

## Design Challenge

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Design-of-experiment method helps solve an adhesive tape production problem.

Intertape Polymer Group (IPG) experienced intermittent production problems in producing a masking-tape product. The adhesive sometimes picked off to the opposite side of the backing, making it necessary to scrap the product and shut down production in order to clean the machinery. Engineers experimented by changing different production variables but were never able to find a combination that worked consistently.

Then Matt Tiza, New Product Development technician for IPG, set up a statistically designed experiment that measured the effects of each chosen factor, as well as the interactions between them. This design-of-experiment (DOE) method determined a combination of materials and processing variables that have since provided consistent performance. A key factor in its success was the use of software that helped to design an experiment and evaluate the effects quickly. It automatically provided graphical results that were easy to interpret.

IPG is known for developing and manufacturing specialized polyolefin plastic and paper-based packaging products, as well as complementary packaging systems for industrial and retail use. In addition, IPG is a woven and flexible intermediate bulk container (FIBC) manufacturer. IPG designs its products, including tapes and cloths, for aerospace, automotive, and industrial applications.

## Challenging Production Problem

IPG experienced a production problem in one of its plants that affected the coating of a particular adhesive onto its backing. The adhesive occasionally picked off the backing and ended up on the roller of the coating machine.

“Operators had to stop the process to clean the machinery, which forced them to scrap a considerable amount of product and - even worse - left expensive machinery and workers sitting idle,” Tiza said.

“The problem seemed to be a result of the temperature of the plant,” he said. “Plant personnel tried

changing production variables such as the curing agents and the fillers. They were always able to get the line running again, but it was only a matter of time before the problem cropped up again. This is a value-driven product, so we wanted to solve the problem without any capital investment.”

## The Need to Look at Interactions Between Variables

“The most likely reason why the plant personnel were not able to permanently solve the problem was that they were experimenting only with one factor at a time (OFAT); yet, like most production problems, this one involved complicated interactions among multiple variables,” Tiza said. “What we needed was a way to measure these interactions and determine a combination of variables providing robust operating conditions that would enable production to continue without interruption. I had used DOE in the past to address similar problems and was confident that it would provide an answer in this case.”

Properly designed and executed experiments will uncover not only the main effects of each variable, but also the interactions between them while requiring substantially fewer experimental runs than the OFAT approach. One interprets the results using statistical methods that demonstrate when an optimal process configuration will consistently produce products meeting the predefined requirements.

“Not long after our organization recognized the power of DOE, we began looking for a software package to automate the otherwise tedious process of designing experiments and statistically analyzing their results,” Tiza said. “We picked Design-Expert® software from Stat-Ease Inc. (Minneapolis, MN) because it provides a very logical and methodical approach that makes it easy to design an optimal experiment for the application and to evaluate the results.”



Factorial design-builder in Design-Expert software.

## Designing an Experiment

Tiza communicated with engineers and operators at the plant to determine the variables that influenced the production concern. Tiza then selected five factors to run at low versus high levels:

1. Concentration of the curing agent
2. Concentration of a new experimental curing agent
3. Concentration of filler
4. Application temperature of the curing agent
5. Temperature in the plant

Tiza then used Design-Expert to configure the runs used to evaluate the effects of these variables. It created an experimental design that varies all factors at once, thus revealing interactions among the

variables as well as their main effects. Using a simple color-coding scheme (see figure) – green for “go,” yellow to “proceed with caution” and red to “stop and reconsider” - the software helps users trade off the number of experimental runs against the goal of accurately detecting interactions between the variables.

“In designing the experiment, you need to trade off cost (which in this case means research and development time needed to run the experiments) against accuracy (which you can increase by running more experiments),” Tiza said. “We decided to do a half-fraction, which still provides a high resolution. This design [highlighted above] requires only 16 runs for five factors.” This level of resolution provides the ability to detect the causes of most production problems. Yet for the statistical power provided, the number of runs required is fewer than a traditional design, which varies only one factor at a time (OFAT) and is not able to detect interactions.

## Evaluating the Results

Tiza performed 36 different tests on each of the batches produced in each experiment. He entered the results into the Design-Expert software and generated reports that indicated the effects of each of the main variables, as well as their interactions.

“We looked first at the charts and statistics that indicate which effects have a significant impact on the results,” he said. “Then we looked at the graphs, which display the predicted effects. Finally, we used the program’s numerical optimizer, which enabled us to find the most desirable values of each factor.

“The results were very helpful because they showed us that we could run successfully with our desired combination of materials as long as we used the right processing conditions. This was valuable because the experimental curing agent that we tested is more expensive than the one that we have used in the past. The experiment enabled us to save a substantial amount of money by demonstrating that we could run without problems while conserving the original product formulation and processing parameters and simply compensating for the temperature of the materials and the plant.”

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