

Troubleshooting Industrial Problems

using Good Science & Critical Thinking



Neal Michal

Principal

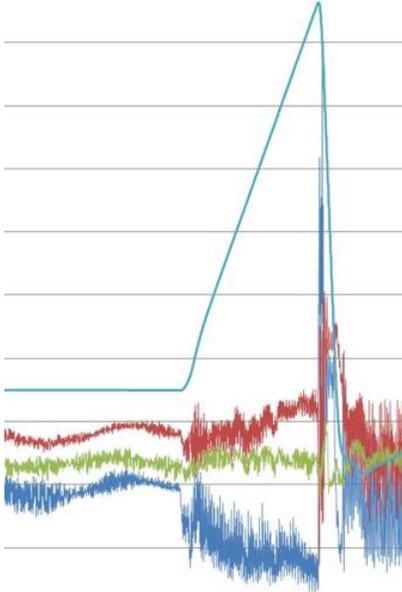
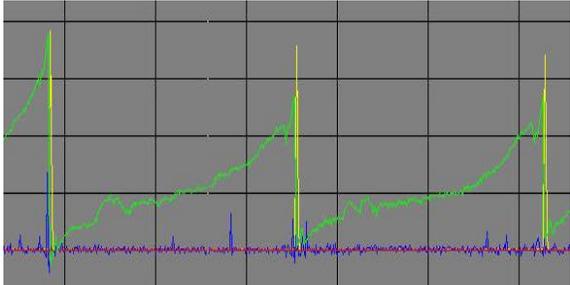
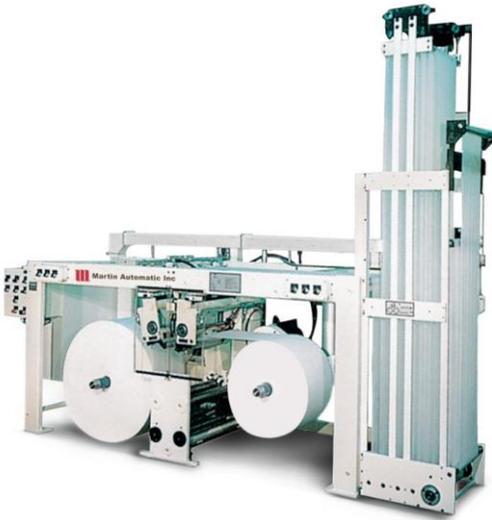
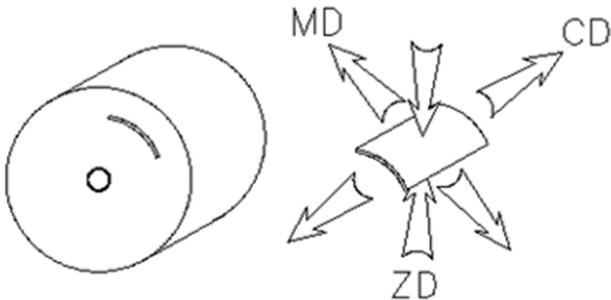
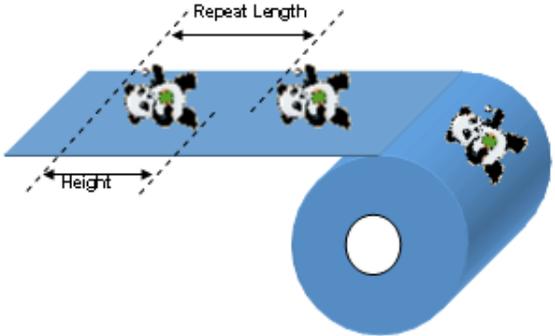
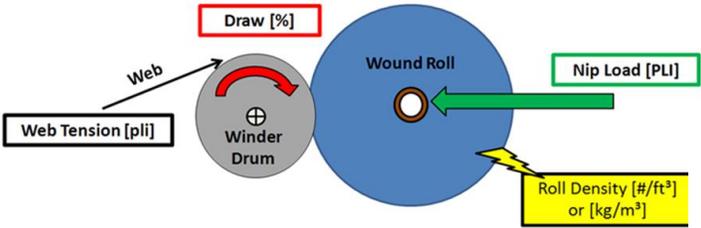
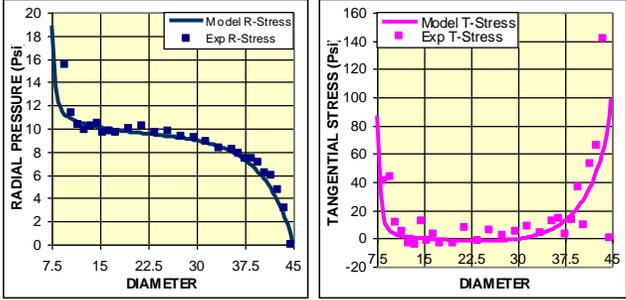
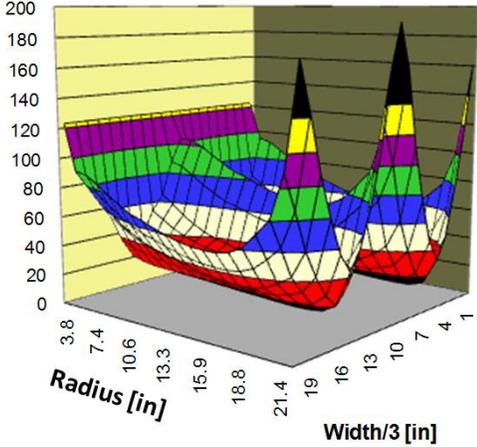
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About me

