Design Expert DOEs it better.

By Anny Dentener

Software package: Design-Expert 6.0.6
Function: DOE, Experimental Design and Analysis.
Website: www.statease.com
Rating: ✪✪✪✪ (out of five stars)

LOOKING FOR help with better product or process design? The most important step in lifting your 'game' is probably starting to use Design of Experiment (DOE) software. Examples in which DOE has been used to great benefit (time, cost and quality) range from optimising a canning line and the curing of adhesive in laminate packaging, to food formulations and processing. Working with dedicated DOE software has advantages over general statistics package add-ons, with reduced cost, enhanced focus and more features. One such dedicated package is Design-Expert (DX), which has been around since 1985. At a cost of US$995, it is only 20% of the price of Guideline, the food industry dedicated "take-you-by-the-hand" software reviewed recently (FTNZ, May 2002). So will Design-Expert be easy enough to use for non-statistician food industry users, and deliver on those essentials outlined in a previous DOE article (FTNZ, July 2001; and www.foodinc.co.nz)?

Opening Design-Expert throws you straight at the designs, which can be daunting if you have only done "DOE 101". A "what would you like to achieve" interface, based on some of the excellent guidance given in its Help files, would be a welcome option. The Help files are written clearly and with lots of common-sense suggestions. For instance, it recommends not to attempt a "one big-bang"

trial, but to go for sequential smaller designs. It also recommends to make sure you set up the design in such a way that both "good" and "bad" results appear, so that you know the boundaries. Most designers would be inclined to choose experiments in areas where they are confident to get good results, thus missing out on understanding causes of failure and critical "no-go" areas.
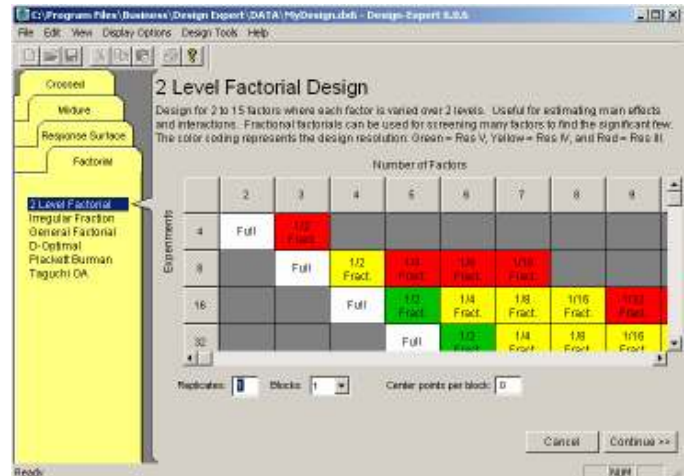

Figure 1: Design interface showing factorial design

Design-Expert offers different designs that suit screening, and a range of response surface designs for optimisation of interacting factors. It has mixture designs (that take into account that your main raw materials need to add up to 100%), and so called "crossed" combined mixture and process (and additives) designs. 'D-optimal' design practically halves the number of runs, always important as doing more trials than necessary wastes time and money. "Crossed" designs are often missing in general statistics DOE add-ons, but are essential for food technologists when combining the mix of main ingredients with other product and process factors. A typical example could be a chicken burger: looking at different meats, additives and cooking times and temperatures. Researching all factors with the "one step at a time" approach would take longer, and you are unlikely to find the optimum combination of factors to

make the most economically to produce, best tasting and keeping burger. Only a systematic approach with a DOE program will do that. The program also allows for "blocking", e.g. trials that need to be done on different days as you get plant access. It is done automatically with most designs, but the FAQ section mentions that you have to do it manually for mixture design. Missing data can be accommodated with no entries. Testing this indicated that the part data may be fitted with a simpler model with reduced significance, but the software will still proceed with the analysis. A relief when you do trials and botch the odd run.

Design-Expert provides several examples to familiarise yourself with the program. It starts with different factorial designs, for screening important factors from not so vital ones. The interface for the factorial designs uses colour marking to indicate which designs are safe to use at all times, where in the reduced fractional factorial designs to proceed with caution, and where it is dangerous to go, unless you really know what you are doing (Figure 1). It warns against using the well known Plackett-Burman screening designs if you suspect interaction between factors. You get warned where interactive effects are "aliased" (lumped together), as you may not be able to separate these effects, and should consider another design.

