WOOD INDUSTRY WEEK @ WERC

Presented by:

WERC
WOOD EDUCATION AND RESOURCE CENTER

FOREST SERVICE US DEPARTMENT OF AGRICULTURE

Woodworking Network

WOOD Products

Upcoming Workshops

Wood Industry Week @ WERC '14

Register Now

March 11 - 13, 2014

To be held at the Wood Education and Resource Center, Princeton WV.
For more information on this 3-day workshop, please see here or contact Urs Buehlmann.

For other information on the USDA FS' Wood Education and Resource Center:
http://www.na.fs.fed.us/werc/events.shtm
Phone: (304) 487-1510

Why you should attend

- To get an update on techniques to improve your operation
- To learn about new trends and opportunities in the industry
- To learn from experts and colleagues
- To learn about customer expectations, global implications and the future
- To network and to benefit from five days of learning, discussing, and observing with experts

Past Workshops

Wood Industry Week @ WERC '12

Design of Experiments

A Brief Overview

Identifying the root cause(s), critical factors, optimization, etc.

DOE - What is it?

- "...a method by which you make purposeful changes to input factors of your process in order to observe the effects on the output."

  Stat-Ease Inc. 2000

- A way to learn about your process –
  - What are the critical factors?
  - How do they influence the output?
  - What are the optimal settings?
  - Is the process robust to variation?

What's the difference…

- between 'designing an experiment' and DOE?
  - 'designing an experiment' is one of the tasks within the methodology known as DOE
  - Good experimental design leads to valid and reproducible results

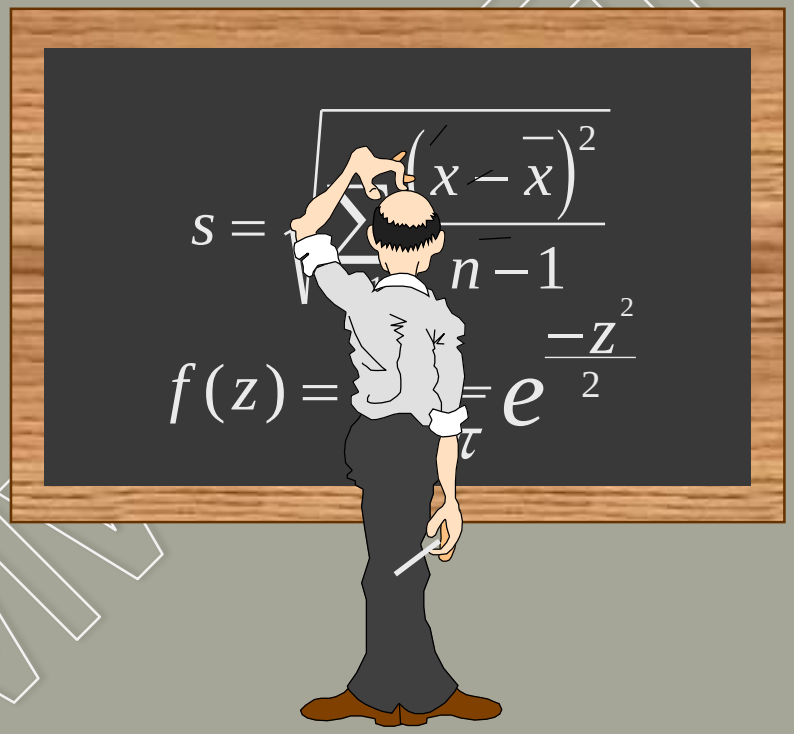
DOE - Methods

- Traditional approach – vary “One Factor at a Time” (OFAT) and observe results
  - inefficient and ineffective
- Factorial designs
  - effective, efficient, can detect interactions
  - reliance on relatively complex statistics

What's wrong with OFAT?