- 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

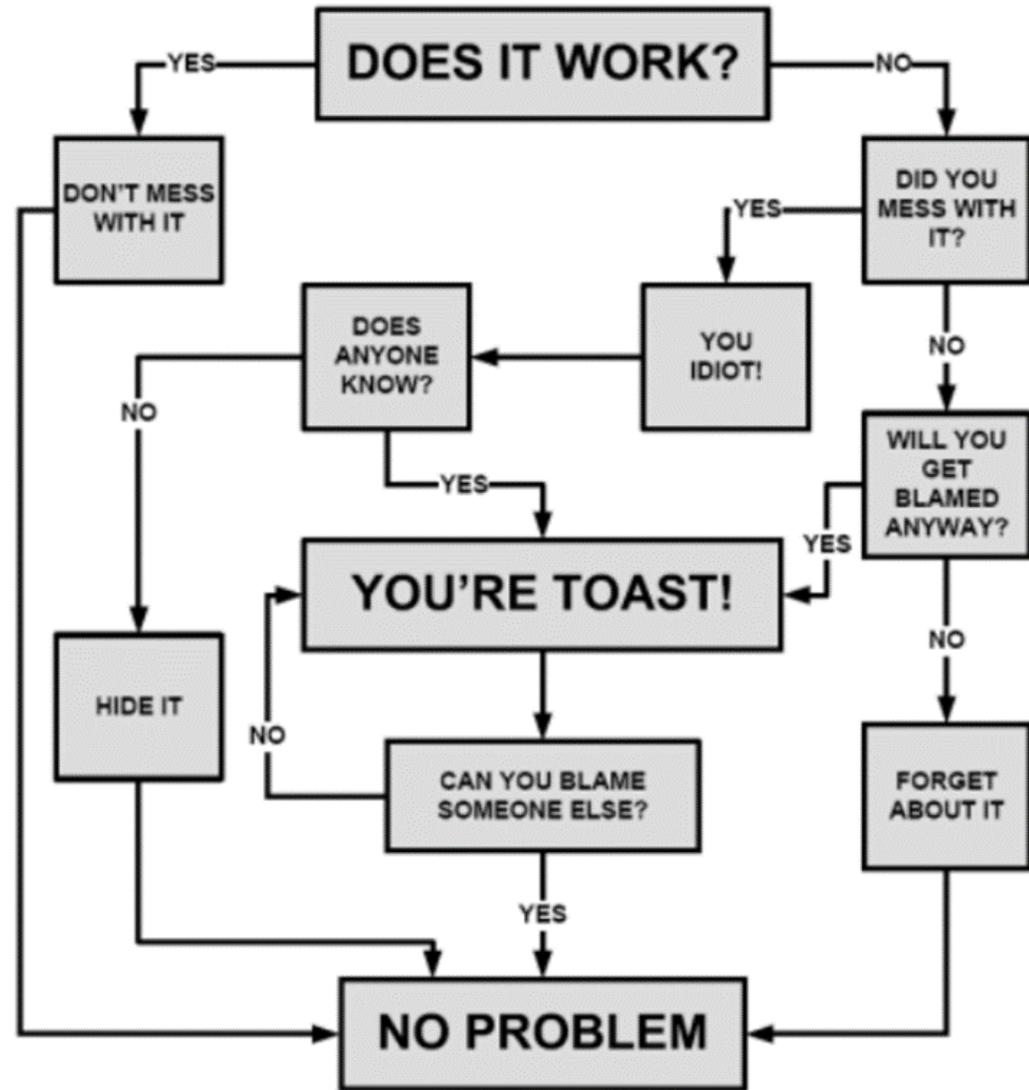


Areas of interest





Problem Solving Flowchart



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

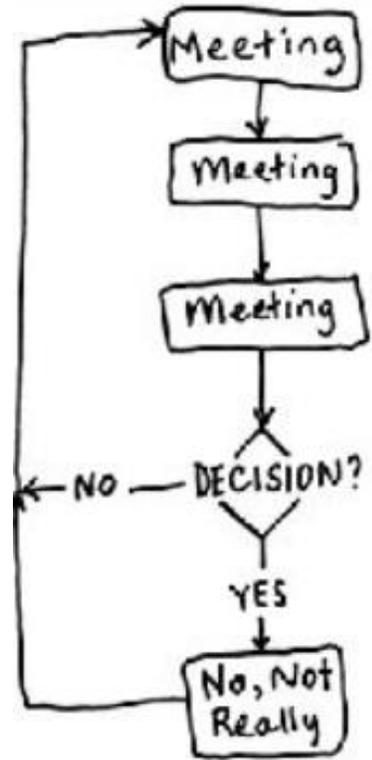
- What factors are important?
- What options are available?
- The most important but neglected step

3. Decide what to do

- Balance risk versus reward
- Good homework → good decisions

4. Do plan your project

- Proper prior preparation..
- Document results & recommendations



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?*



Productivity: Speed, Uptime, Waste



- *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.

