	26.6

- Almost 50% decline in number of times the booth stopped operating
- Daily number of undercoated parts decreased 1/3
- Shows increased productivity as a result of maintenance

PROCESS CAPABILITY



- Performed Post-Maintenance
- 3 inch basket parts
- 100 baskets total
- Tested process capability at achieving 1 mil target

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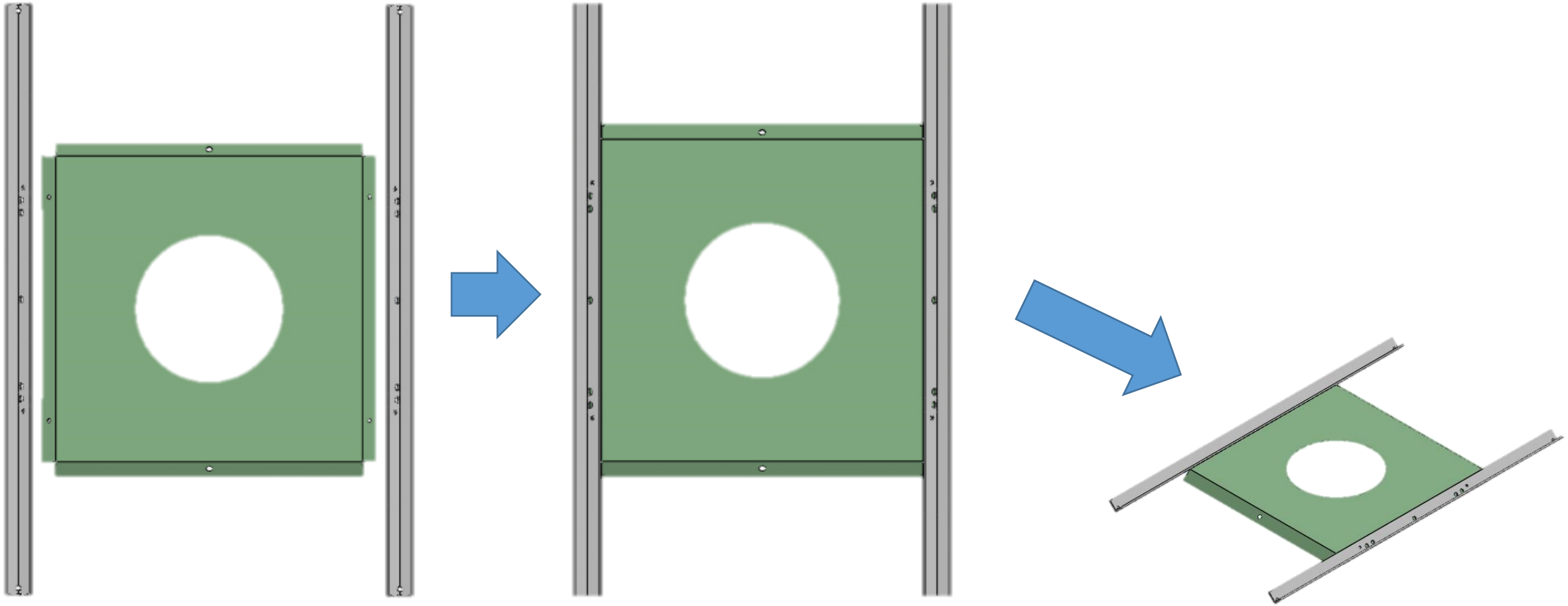
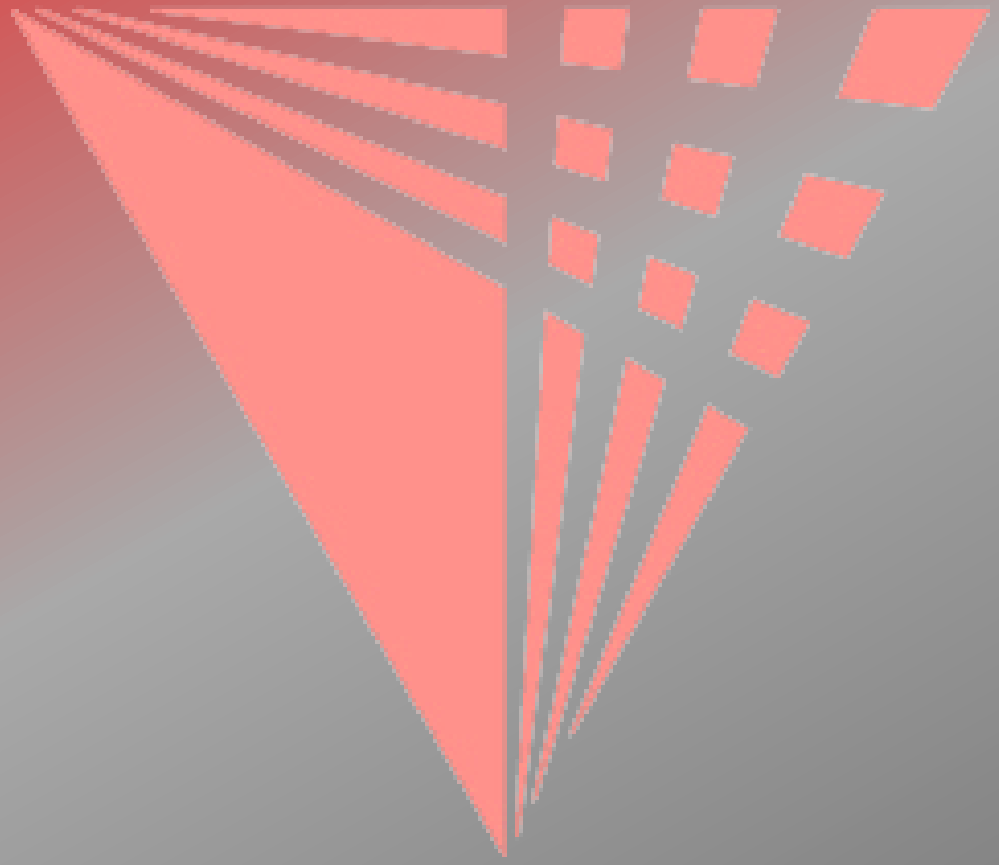
Automation Team

