Stat Teaser

NEWS FROM STAT-EASE CORPORATION • SEPTEMBER 1997
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Workshop Schedule

• Experiment Design Made Easy
November 11–14, 1997: Philadelphia, PA
December 2–5, 1997: Anaheim, CA — *New location and date!*
January 20–23, 1998: Denver, CO
Covers the practical aspects of Design of Experiments (DOE). Learn about simple but very powerful two-level factorial designs.

• Response Surface Methods for Process Optimization
October 7–10, 1997: Minneapolis, MN
February 10–13, 1998: Minneapolis, MN
This workshop builds from factorial DOEs into Response Surface Methods (RSM), which produce maps to help you find the optimum and/or robust conditions for your process.

• Mixture Design for Optimal Formulations
October 21–24, 1997: Minneapolis, MN
March 17–20, 1998: Minneapolis, MN
If you do product formulation, you know standard factorial designs just don't work. You need the mixture design skills presented here.

• Robust Design for Quality Improvement
December 9–11, 1997: Minneapolis, MN
Learn to meet your tightest specifications with minimal variation. Push the envelope with saturated fractional factorials.

Attendance limited to 24. Reserve your place by calling Carol, ext. 18, at
800-801-7191
Or, bring us on site. Ask for a quote.

Bigger and Better Bubbles via Mixture Design

Mark's Experiment

by Mark J. Anderson

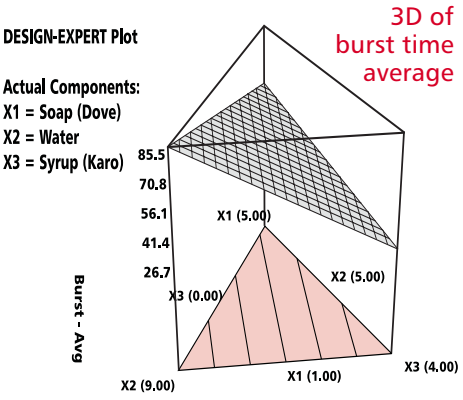
Recently, while waiting in the lobby of a Stat-Ease client, I observed a curious pattern of circles on the carpet. I quizzed the receptionist. She gave me sheepish look and then confessed that she'd been blowing bubbles. A vendor got the blame for sending a "bubble-pen" (a ball-point pen on one end and a wand on the other end with bubble solution in the barrel). The fun ended when the barrel went dry. The receptionist then refilled the bubble-maker with pure dish-washing liquid. The unsightly rings of residue were an unfortunate side-effect.

I decided to take a more scientific approach to bubble formulation. To get the experiment off to a good start, I did some subject-matter research. I raided the kids' project cabinet and found a recipe on a bubble wand:

2 cups dish-washing liquid (preferably Joy®)
6 cups water
¾ cup white corn syrup (preferably Karo®)

The directions say to mix thoroughly, and then to let the solution settle for four hours. It suggests that you blow the bubbles in a calm, humid area that's sheltered from direct sunlight.

With the aid of Design-Expert® software, I set up a mixture design. To simulate the bubble-making process, I made 10 milliliter blends of soap (1–5 ml), water (5–9 ml) and syrup (0–4 ml). Then I dipped the open end of a



3D of burst time average

seven-ounce paper cup in the solution. As an indication of quality, I determined how long it took for the bubble to burst. I tested each formulation three times and then entered the mean

— *continued on page 3*

Don't Let R^2 Fool You

Pat's Stat Tips

by Pat Whitcomb

Has a low R^2 ever disappointed you during the analysis of your experimental results? Is this really the kiss of death? Is all lost? Let's examine R^2 as it relates to design of experiments (DOE) and find out.

R^2 measures are calculated on the basis of the change in the response (ΔY) relative to the total variation of the response ($\Delta Y + \sigma$) over the range of the independent factor:

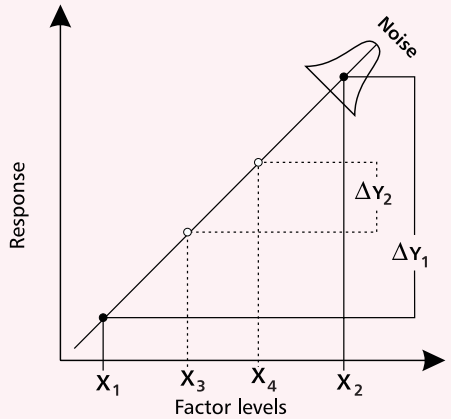
$$R^2 \cong \frac{\Delta Y}{\Delta Y + \sigma}$$

Let's look at an example. Response Y is dependent on factor X in a linear fashion:

$$Y = \beta_0 + \beta_1 X$$

We run a DOE using levels X_1 and X_2 in figure 1 to estimate β_1. Having the independent factor levels far apart generates a large signal to noise ratio and it is relatively easy to estimate β_1. Because the signal (ΔY) is large relative to the noise (σ), R^2 approaches one.

BELOW: Figure 1.



What if we had run a DOE using levels X_3 and X_4 in figure 1 to estimate β_1? Having the independent factor levels closer together generates a smaller signal to noise ratio and it is more difficult to estimate β_1. We can overcome this difficulty by running more replicates of the experiments. If enough replicates are run, β_1 can be estimated with the same precision as in the first DOE using levels X_1 and X_2. But, because the signal (ΔY) is smaller relative to the noise (σ), R^2 will be smaller, no matter how many replicates are run!