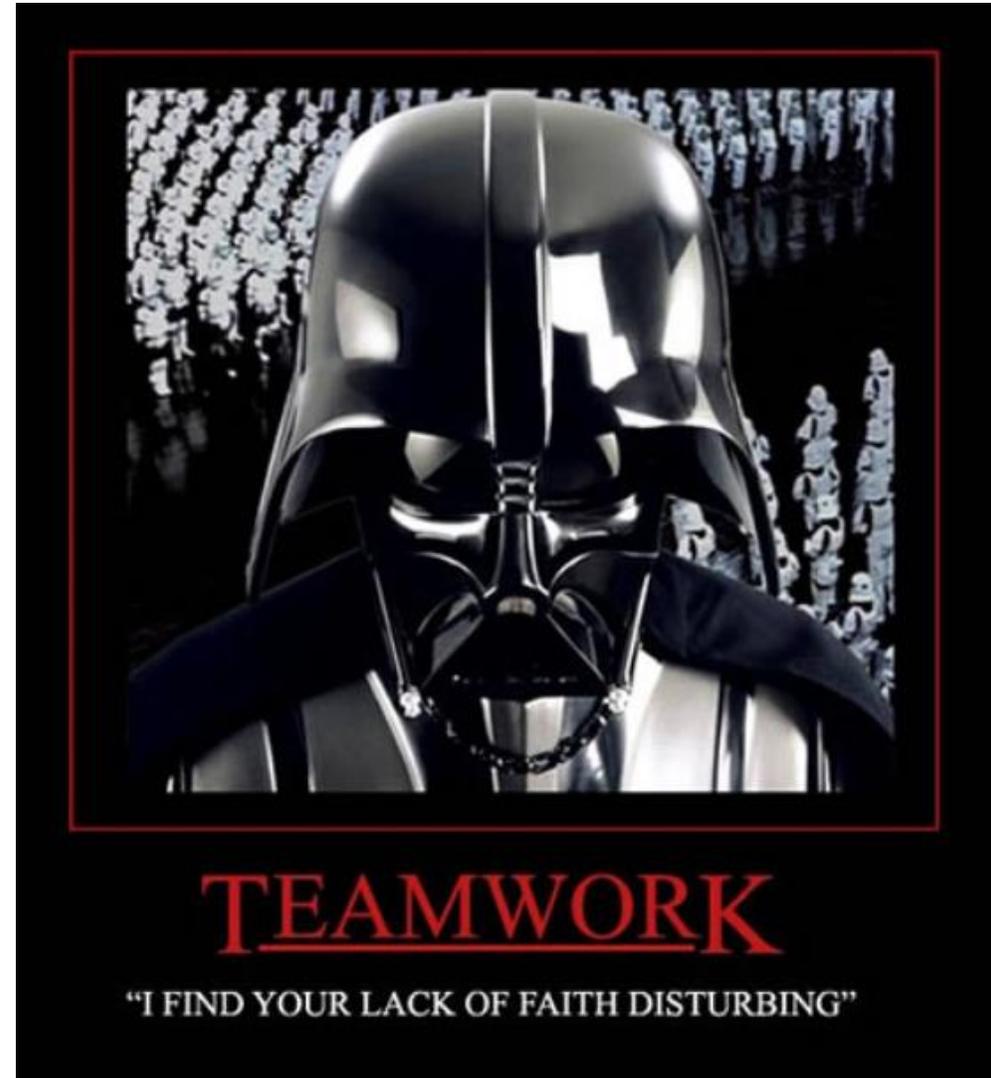
- King Solomon



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

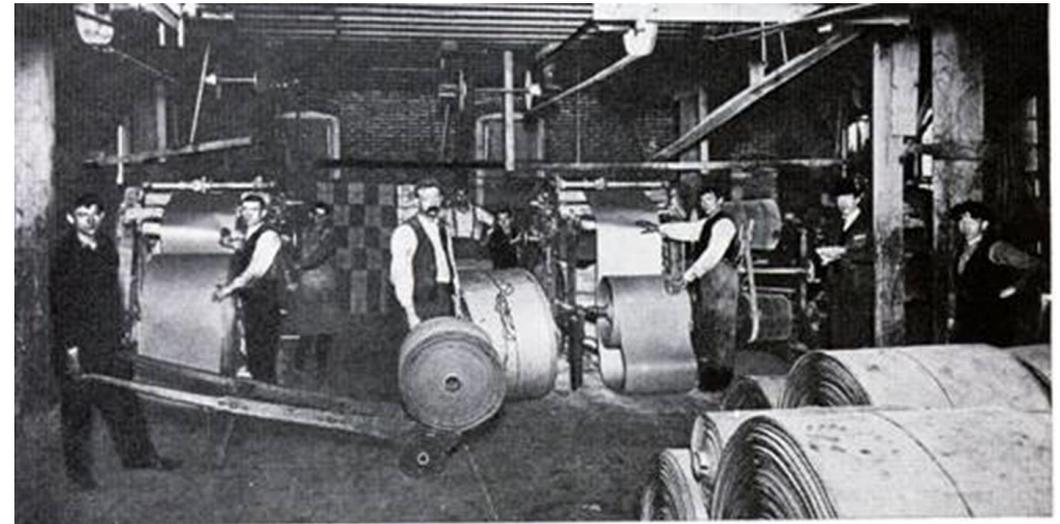
- Take all the feedback you can gather
- Go see for yourself
- Direct observation is more powerful than a theory or equation
- Ask lots of questions
- Take lots of notes
- Don't be quick to jump to a conclusion
- Bad assumptions...
- Make sure you are working on the right problem