Team Members:
Pablo Portilla
Robert Farmer
Chi Moon

Bridge Assembly



Bridge Assembly



Goals

- To produce 4000-5000 units per week
- Consistency is more important than faster/efficient production
- Incorporating a form of automation
- Eventual total automation

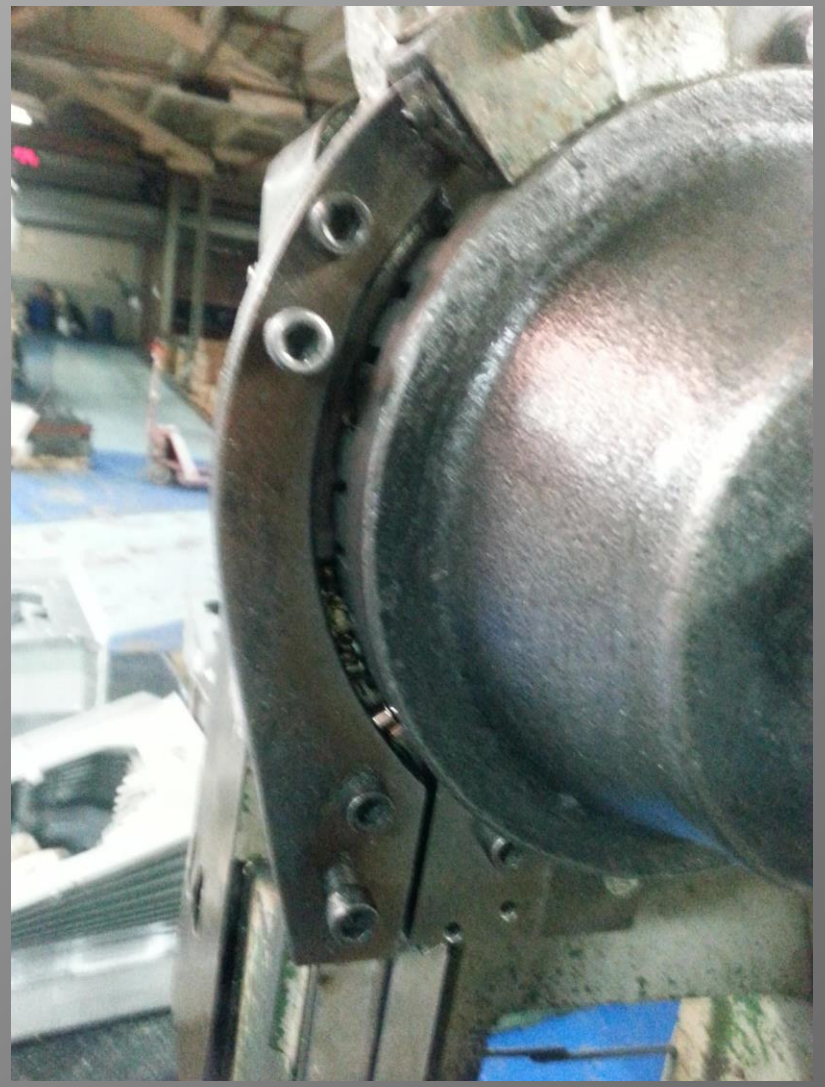
Current Process Observations

The automation team made four visits to observe the current process

- Pictures/Videos
- Time-motion studies
- Conversations with the line workers

Current Process Observations

- Riveting machines - misfires and jams
  - Jams
    - Average of 2.5 minutes per hour spent on fixing jams
    - More serious incidents can shutdown a machine up to 10 minutes
  - Misfires
    - Less hindering than jams, but important according to worker interview



Current Process Observations

- Simple repair processes can require the plant supervisor
  - Production stops for several minutes while the supervisor is located

- There is no set production procedure that the workers follow
  - - For a box of 25 products,
    average time: 179 seconds
    standard deviation: 62.9 seconds.

