Troubleshooting Industrial Problems

using Good Science & Critical Thinking

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About me

• Mechanical Engineer – Go Boilers!
• 31 years with Kimberly-Clark Corporation
  • Infant Care Staff & Plant Engineering
  • Infant Care Operations Team Leader
  • Nonwovens Plant & Staff Engineering
  • Two year international assignment
• Corporate Expert: Web handling, Winding, Unwinds, Converting, Process design, Troubleshooting and Optimization
• Led KC’s 20 year partnership with the Web Handling Research Center at Oklahoma State
  • Chair, Industrial Advisory Board
• Partner with internal customers, external suppliers and OEM’s to develop & optimize total supply chain solutions
• Recently retired to give back via consulting and disaster relief
Areas of interest
Problem Solving Flowchart

1. **Does It Work?**
   - **Yes**: Don't Mess With It
   - **No**: Did you mess with it?

2. **Did you Mess with it?**
   - **Yes**: You idiot!
   - **No**: Will you get blamed anyway?

3. **Will you Get Blamed Anyway?**
   - **Yes**: You're toast!
   - **No**: Forget about it

4. **You're Toast!**
   - **Yes**: Can you blame someone else?
   - **No**: Hide it

5. **Can you Blame Someone Else?**
   - **Yes**: NO PROBLEM
   - **No**: NO PROBLEM

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**Images:**
- A close-up of a gear assembly.
- A close-up of a damaged hard drive.
Problem solving

In college:
An engineering problem is quickly boiled down to:
  • Given
  • Find
  • Assumptions
  • Equations
  • Solve

In industry:
• Given – Typically not well defined. Never defined in engineering terms.
• Find – There are many different ways a problem can be solved. Often drowning in data that is not important.
• Assumptions – Personal biases are often wrong. Must collaborate with many. Trust but verify.
• Equations may not be available. Multiple factors may not be understood. Use good science to filter data.
• Solve – Team work is required to build consensus. Sell your idea to drive action.
Four step process

1. Define the problem
   - Productivity, quality, capability?
   - How much does it cost?

2. Determine the options
   - What factors are important?
   - What options are available?
   - The most important but neglected step

3. Decide what to do
   - Balance risk versus reward
   - Good homework → good decisions

4. Do plan your project
   - Proper prior preparation..
   - Document results & recommendations

- “Critical Thinking in Converting”, David R Roisum
Define the problem

*Show me the money*

- “Lies, damn lies and statistics”
  - Mark Twain
- “Until you use dollars you will not make cents”
  - Neal Michal

**Focus on the $$ opportunity**
- What does 1% waste cost?
- What does 1% downtime cost?
- What does 1% reject rate cost?

“Money don’t mean everything it’s true
But what it can’t buy I can’t use
I want money, that’s what I want”
- 1959; Berry Gordy, Janie Bradford
Define the problem

Example

• Disposable diapers cost between $0.19 to $0.43 per product
  - Walmart.com; 18 JAN 2018

• Hypothetical example:
  • Individual diaper: $0.25
  • Raw materials: $0.10

• How fast would you like to turn dimes into quarters?

• How many quarters do you want to throw away?
Determine the options
Collaborate with many

• It is common to overestimate what you can do by yourself
• Don’t underestimate what several people working together can accomplish
• Take the advice of many
• Reach out to those who have first hand knowledge

The way of a fool is right in his own eyes, But he who heeds counsel is wise.

- King Solomon
Determine the options
*Ask the Experts*

- Direct observations are required
- What do the operators think?
- This may take some prodding
- They may not believe that you *really want to listen*
- Be honest. Be transparent. Ask for help.
- Ask your equipment providers
- When desperate call a consultant…
Determine the options

Work smart

• Do your homework
• Educate yourself
• You only have opinions until you have data
• Trend charts are powerful
• Intermittent problems are the most difficult to solve
• Be creative on how to collect relevant data

“Why spend a day in the library when you can learn the same thing by working in the laboratory for a month?”
- Frank Westheimer, Harvard
Determine the options

*Trust but verify*

- Take all the feedback you can gather
- Go see for yourself
- Direct observation is more powerful than a theory or equation
- Ask lots of questions
- Take lots of notes
- Don’t be quick to jump to a conclusion
- Bad assumptions…
- Make sure you are working on the right problem
Determine the options

Other factors

• Separate the issue into the 4M’s
  • Man, Method, Machine, Material
• What factors magnify the problem?
• Often you will need to conduct a trial to find out what factors are important
• You can spend the same amount of time on a small problem with small reward
• Do nothing is an option; so is failure
• Sometimes you must press forward in the absence of cost benefit

“If everything seems to be in control, you are not going fast enough”
- Mario Andretti
Decide what to do

*Balance risk / reward*

- You must make a decision
- Any decision is better than no decision
- Good homework will lead to good decisions
- Gain consensus; make it a team decision
- The size of the prize should drive the level of risk
- Develop abort criteria to reduce risk
- Consider other options to reduce risk
- *Make it happen*

“Lead me, follow me or get the hell out of my way!”
- George S. Patton, Patton Principles
Do plan your project