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



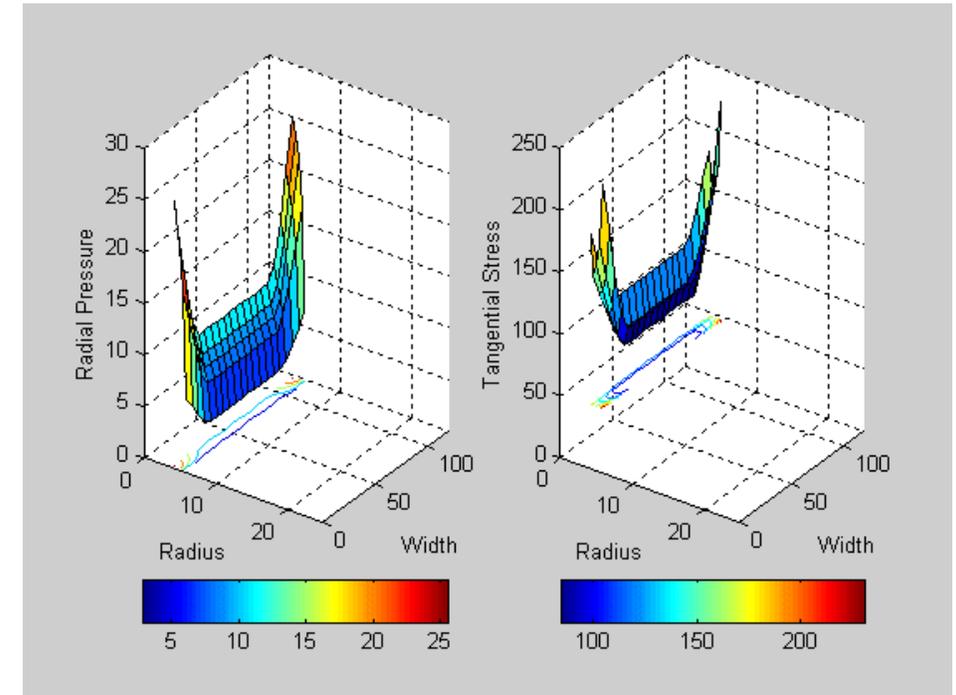
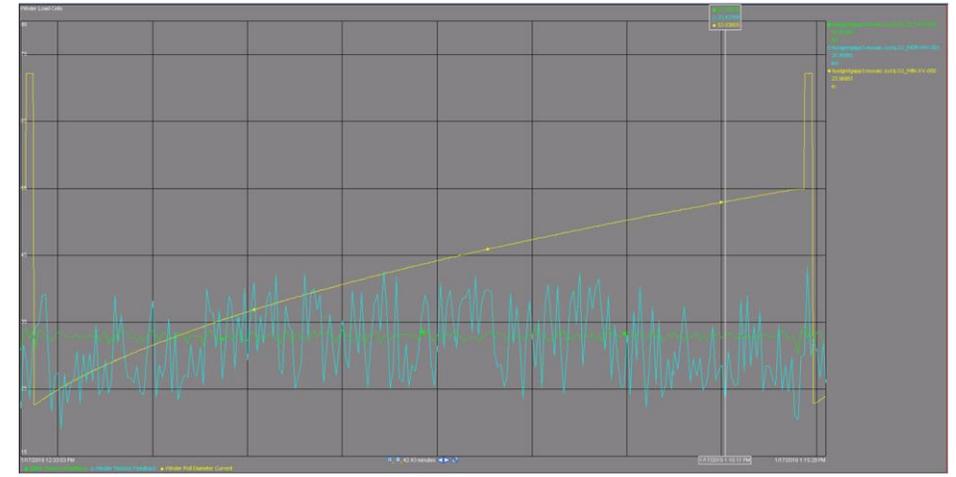
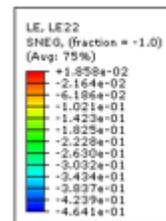
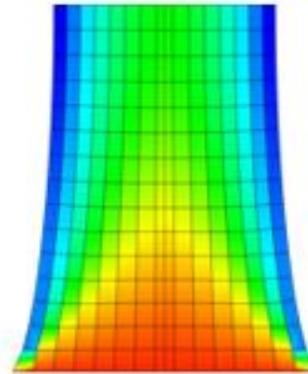
“We can’t solve problems by using the same kind of thinking we used when we created them”

- Albert Einstein



Good Science & Critical Thinking

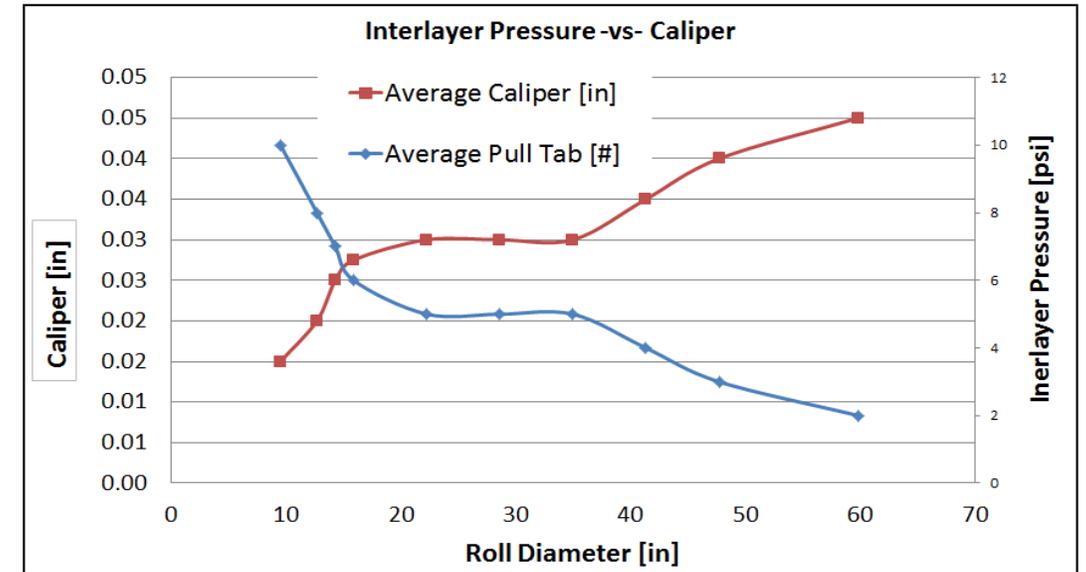
- You must be smarter than the problem
- Do your homework
- Collect high quality data that defines the problem
- Network and ask for help
- Challenge your vendors to help
- Attend technical seminars
- Open innovation
- Importance of models: empirical to computer – it all depends



