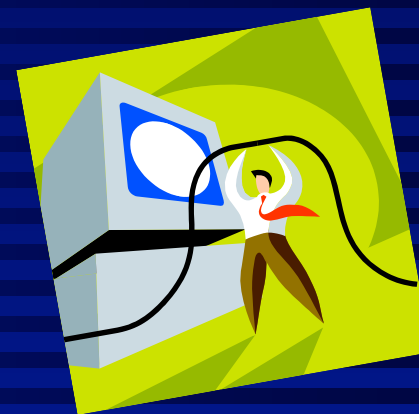


Practical Application of DOE for the Development Process

- Develop faster and better with Design of Experiments (DOE)
 - Do you need it
 - When should you want to use it



Agenda

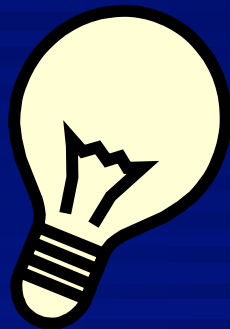
- DOE Definition
- Case Study
- Do I need it?
 - Depends on Experience
 - Depends on Experiment
 - Degree of Effort
- Do you need help?
 - Depends on Expert

DOE Definition

- Your definition?

DOE Definition

- DOE is a testing tool to assist in the process of understanding a system



Motor Cooling versus Noise

- Goal: Quietly fan cool the motor on a device
- Response: Air speed and noise in db



Motor Cooling versus Noise (cont.)

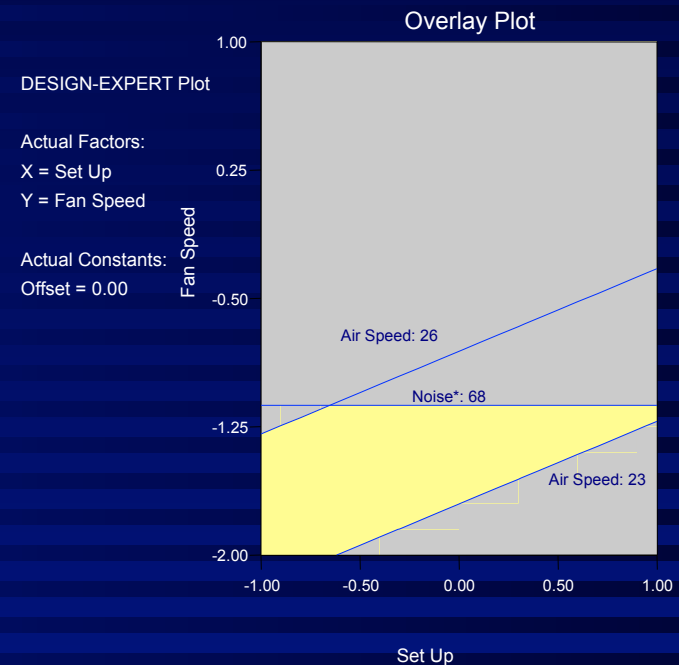
- **Approach:** Explore different fan designs and parameters using DOE. Determine if a window exists for optimization.
- **Result:** Found the window of operation prior to building the first “production” part
 - Eliminated need for custom noise reduction components
 - Provided the answer with reduced development cost



Motor Cooling versus Noise (cont.)

■ Result: Long Term

- Improved time to market
- Predictable end of project
- Scaleable for other systems
- Set the company standard for design of this product, continuing to recognize the benefit



Why do you test?

- What is the purpose?

Why do you test?

■ Depends on Experience

- Testing is performed to gain knowledge
 - More knowledge reduces project risk
- Other people's experience is leveraged through “physics” or other sciences