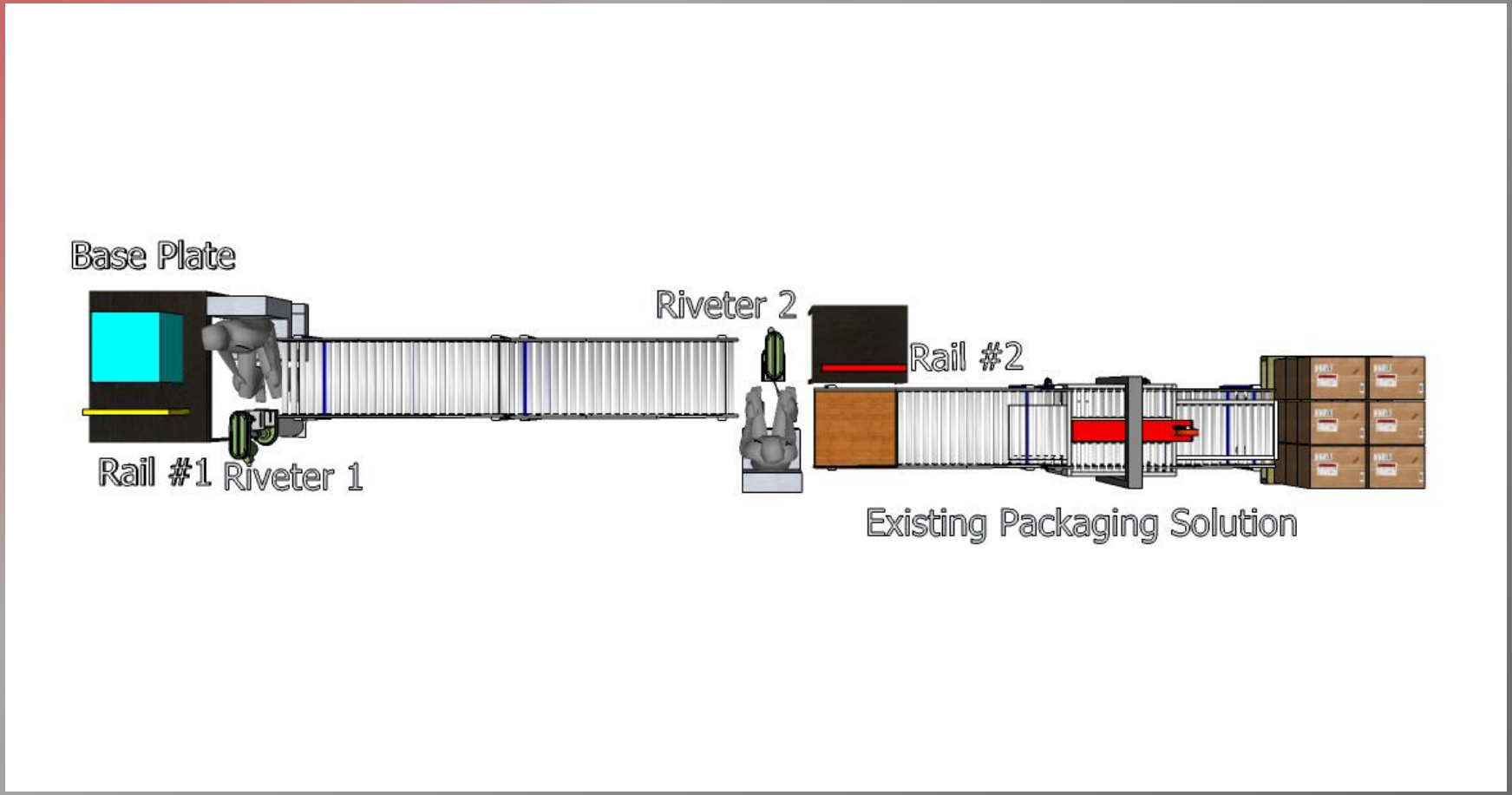
Current Process Observations

Part Handling

- Considerable amount of part handling
- About ⅓ of manufacturing time is spend on flipping over the product

Practical Layout