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*

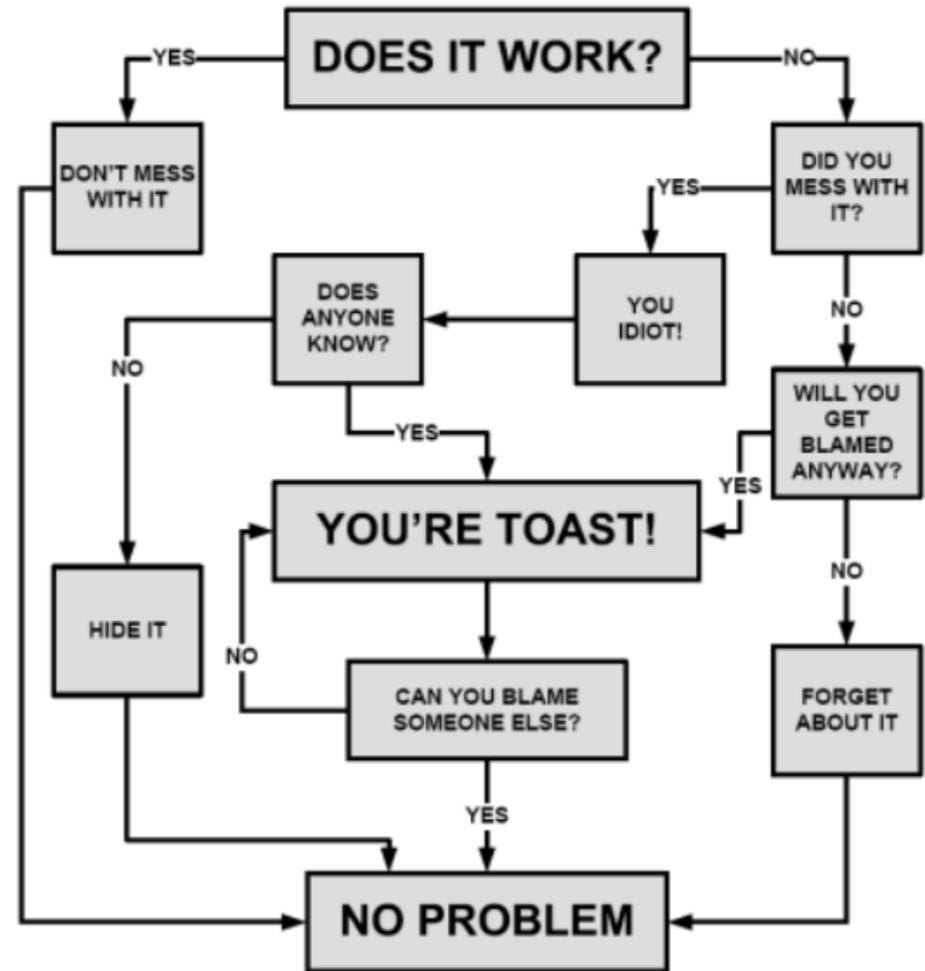


Roadblocks

- “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!

- Practical Methods to Improve Wound Roll Quality, Applied Web Handling Conference, 2015

Problem Solving Flowchart



Troubleshooting Examples

Time

The shape filter can evaluate events that repeat over time.

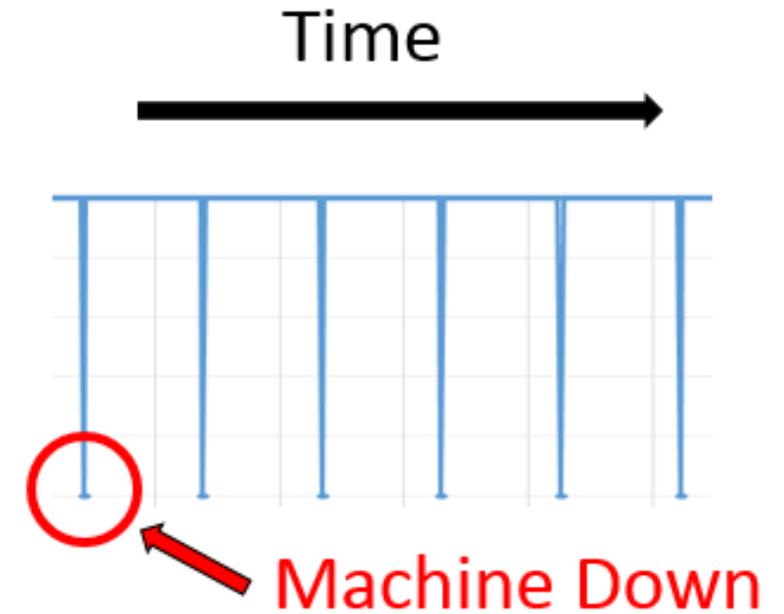
- Recurring mystery stops @ \$10k each
- Shift maintenance would reset drive. Starts up w/o error code
- Shift maintenance works 3 days on / 3 days off
- It took 16 days to identify a repeating pattern
- Originally misdiagnosed as a problem with the drives