The Design stage provides a short description of the design choice and sometimes a graphical display to indicate design points. The lay-out of the screen, once a design is chosen, provides a left bar for different phases of the project, from design through to results, analysis and optimisation and predictions. To test the program I used 3 sets of old experimental data, and loaded them in the unique "Historic Data" feature. Entering data from a spreadsheet is easy, although it does not allow cutting/pasting of more than 6 columns at one time. The randomised design is also available on worksheets, so you can print

these off to record results. However, run information often overflows sheets and a better separation into separate runs is needed. Alternatively, it is easy to cut/paste into a spreadsheet. Once results are entered the program takes you step-by-step through the analysis. It suggests which type of statistical model(s) provide the best fit for the data, in contrast to other software with fixed models.

Analysis is done for each individual result and ANOVA tables give the essential statistical information with good background explanations. The default significance threshold of 0.05 can be changed to 0.1 or 0.01. Models can be "reduced" with different tools to suit. In "Diagnostics" you can check the data for odd "outliers", or if the data need to be "transformed", similar to a log plot for viscosity. The program does not deal well with "yes/no" answer results (binomials) as it treats them as continuous data. The most interesting part for me is always the graphics with 2D contour ("landscape maps") or 3D displays, where the effects of variables and their interactions come to life. In 3D graphing it is possible to turn the plot with an off-graph tool, but I often ended up with the plot upside down and needed the "default" angle setting to return to normal. The quality of the graphs is good and they transfer well into Word, Excel or PowerPoint. While it asks at entry for the units of each result, it does not display those in the graphs. Contour settings start off arbitrarily but can be adjusted to desired steps and gaps.

Lacking in the Options available, but present in other software, is finding maximum, minimum or selected range results, i.e. when you select 'max' the software will find the settings of all inputs to achieve the maximum output. Also, while it is possible to have different graphs open at the same time with the "pop out view" option, it is not possible to have these graphs 'linked'. This means that when you change the input settings using "Gauges" on the Factors Tool for one graph,

it does not automatically adjust results in the other graph displayed. Also missing in the analysis is an overview of order of importance of the different factors. You have to check out the equations to analyse that.

One major omission in the programme is the lack of one single overview after the analysis of each individual result. This may not be important for statisticians who pass on numbers to users. However I need an overview that helps me understand which factors significantly affect what, which ones interact and when, and which ones have negative or positive effects. This is hard to achieve with different sheets and graphs for each output (one set had 14 outputs!).

The program offers 2 optimisation options for meeting conflicting objectives. A numerical one allows you to select for each input and (up to 12) output(s) whether you want them to be taken into account, achieve a target or range, or be at their maximum or minimum. You can add weightings and rank their importance with 1 to 5 stars. This is then converted to a mathematical equation that searches for the best "Desirability" in a number of steps.

A duplicate options filter can be set to remove "same answers". Alternatively, the graphical optimisation can be used which shows areas where targets are met concurrently. Figure 2 shows a simple graphical optimisation for cold and hot viscosity targets for a starch/stabiliser blend (axis set with the 'coded' rather than the 'actual' values option). While values can be entered for predictions, there is no option to compare different settings at the same time. It warns you when predicting outside the tested ranges.
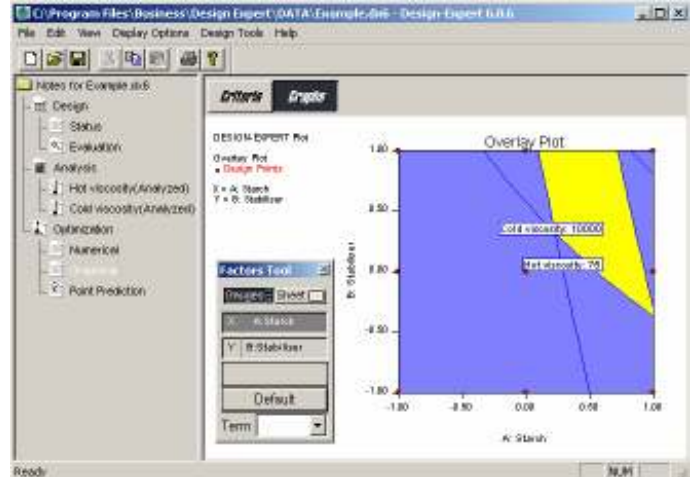

Figure 2: 2D Graphical optimisation plot for hot and cold viscosity

Unfortunately only 1 of 5 references approached answered my request for feedback (holiday time overseas?). This statistician who has worked with Design-Expert for over 12 years recommended it highly and rated it above other packages. Firstly, for user-friendliness even for non-statistician users in his company, and secondly for quickly getting right answers from StatEase to their questions.

Overall I am impressed with Design-Expert, but there is scope for improvement, especially for non-statistician users. The software was definitely stable in all tests under Windows 98 and XP. If you are in the market for a DOE package I suggest you put Design-Expert on the shortlist and download software and manual for a 30 day trial.

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