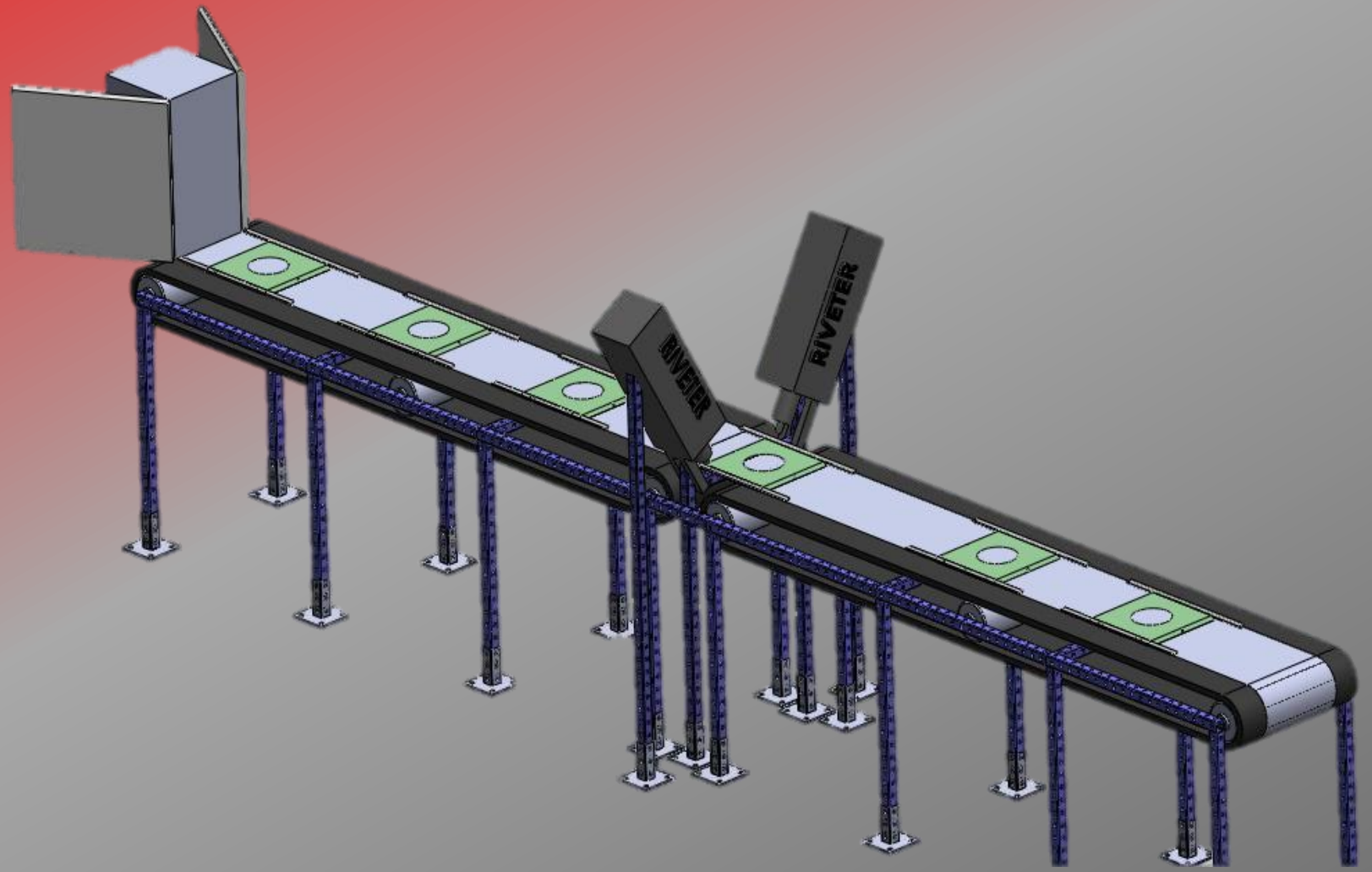
- Allows only one machine to rivet one side of the rail, eliminated excess part handling
- Continuous process, estimated 17% improvement in manufacturing timing