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

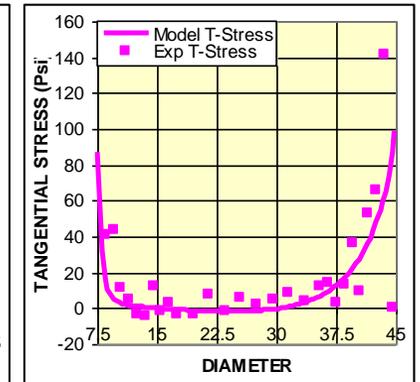
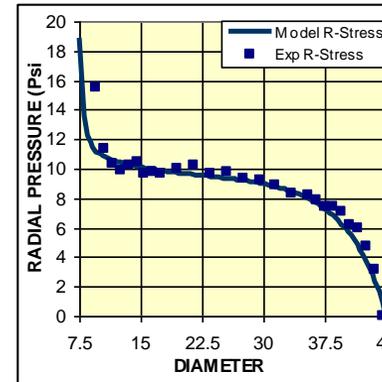
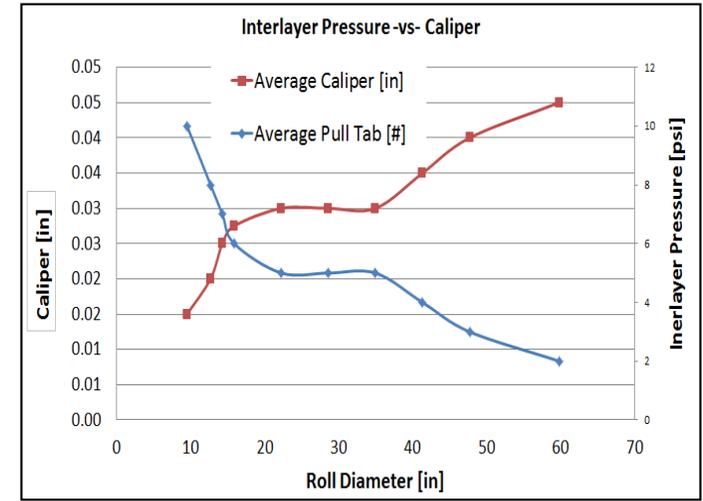
Critical Thinking

- Measure and control roll density
- Set density target with limits
- Reduced total delivered cost by 20%



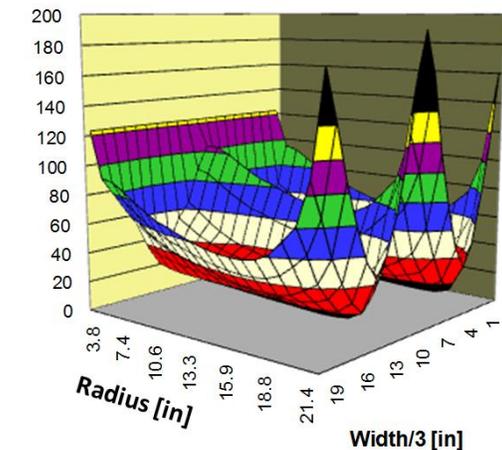
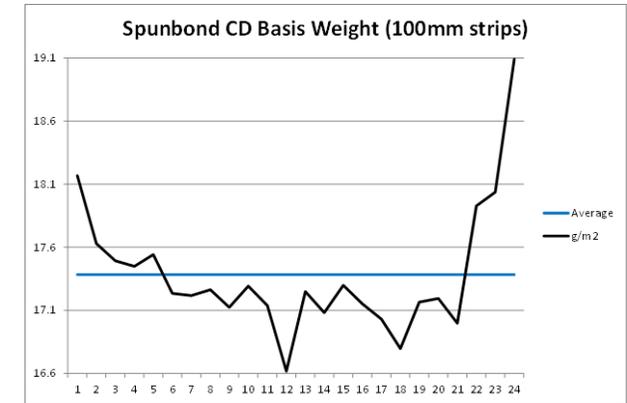
Caliper

- 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

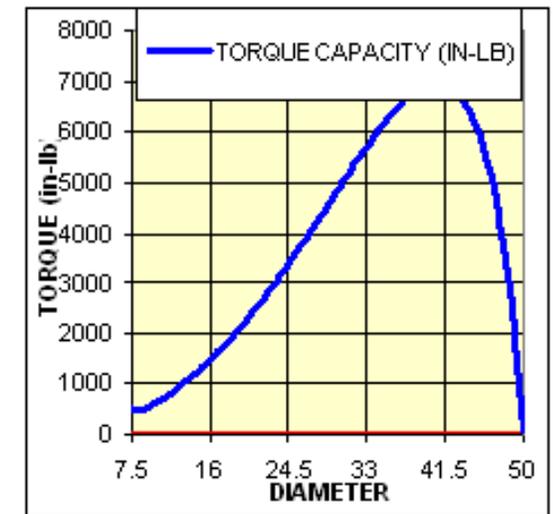
- Extreme examples will “telescope”

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

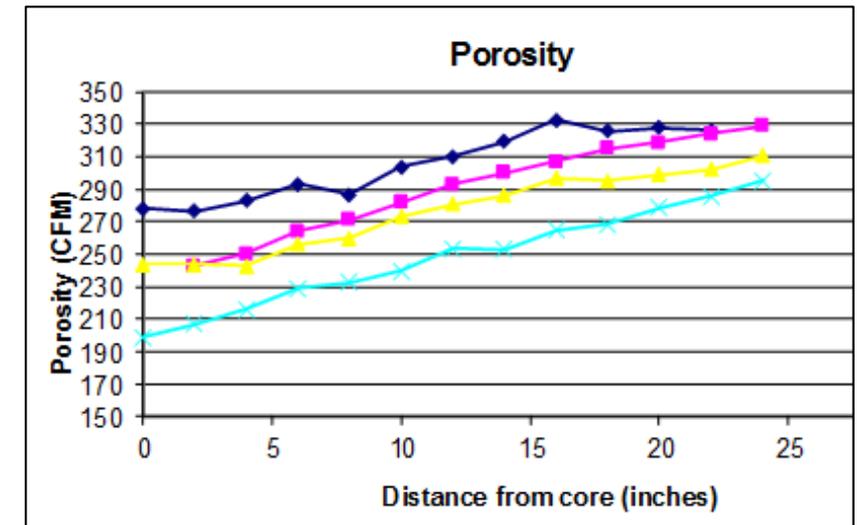
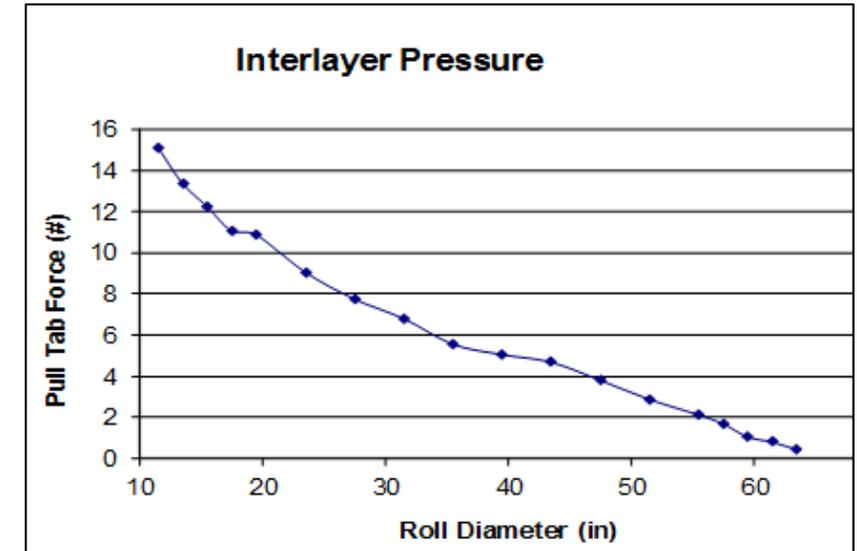
- Changes in porosity thru roll results in converting waste