• Develop your plan
  • Problem
  • Hypothesis
  • Experiment
  • Observations
  • Conclusions

• Work your plan
• Document your results
• Analyze your results
• Make recommendations

“We can’t solve problems by using the same kind of thinking we used when we created them”

- Albert Einstein
Good Science & Critical Thinking

- You must be smarter than the problem
- Do your homework
- Collect high quality data that defines the problem
- Network and ask for help
- Challenge your vendors to help
- Attend technical seminars
- Open innovation
- Importance of models: empirical to computer – it all depends
The Shape Filter

- The shape filter is a pattern matching technique
- Shape filter is a powerful tool that can look at a wide array of problems
- Premise: The shape of the root cause must match the shape of the problem – or the mirror image
- The shape tool can eliminate 90% of the chaff on the first pass

- *Critical Thinking in Converting, Roisum*
Roadblocks

• “Don’t fix it if it is not broken.”
• Rarely is it true in a manufacturing or converting.
• Most everything is broken at some level once you start digging into it.
• Don’t be surprised what you see.
• Find the opportunity. Go for it!

Troubleshooting Examples
Time

The shape filter can evaluate events that repeat over time.

• Recurring mystery stops @ $10k each
• Shift maintenance would reset drive. Starts up w/o error code
• Shift maintenance works 3 days on / 3 days off
• It took 16 days to identify a repeating pattern
• Originally misdiagnosed as a problem with the drives

Good Science

• Document exact time of failure
• Set up cameras to watch the communication modules

Critical Thinking

• Found that it was 4:58pm every other day → Man made event
• Network would ping all open IP addresses → Caused failure
• Protected IP addresses. Issue resolved.
Packaging

Waste due to packaging failures are frustrating
• “Top 3” issue with customer

Critical Thinking
• Audit entire supply chain
• Slits are moved > 17 times
• Determined failures are 12-24” above floor
• Backside of roll clamp damages adjacent rolls when unloading from trailer

Good Science
• Partnered with film vendor
• Developed performance tests
• Developed & standardized improved packaging
• Virtually eliminated failures
Buckling

Rolls are traditionally stored axis vertical
• Found rolls with local buckle defects

Good Science
• Roll density is a sensitive measurement
• Rolls with low density will collapse
• Column buckling failure over time
• Note increase of buckles toward the bottom

Critical Thinking
• Measure and control roll density
• Set density target with limits
• Reduced total delivered cost by 20%
Caliper

- Caliper loss is common in delicate materials such as tissue
- The pattern of caliper loss is consistent
  - Best caliper at the outside of the roll
  - Reduced caliper thru the middle
  - Significant loss of caliper at the inside of the roll
- Good science:
  - Wound roll mechanics describes how stress and strain is distributed
  - New technique to directly measure interlayer pressure
- Critical thinking
  - Caliper loss is inversely proportional to interlayer pressure
  - Reduce interlayer pressure → less caliper loss → higher profit margins
Floppy edges

- Floppy edges are the most common defect in web processes
- Critical Thinking
  - Literature search reveals hundreds of references that correlates cross web mass profile to floppy edges
  - Develop cost model to determine economic solutions
- Good Science
  - Document cross deckle basis weight profile; correlate to floppy edges
  - Use computer model to predict floppiness and what can be done to minimize impact
  - Reduce basis weight profile, take more trim or increase tension
  - Reduce roll density and/or web temperature
Telescope

Internal roll slippage is common on slick webs
• Extreme examples will “telescope”

Good Science
• Computer models predicts torque capacity
• Torque capacity is a function of several factors: interlayer pressure, COF, ratio of OD/ID
• Slip plane will always be near the core

Critical Thinking
• Directly measure torque capacity and the slip plane diameter
• Increase tension or nip beyond the slip plane
• Increase overall roll density
• Reduce acceleration rate in converting
Porosity

Vacuum is often used to place registered components
• Changes in porosity thru roll results in converting waste

Good Science
• Interlayer pressure peaks at the core and decays linear to diameter to the OD for elastics
• Porosity is inversely proportional to interlayer pressure
• Porosity decreases over time due to viscoelastic creep

Critical Thinking
• Allow rolls to age before converting (?)
• Change vacuum puck design
• Adjust vacuum thru roll to provide constant force
Strain

Nonwoven elastics are expensive
• Strive to place same coupon length to reduce delivered cost

Good Science
• Physical properties follow stored strain
• Developed computer model

Critical Thinking
• Developed patented winding technique
• Reduced Variability 60% - 80%
• Increased Roll Length 8 -30%
• Reduced Basis Weight 4% - 9%
• Reduced converting waste
Summary

• “Until you use dollars you will not make cents”
• Fallacy of “Don’t fix it if it is not broken”
• Don’t jump to conclusions; follow the facts
• Make direct observations
• Be humble & ask many questions
• Collaborate with many; trust but verify
• Gain trust with the machine operators & ask for their help
• Use the “Shape Tool” to filter the evidence you collect
• Use advanced tools: trend charts, cameras, FFT analysis, etc
• Educate yourself; do your homework
• Make a decision and go for it
Questions?

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