Other Practical Propositions

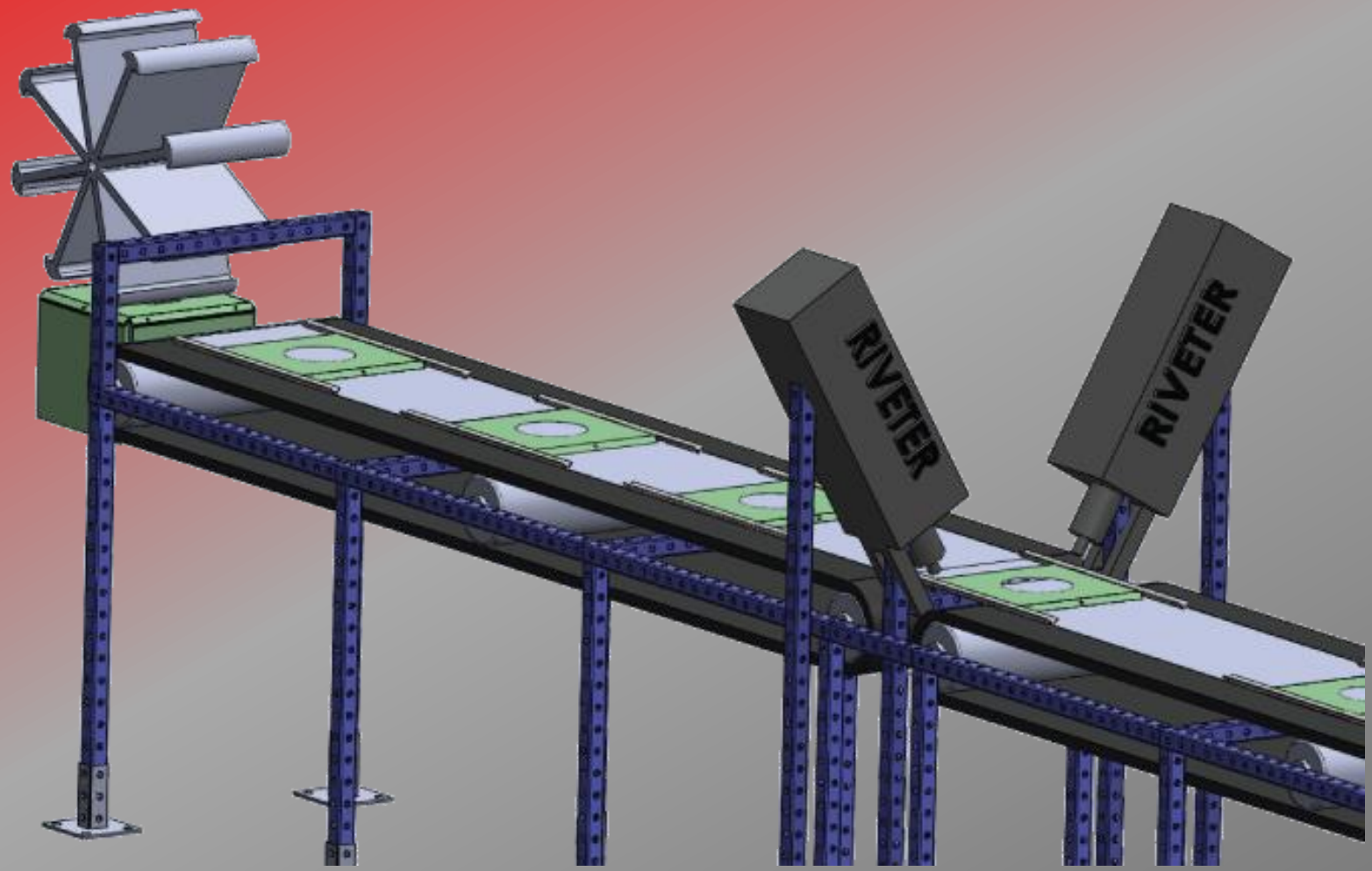
- Repair training
  - Train the line workers to un-jam the riveters
- Resupply signal
  - Can reduce downtime due to lack of parts
- Walkie-talkies
  - Fast communication in events of serious malfunction