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

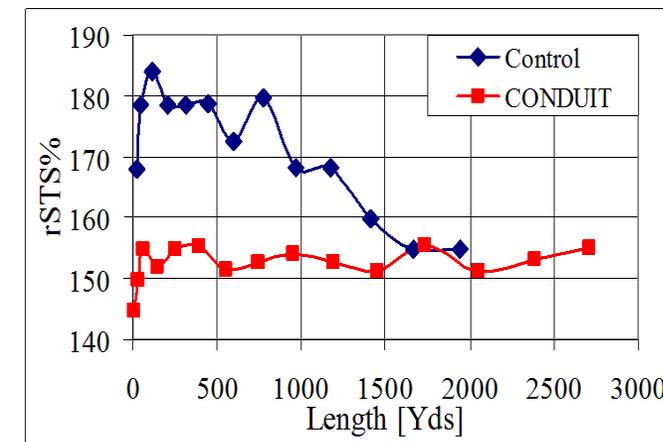
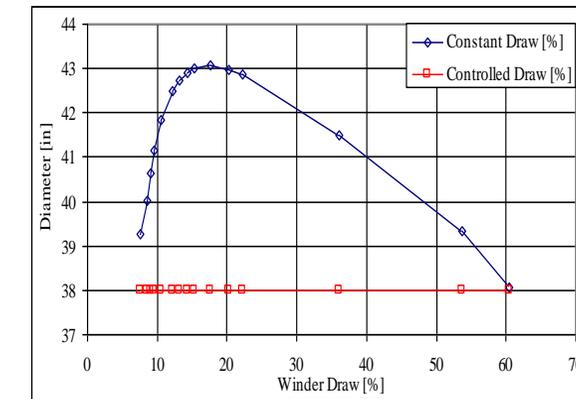
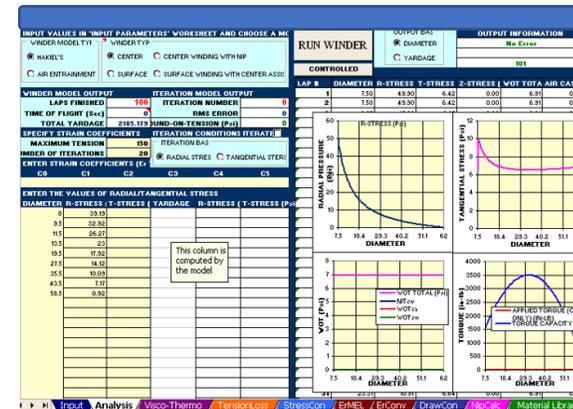
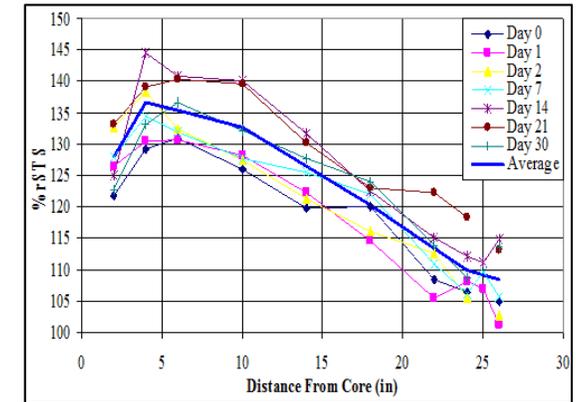
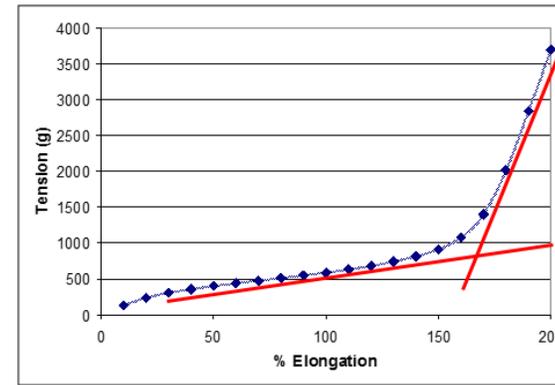
- Strive to place same coupon length to reduce delivered cost