In design of experiments our goal is to identify the active factors and measure their effects. Experiments are designed with replication so active factors can be found even in the absence of a huge signal to noise ratio. In many real DOEs we intentionally limit a factor's range to avoid problems. Success is measured with the ANOVA and the t-tests on the model coefficients. A significant p-value indicates an active factor and a reasonable estimate of its effects. A significant p-value, along with a low R^2, may mean a proper job of designing the experiments, rather than a problem!

R^2 is an interesting statistic, but not of primary importance in DOE. Don't be fooled by R^2!

Another Tip: Statistical questions? Select Help in your software. Use the hypertext search to find the answer you need.

Stat-Ease Consultants Spark New Interest in DOE

Stat-Ease statistical consultants have been busy this year presenting on various DOE-related subjects all over the country. Their motive — to promote the use of designed experiments in all industries and present techniques to improve experimental analysis.

In March, Mark Anderson presented "Optimize Your Process-Optimization Efforts" at the Petrochem Expo. April found Pat Whitcomb at the Rochester Institute of Technology Quality Conference presenting "Robust Design — Reducing Transmitted Variation." Mark spoke on the topic of "How to Analyze Two-Level Factorials with Missing Data" at both the Quality and Productivity Conference in May and the Applied Statistical Conference in June.

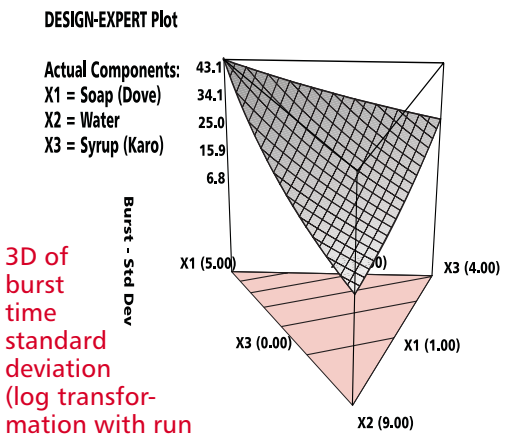
Pat, Mark, and new consultant Shari Kraber are always willing to speak at public as well as private events. Stat-Ease also has an extensive network of local DOE experts to draw from.

ABOVE: Mark Anderson presented a talk on DOE to a meeting of applied statisticians in Orlando, Florida, last May.

— continued from page 1

and standard deviation as two separate responses.

The results show that minimal amounts of soap give longer-lasting bubbles. The optimal formulation was 9 ml of water, 1 ml of soap and no syrup. Obviously, some soap will be needed, but it appears that the level could be reduced further. No significant interactions or nonlinear behavior were observed — a simple linear model sufficed.



3D of burst time standard deviation (log transformation with run 12 removed)

The response surface for the standard deviation (transformed with log base ten) looked more interesting. It curves upward as the soap increases. In fact, the mixture that gave the longest-lasting bubbles also exhibited the least amount of variation.

The syrup did not appear to have any beneficial effect, but I have a hunch that this may be a problem with the way I did the testing. Presumably the syrup adds viscosity and affects surface tension. I would like to do a more realistic test with a giant bubble wand. I'll need a couple of assistants to measure the bubbles before they float off and disappear. Fortunately, I've got two daughters, ages seven and nine, who will be delighted to help. My wife has become very leery of my at-home experiments, particularly since I burnt up a microwave while testing popcorn, so I must be careful not to leave too many soap rings. Perhaps I should add another response — the decibels of spousal complaints about residue.

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Where can you find us?

October '97

- Scientific Computing Exhibition, Sandown Park, U.K.: *Alan Collins (rep.)*

November '97

- Rubber and Plastics Joint Meeting, Sutton, MA: **"Breakthrough Improvements with Experiment Design,"** *R. J. DelVecchio (rep.)*
- SME AutoFact Conference, Detroit, MI: **"Planned Experimentation Solves Engineering Problems,"** *Shari Kraber*
- Medical Design and Manufacturing Conference, Minneapolis, MN: *Mark Anderson*

December '97

- Deming Conference on Applied Statistics, Atlantic City, NJ: "**Robust Design — Reducing Transmitted Variation,"** *John Guerin (rep.)*

January '98 and beyond

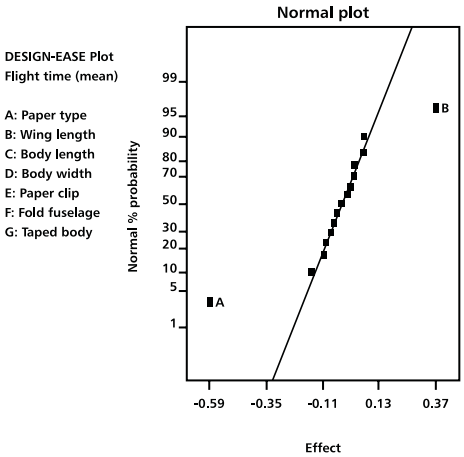
- Invite us to your meeting of technical professionals. Call us at toll-free **800-801-7191.**

Real Life DOE Offered by Student Request!

Our newest class, designed by student request, teaches you how to deal with difficult data analysis decisions such as:

- What happens when you have several outliers?
- How can proper residual analysis help you salvage data?
- How can my data be interpreted best?

All of these questions and more will be answered in our "Real Life DOE" course! Students are encouraged to bring their own data for specialized analysis. Watch for the next one in May '98, or contact us about doing a session in-house.



RIGHT: Normal plot of effects from an in-class DOE on paper helicopters. This graph produced with version 5 of Design-Ease. (See details on page 4 on how you can upgrade or buy this new software.)

Final offer for fantastic savings on latest and greatest: Design-Ease® Software v5.0

Features include:

- Progressive toolbar icons
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"The right-click features are cool. The graphics are wonderful. Wow!"

- Irregular (minimum) fractions
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