Unistrut Automation



Unistrut Automation

Unistrut Automation



- In-line process streamlines productivity
- Use of clinching technology allows for rivetless, jamless assembly

Unistrut Automation

Unistrut Automation

Several possible outcomes:

- Unistrut based design with Norlok clincher
- Unistrut based design with existing riveters
- Norlok based design

Practical Riveting

- Jamming due to possible problem with clutch release
- Refurbishing machine
  - Low cost repair
  - Large availability of replacement parts
- Scheduled maintenance work
  - Monthly or quarterly re-greasing parts

Norlok

- Norlok is a Canadian manufacturer company of fastening machines
- Experienced with building simple to complex designs
- Wide distributor network across the U.S

Clinching

- Consistent joining
- Easy to operate
- No rivets, bolts, fasteners or adhesives used
- Prevenient resilient bond
- Wide variety of material thickness
- Reduced maintenance and simple adjustments

Clinching

Norlok Automation Option

Norlok Automation Option

- Automation system fits a small footprint
- Workers trained through company
- Operator safety
- Environmental friendliness
- Unnecessary parts removed
    - Removing belt (recommended by Norlok)

BAXTER

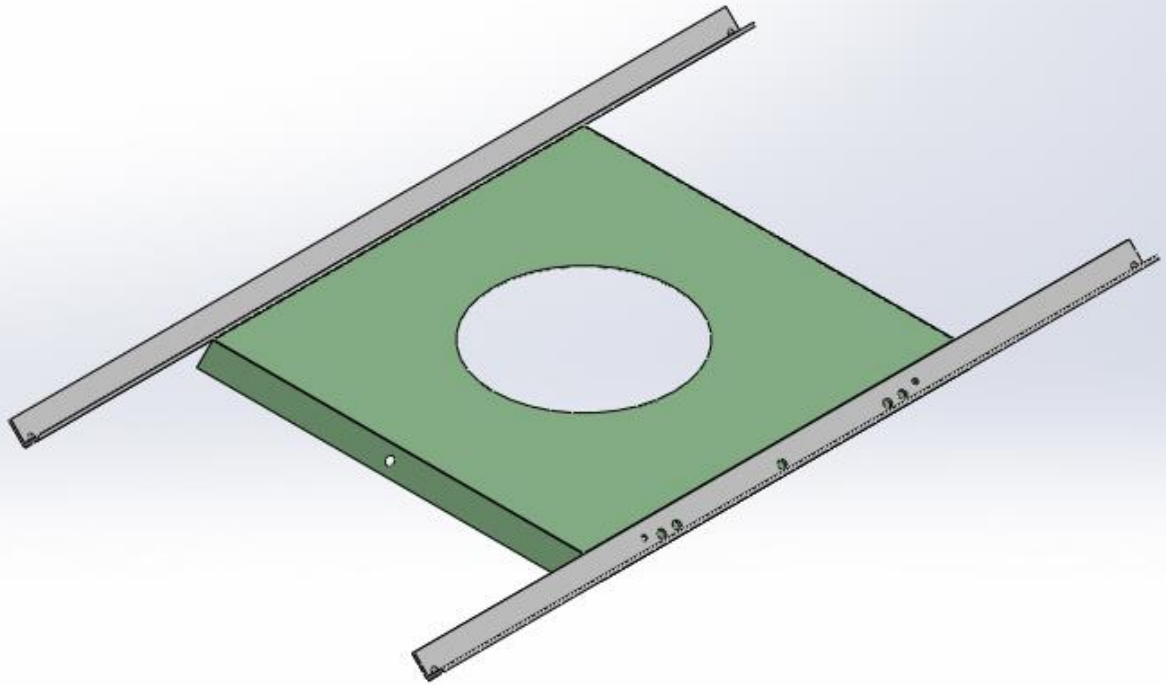
Industrial Robot Extraordinaire

- It requires no safety cages and is safe to operate directly next to people
- There's no programming required – line workers can train Baxter manually
- It's very capable and versatile for a range of repetitive tasks
- It allows streamlined integration with your system, when compared with traditional industrial robots
- It works intelligently – it knows what you want and does what you expect
- It is an extensible platform – add tasks and capabilities via software upgrades

