# DOE Perspectives

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The Experiment Strategies Foundation

# What's Wrong with Taguchi?

Taguchi methods are very popular in industry. Many people think they are the best way to perform industrial experiments. We teach that DOE and RSM (Response Surface Methodology) is a better strategy for engineers and scientists.

*Taguchi methods will often mislead you. ...Experiment Strategies teaches you how to find the right answer...*

Sometimes we hear the question, "What's wrong with Taguchi?" Our answer is always, "Plenty!" Here's why.

Dr. J. Stuart Hunter published a great example of what is wrong with Taguchi methods in the article, "Beware the Latin Square."* He cheats a little in this example — he *invents* the following model to connect carbon monoxide production when fuel is burned to ethanol addition and air-to-fuel ratio:

$CO = 78.5 + 4.5x_1 - 7.0x_2 - 4.5x_1^2 - 4.0x_2^2 - 9.0x_1x_2$

where CO is carbon monoxide produced when fuel is burned, $x_1$ is the amount of ethanol added to a fuel, and $x_2$ is the air-to-fuel ratio. The true standard deviation is 2.27. Remember, in a real experiment you will never *know* the true model or standard deviation: response variation clouds the picture. Knowing the true model will help us understand the problems with Taguchi methods.

Now suppose you want to study CO production for burning fuel using the Taguchi approach. You will list all of the variables that might be important. You think ethanol additions, air-to-fuel ratio, air temperature, and relative humidity may be important, so you choose an L9 design with four factors. You very carefully collect and analyze your data and find that all four factors are very important.

Wait a minute! We know, in this invented problem, that air temperature and relative humidity are not in the true model and so have no effect. But our Taguchi approach tells us that they are very important. It also tells us that the best operating conditions for low CO, the Sweet Spot, is at 0.1 for ethanol addition and 16 for air-to-fuel ratio. The true Sweet Spot is at 0.3 for ethanol addition and 16 for air-to-fuel ratio. How can this be? Dr.

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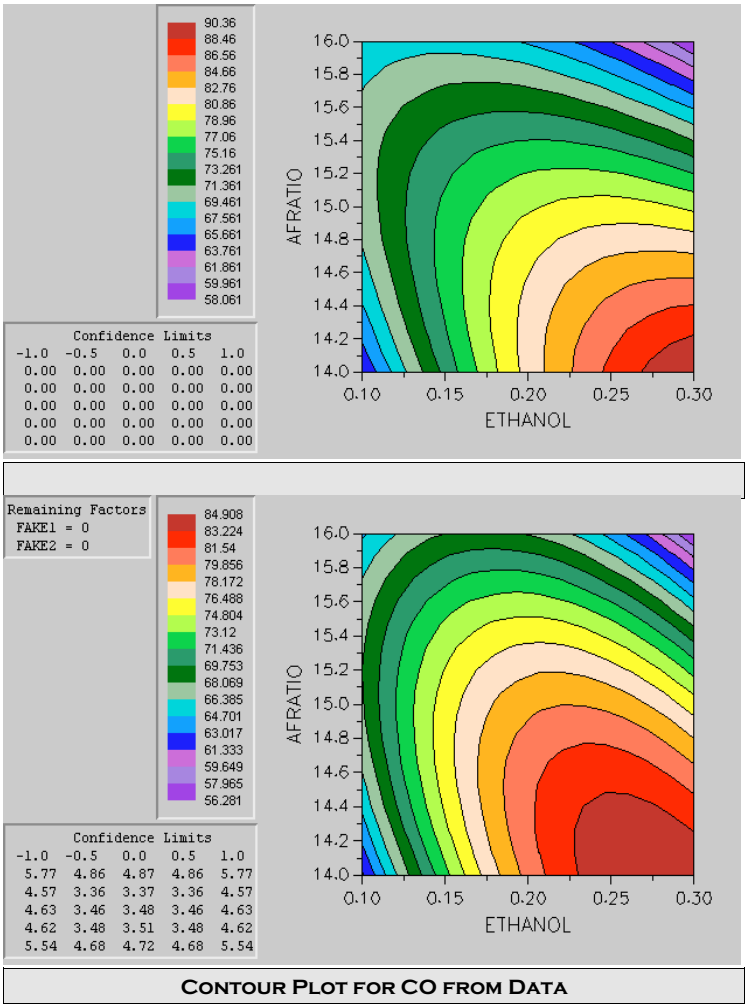
Hunter explains that this incorrect conclusion will occur whenever a two factor interaction exists. And two factor interactions are extremely common in industrial problems. He also points out that the L18, L27, and L36 designs also suffer from this problem. Taguchi methods will often mislead you.

Now you see what's wrong with Taguchi. What can you do to that will lead you to the right answer?

Experiment Strategies teaches you how to find the right answer — the Sweet Spot. Our approach uses DOE and RSM (Response Surface Methodology), well developed before Taguchi came along. Let's take a look at how our strategy works for this example.

You list the factors which might be important, the same four factors that were used in the Taguchi experiment: ethanol additions, air-to-fuel ratio, air temperature, and relative humidity. You choose a 4 factor Hardin-Sloane design for a quadratic model. You carefully collect and analyze the data. You make contour plots of your results and recognize that air temperature and relative humidity have little if any effect. You also recognize that an ethanol addition of 0.3 and an air-to-fuel ratio of 16 looks promising as a Sweet Spot. You test the Sweet Spot, and find that it does produce low CO. And it's the true Sweet Spot. That's much better!




**Contour Plot for CO from Data**

Please take a look at the contour plots above. The upper plot is the true plot from the invented model. The lower plot is the result of our experiment. (The other experimental plots are essentially the same.) The upper and lower plots are not identical because of response variation. But the lower plot (which came from data) is a very good approximation of the upper (true) plot.

What is the moral to this story? Leave Taguchi for your competitors, and use the strategies taught in the class *Basic Experiment Strategies*. They will help you find the Sweet Spot the first time.

** Hunter, J. Stuart, "Let's All Beware the Latin Square," Quality Engineering,1(4), 453-465 (1989).*

*If you would like a copy of our analysis for this problem, send us a note at info@ExperimentStrategies.com*

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