Good Science

- Physical properties follow stored strain
- Developed computer model

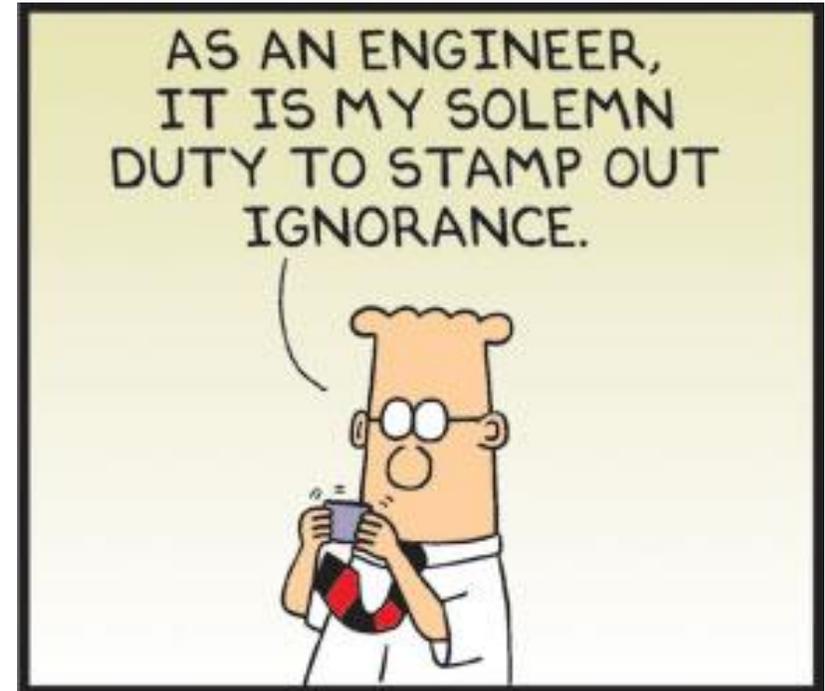
Critical Thinking

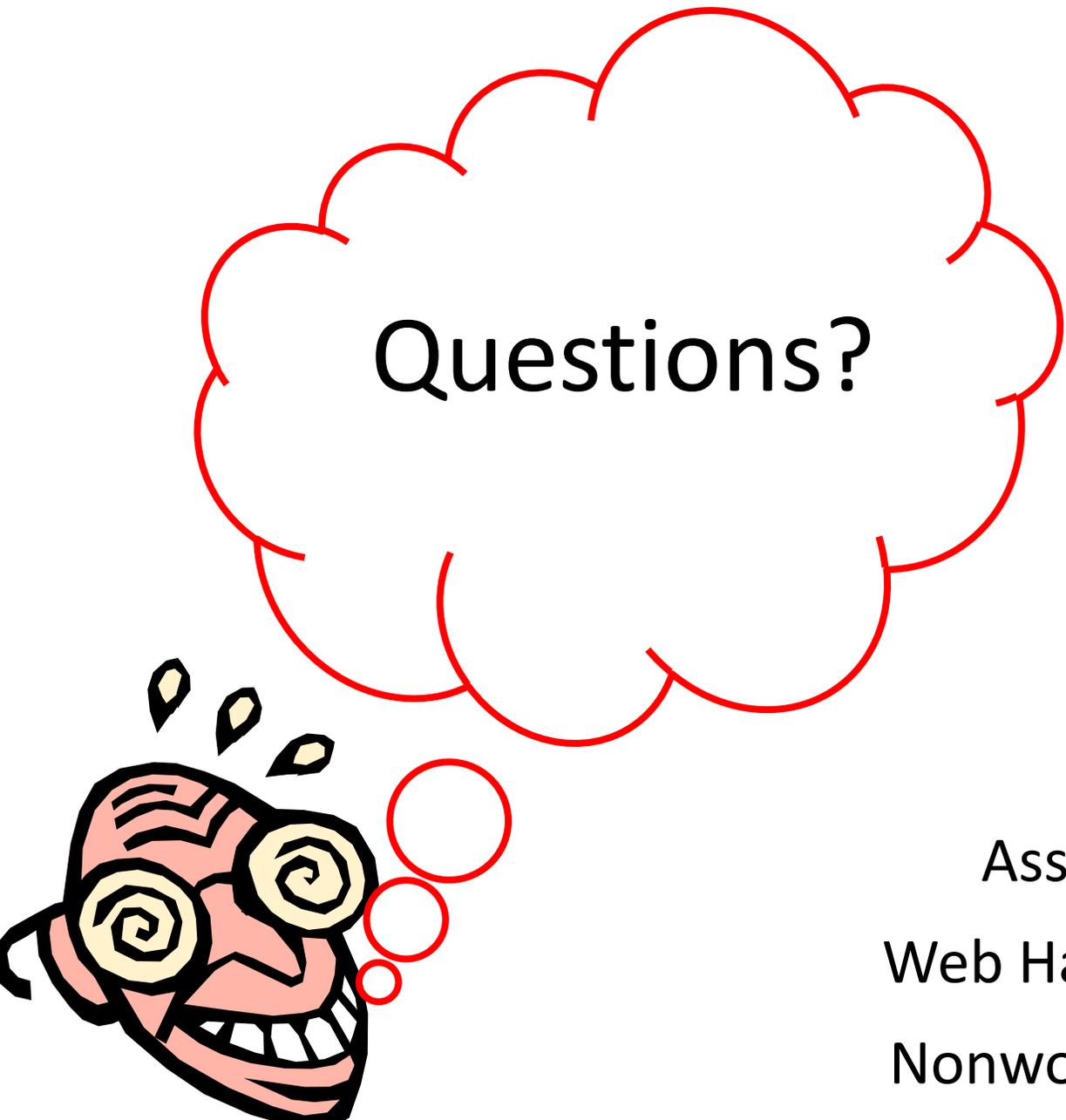
- Developed patented winding technique
- Reduced Variability 60% - 80%
- Increased Roll Length 8 -30%
- Reduced Basis Weight 4% - 9%
- Reduced converting waste



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, ect
- Educate yourself; do your homework
- Make a decision and go for it





Questions?

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Assess – Troubleshoot – Optimize - Train

Web Handling - Converting - Unwinds - Winders

Nonwovens - Elastics - Film - Tissue - Laminates