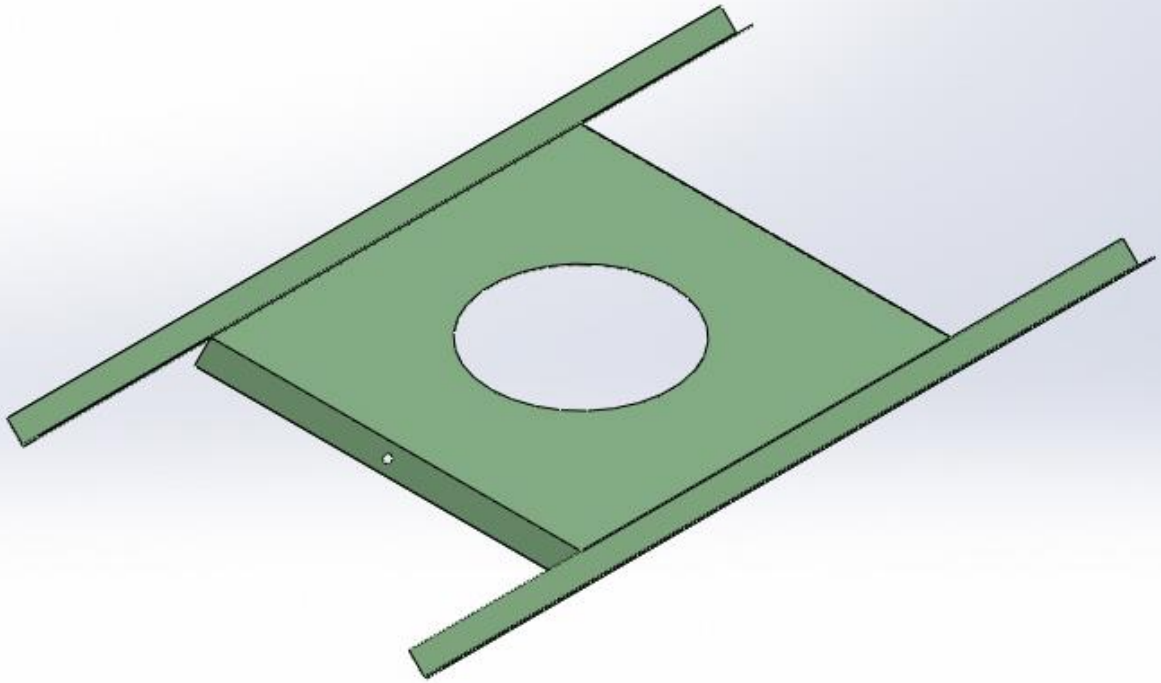
BAXTER

- Allows for continuous production at a lower rate, but a higher overall production
- Regardless of final setup Baxter can be placed in any typical line working position