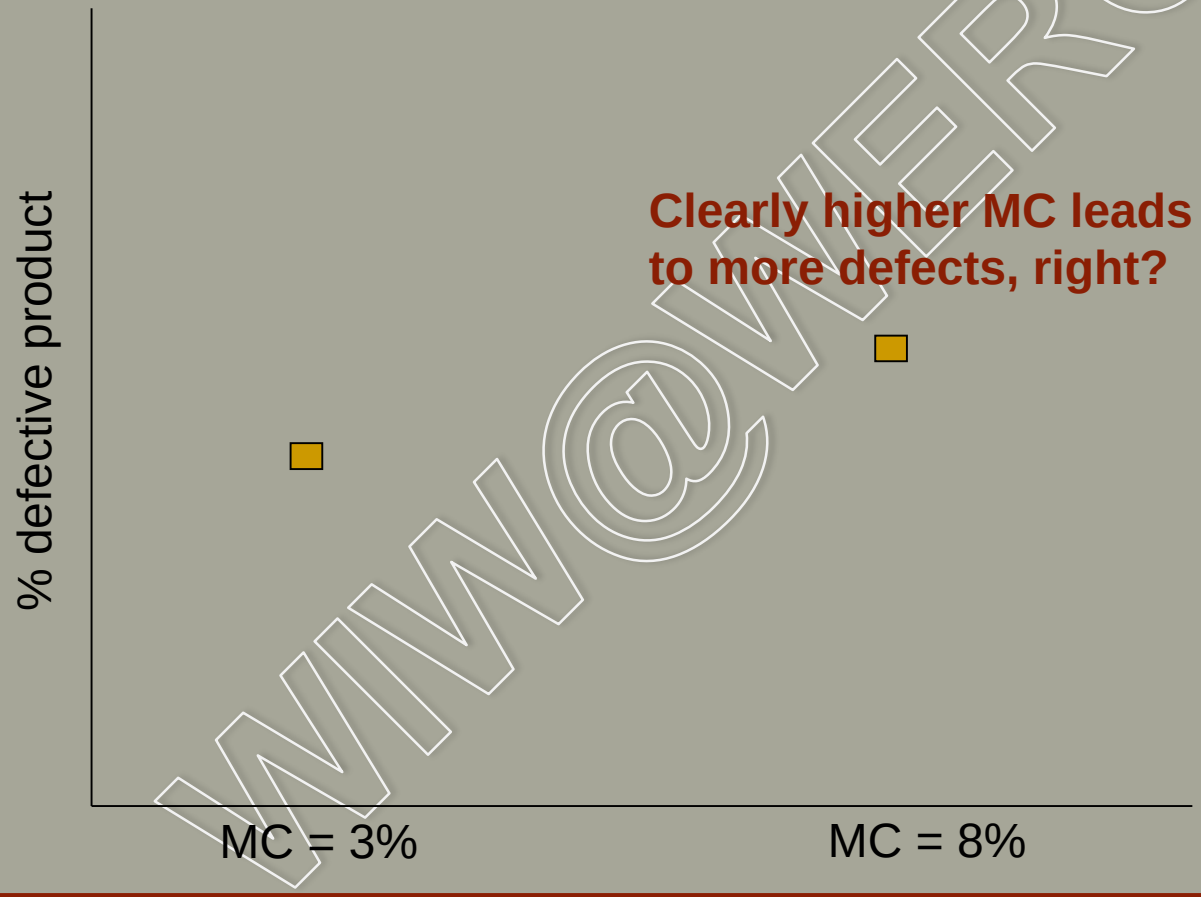
- Can take many, many more experiments (time & $) than DOE
- **Presumes that factors don't interact**
  - **and if they do, you'll never know**

Why do we need statistics?



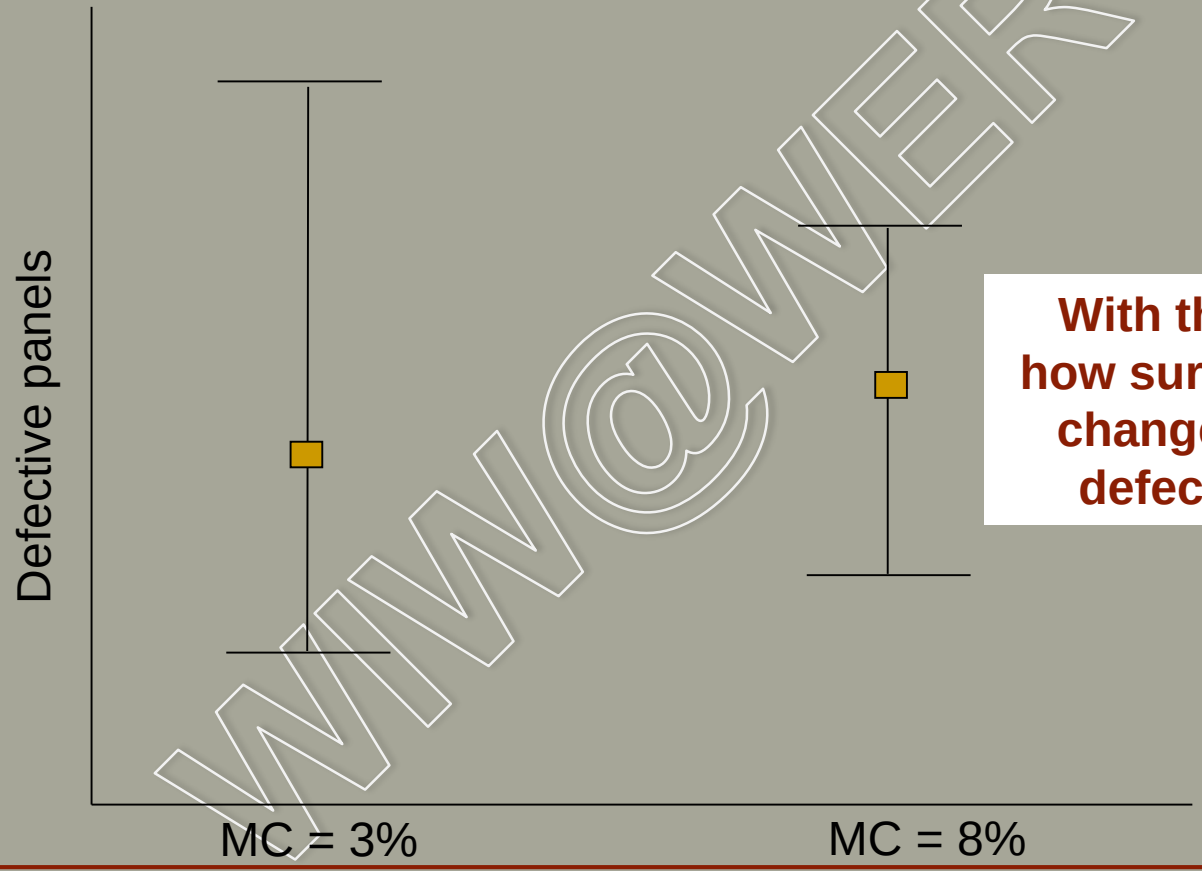
Why do we need statistics?

