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BY DAVID DRICKHAMER

BASF Breaks Through With Statistics

THERE COMES A TIME WHEN CHIPPING AWAY AT a trouble spot in a production process one incremental improvement at a time isn't enough—when it's time to force it and, as the saying goes, "get a bigger hammer."

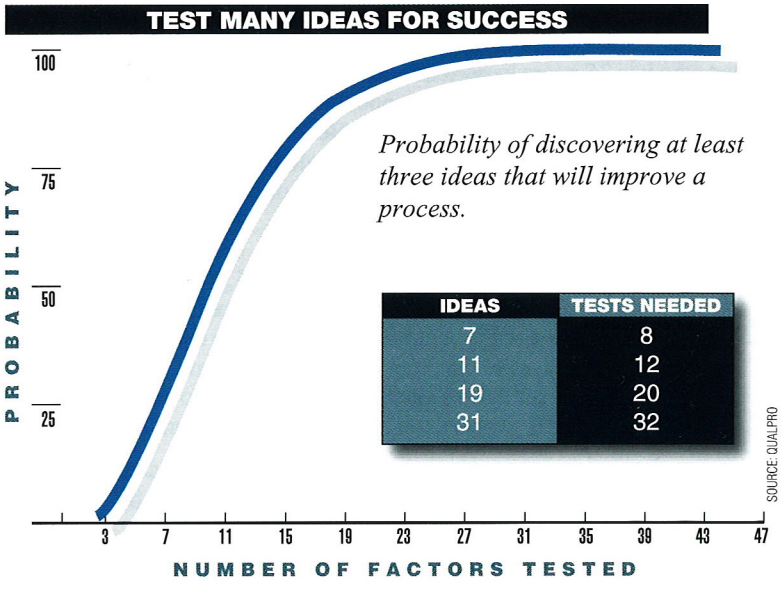
Such complex problems cry out for a breakthrough strategy. In slow times, as companies renew their focus on operational efficiency, one strategy that deserves dusting off is statistically designed experiments, also known as design of experiments (DOE) or multivariable testing (MVT).

Last year the employees at the 500-acre BASF facility in Freeport, Texas, applied these experimental techniques to trim $742,000 in annual costs—plus avoid a $750,000 one-time capital purchase—from their 41-year-old process for producing cyclohexanone, a critical compound used to make caprolactam and, eventually, nylon 6.

The theories behind the tools applied so successfully at BASF are nothing new. They were developed by a couple of mathematicians during World War II who were perfecting an antiaircraft shell and didn't have time to run a lot of tests. In traditional tests, researchers change one factor at a time and run every possible combination. Using DOE, one follows a carefully designed series of experiments and can study a much larger number of factors and also gather some information about interactions among factors. With four variables, to test every possible combination one variable at a time would require 16 experiments. Using a statistical screening design, one can evaluate up to 15 variables with the same number of experiments.

"The designs lay out the series or recipes, such that there are built-in statistical efficiencies. That is the key to any kind of statistically designed experimentation," says Kerry Stone, an account director with QualPro, a Knoxville, Tenn.-based consulting firm specializing in such techniques.

On the project at BASF, the team tested 13 factors in the initial test, requiring 16 experiments, which the team doubled to 32 so that analysis would be based on the best possible data. Conducted in concert with the plant's ongoing production, this first experimental phase took a full two months to complete.



The project team reports that management commitment and faith in the effort were critical at this stage. Many DOE projects fail in fact because they lack such support. They also fail because the processes being tested are not stable. To set the stage for success, QualPro advocates a 12-step process, where actual implementation is the final step.

"You have to try to get the system as stable as you can so that you can see any variable changes above the baseline," says Merritt Sink, process development quality assurance manager for BASF. Sink notes that every system is different and requires a different level of stability, and that the accuracy of measurement systems is critical.

"Does the meter pump what it says? Are you really getting the concentration and the quantity that you think you are?"

These questions should be familiar to Six Sigma practitioners, who typically begin their

At BASF's Freeport, Texas, plant, employees used design of experiments (DOE) to save hundreds of thousands of dollars. Pictured, from left, are team members Tracie Coldiron, Jessie Delmundo and Troy Harris. The plant makes cyclohexanone.

improvement projects by evaluating the capability of monitoring systems, and who also apply DOE methods to tackle particularly difficult problems. One of the differences at BASF is that such projects aren't directed from the top down by a few highly trained black belts but follow an empowered team-based approach.

"We want to run a leaner ship here, but still get the advantage of using experimental tools," says Sink. "We feel like the tools are great, but we can train our people to use them effectively."

In the experimental phase this bottom-up approach has proven to be particularly valuable because it involves everyone in the search for possible solutions. During the brainstorming process, QualPro makes a particular point of calling on people with a diversity of expertise.

"I want the Ph.D. chemical engineer, plus the supervisor who has 25 years experience, plus the operator who has 20 years experience, and the operator who has only been there six months," states Stone. He observes that those with the most experience and knowledge are often the most ingrained in thinking that there is only one way a job or process can be done.

LOOKING AT THE RESULTS FROM MORE THAN 11,000 experiments during 20 years—ranging from process industries such as chemical and paper producers to discrete manufacturers, sales operations, telemarketing and even cover designs for the National Enquirer—QualPro has found that 53% of the ideas it tests don't have a significant impact, 22% of ideas actually make a process worse, and about 25% improve it. And there's no correlation between where the good ideas come from and job title.

"Our thinking is, 'Let's do a screening experiment and take the bias out,' " says Stone. "Let the data tell us which variables matter and which don't."

Once the factors that improve a process have been identified, additional refining experiments are necessary to confirm the results, further evaluate potential interactions, and establish linearity for the variables. QualPro's Stone offers an example of crop yield versus the amount a farmer waters. Increasing water, similar to increasing the temperature in a chemical reaction, will typically boost yield, but there's a point where too much water has a negative effect and brings the yield curve down.

BASF has been conducting these types of experiments in Freeport since the early 1990s. When asked why BASF still needs to bring in a consultant after so many years, Sink says that experience is extremely important on these types of projects, and the targeted savings are significant enough that the cost is not hard to justify. At BASF, QualPro helps the project teams lay out the experimental designs and offers additional assistance when combinatorial effects—where several factors that don't have much effect individually but a huge impact together—have to be sorted.

"In a manufacturing world it's hard to organize and run these experiments," says Sink. And he welcomes all the help he can get.

Send submissions for Best Practices *to Editorial Research Director David Drickhamer at* ddrickhamer@industryweek.com.