Current Bridge Assembly

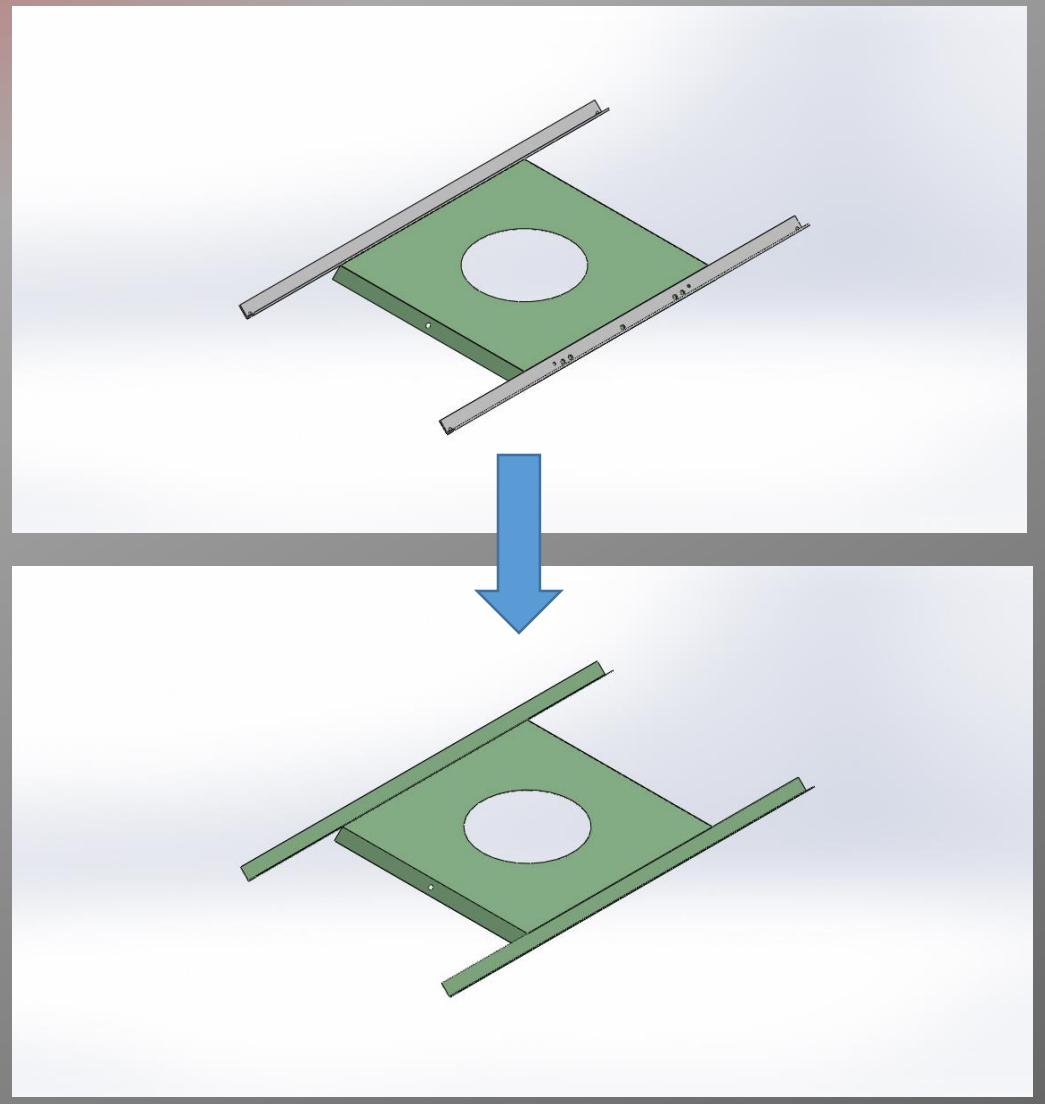


Single Piece Product Concept



Single piece stamp

- Would eliminate the assembly process
- Cuts down on processing mistakes
- Production time would be significantly decreased



AUTOMATION RECOMMENDATIONS: EXISTING MACHINERY

- Rearrangement of process, including changes to the procedure

AUTOMATION RECOMMENDATIONS: UNISTRUT SOLUTION

- Automate system using Unistrut and basic controls system

AUTOMATION RECOMMENDATIONS: NORLOK SOLUTION

- Custom build riveting solution with Norlok

AUTOMATION RECOMMENDATIONS: SINGLE-PIECE CONSTRUCTION

- Investigate possibility of a one piece bridge and eliminate assembly process completely.

POWDER COATING RECOMMENDATIONS: VISION SYSTEM

- Addressing the cause of poor coverage – booth performance – identified as more effective than spotting problem
- Noncontact scanning instruments (which would measure parts on line) not available commercially
- Camera systems cannot detect overcoating

POWDER COATING RECOMMENDATIONS: DATA COLLECTION

- Continue booth data collection sheets to spot worsening booth performance and fill gap in QC data

- Revamp existing QC thickness measurement procedures

  -Rather than once a day, measure parts at startup and throughout day

POWDER COATING RECOMMENDATIONS: MAINTENANCE

- Follow standard operating procedures designed from the Nordson manual to ensure proper use of the equipment
  - Perform regularly scheduled booth maintenance to ensure optimum performance

POWDER COATING RECOMMENDATIONS: PART-SPECIFIC BOOTH SETTINGS

- Booth settings should be established for each type of part to be powder coated (i.e. larger speaker assemblies require higher voltage or air pressure settings)

POWDER COATING RECOMMENDATIONS: NEW RACK DESIGN

- Begin using a rack design that exposes the parts (T-Rack design is suitable for this)

POWDER COATING RECOMMENDATIONS: REPLACE OHMETER

- Replace the ohmmeter used to measure rack grounding

And A Special Thanks To:

- **Randy** for all of his help and guidance
- **Tony** for helping us understand the powder booth and process, providing ideas on improved operation & recording booth data
- **Chuck** for assisting us with our tests
- **Angie** for explaining the QC procedure and