Can test on product hardware,
process or computer models

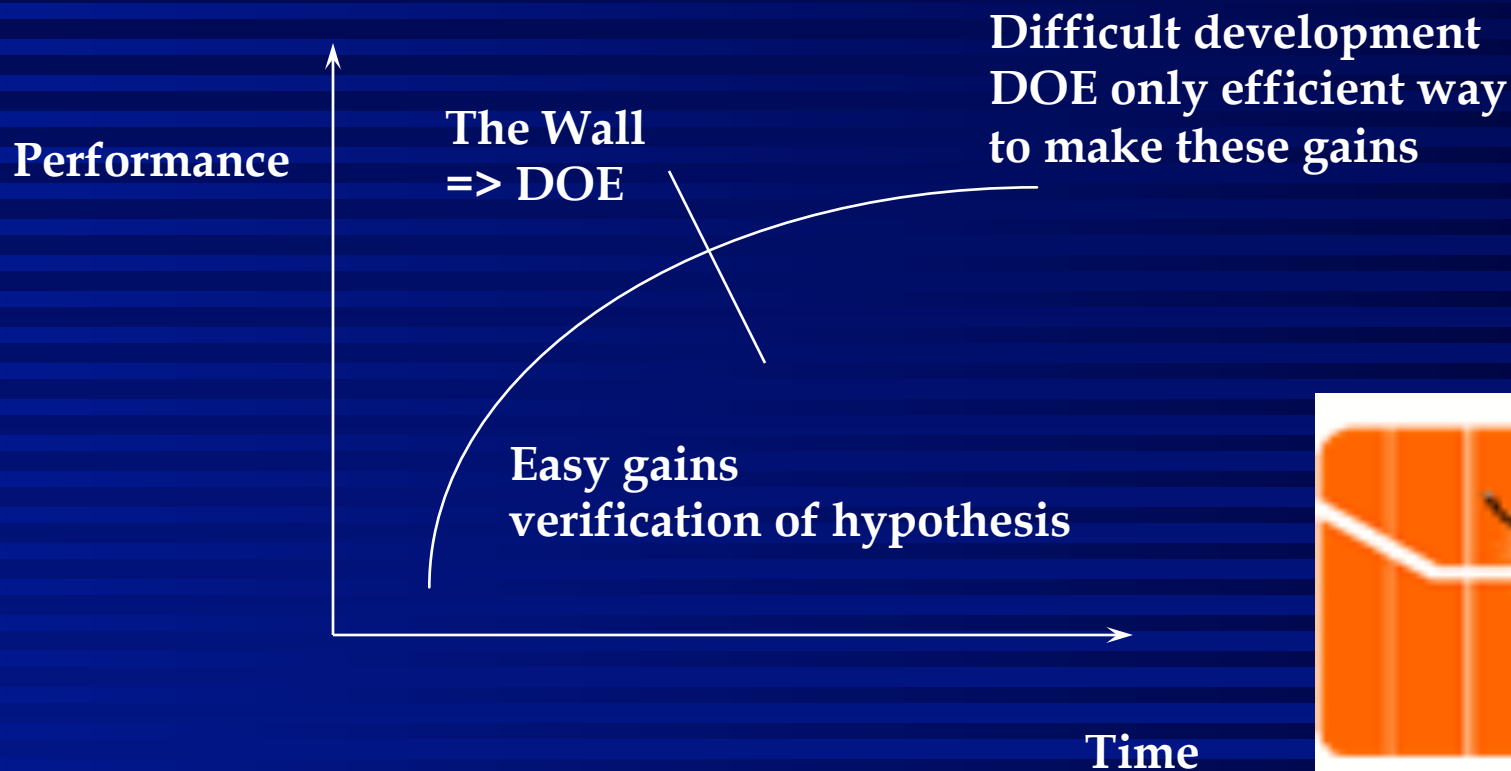
If I test, do I have to use DOE? Why do I need it?

■ Depends on Experiment

- If your situation asks the questions “what if” and “what else”, you do not have the required understanding and will most likely need DOE
- If the Experiment is “proving” you know something, DOE does not make sense
 - For example, if high confidence you are applying well known technical principles – simple confirmation testing is all that would be required



Design Stages



What can it do for me?

■ Degree of Effort

- Reduces number of tests to achieve a level of information to describe relationship between inputs and outputs
 - This reduces: schedule, cost, risk and improves probability of meeting requirements
 - Only goes as far as your concept will allow it to go
 - Information obtained limited by number of tests conducted



Project Examples

- Welding, web processes, heat treat, stamping
- Molding plastic and rubber, foaming (gaskets, diaphragms and piece parts)
- Adhesive in assembly, epoxy curative reaction, powder coating colorization, adhesive delivery
- Plating, vapor deposition, cleaning, soldering, polishing
- Laser cutting, drilling and surface grinding equip.
- Medical fluid sampling equipment
- Electronics, composites, food, resin, product comparison, control systems
- Seal repeatability, product durability/ reliability
- Office process flow, process waste, mfg sim.
- Analysis of hydraulic, thermal & molding



223 of these projects saved an estimated \$9,193,400.

Is it complicated?

■ Depends on “Expert”

- While it takes some time to learn the details, the overall foundation is very straight forward.
- Important to understand and follow a simple process but not at the expense of the creative side
- Some teach with a flare for “the elegance of the mathematics” making it appear complicated
- Hardware or computer model used to generate data



DOE Process

- Define goal - need
- Define response(s) to measure progress to goal
- List all variables and down select to “key” variables using engineering judgment
- Select appropriate design matrix - approach *
- Select safe/consistent test levels for variables
- Address tradeoffs between responses
- Perform test
- Analyze results *
- Discuss next step

* Where DOE software helps

Tools

- What DOE tools are you aware of?

Tools

■ Factorial Designs

- Full (2^k form)
- Fractional (2^{k-p} form)
- Taguchi - maximum assumptions

Organizing the collection of data to determine the most statistically confident relationship

■ Advanced Designs (Response Surface Methods)

- 3 level (not a 3^k form)
- 5 level (composite with factorial as a basis)
- Optimization

■ Related Statistical Tools

- Measurement System Analysis (Gage R&R)
- Probabilistic Failure Assessment (Monte Carlo analysis)
- Statistical Process Control (SPC)

Perry's Solutions, Inc.

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