Experimental results – sample average only



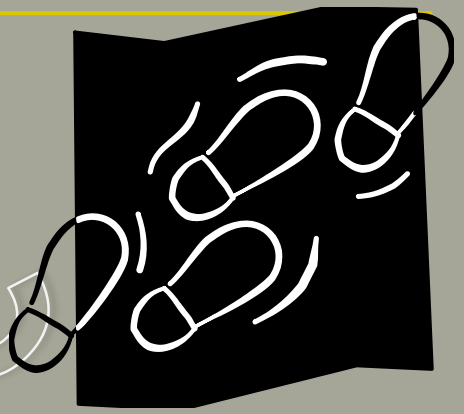
Why do we need statistics?

Experimental results *accounting for sample-to-sample variation*



With this much overlap, how sure are you that if we change MC target to 3% defects will go down?

DOE: Step-by-Step



1. Define objectives of experiment
2. Determine response variables and measurement
3. Brainstorm process variables (factors) to be studied
4. Determine number of replicates
5. Develop detailed experimental plan
6. Decide which factors to hold constant
7. Make post-experiment plans

DOE – Example 1

- Influence of dip coating and species on shrinkage (1x12 flatsawn, 18% to 6% MC)
  - Coating – tung oil (TO) and propylene glycol (PG)
  - Species – pine and fir
  - Combinations (10 pieces each):
    - Pine in TO
    - Fir in TO
    - Pine in PG
    - Fir in PG

DOE – Example 1

- Results
  - Pine TO – avg. = 0.274
  - Pine PG – avg. = 0.254
  - Fir TO – avg. = 0.339
  - Fir PG – avg. = 0.337
- Pine < fir; but what about coating?

Pine TO	Fir TO	Pine PG	Fir PG
0.286	0.353	0.285	0.362
0.292	0.343	0.254	0.334
0.275	0.323	0.265	0.342
0.233	0.351	0.224	0.339
0.281	0.311	0.274	0.344
0.246	0.325	0.267	0.335
0.279	0.343	0.281	0.341
0.293	0.345	0.210	0.311
0.288	0.335	0.239	0.320
0.265	0.361	0.238	0.338

DOE – Example 1

- Let's try analyzing it using Excel
  - Open `DOE example1.xlsx`
  - Click on 'Data', 'Data Analysis', 'Anova: Two-Factor With Replication'
  - Input range = A1:C21
  - Rows per sample = 10
  - Alpha = 0.05

DOE – Example 2

- XYZ Forest Products decides to explore size-out-of-specification
  - Objective - What is the influence of species, moisture content (MC) and tooling on size-out-of-spec?
- So what's the response variable?

DOE – Example 2

- Process variables (factors)
  - Species – poplar and birch
  - Moisture content – 6% and 12%
  - Tooling – existing and new
- Number of replicates (batches of 50, n=5)
- Detailed plan
- Factors to be held constant
- Post-experiment plans

DOE – Example 2

- Results:

Combination	Avg. # defective pieces
6-existing-birch	5.0
6-existing-poplar	3.8
6-new-birch	5.6
6-new-poplar	3.0
12-existing-birch	7.4
12-existing-poplar	6.4
12-new-birch	8.2
12-new-poplar	3.8

DOE – Example 2

- Difficult (impossible?) to analyze using Excel due to more complex design
  - So we'll use specialized DOE software

DOE – Example 2

- Recommendations:
  - If can tightly control & monitor MC, and opt not to change tooling each time they switch species – machine poplar and birch at 6% MC using new tooling.
    - Note the trade-off: results suggest using new tooling results in fewer out-of-spec handles w/poplar but slightly more w/birch. If birch is by far the dominant species used in production, the company might want to continue using existing tooling.
  - If can't tightly control MC and changing tooling between species is feasible – use existing tooling for birch and new tooling for poplar (regardless of MC).

Q&A/Wrap-Up

Acknowledgements