

Example: Taguchi's Designed Experiments



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Introduction

- The purpose of product or process development is to improve the performance of the characteristics of the product or process relative to customer needs and expectations.
- Designed experiments serve two purposes:
 1. to determine the important parameters (factors) affecting a certain outcome and
 2. to optimize the outcome by controlling such parameters.



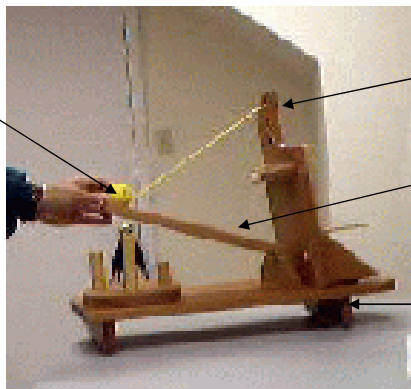
Introduction (cont.)

- The quality engineering methods developed by Genichi Taguchi have been used in Japan for many years.
- In the 1980's, his philosophy and ideas on statistically designed experiments were introduced to the U.S. and, since then, the Taguchi methods have been used extensively.
- Taguchi methods aim at attaining optimum process and product design while reducing the effects of uncontrollable (noise) factors.

The Experiment

- In this experiment, the catapult (process) is used to launch a ball.
- There are several factors that affect the outcome of the process (distance)

Ball seat



Fixed Tension

Arm Tension

Elevator

The Experimentation Process –With Example-

- **Define the problem and/or objective of the experiment:** The objective of this experiment is to obtain consistent measurements of the distance with a target of 100 inches
- **Select the quality characteristic (response), unit of measure, and the measurement system:** Distance, Inches, and Tape Measure
- **Identify factors that might influence the response, classify them into control vs. noise and select the levels for each factor:**
- **Select the design (Orthogonal Array) that best fits the experimental conditions taking into consideration interactions that might influence the response.**

| Factor | Type | Levels |
|---------------|---------|--------|
| Arm Tension | Control | L1 L2 |
| Ball Seat | Control | L1 L2 |
| Elevator | Control | L1 L2 |
| Fixed Tension | Control | L1 L2 |
| Operator (O) | Noise | 1 2 3 |

The Experimentation Process –With Example- cont.

| ID | A | B | C | D | (O1) | (O2) | (O3) | AVG (D) | S/N |
|---|----|----|----|----|------|------|------|---------|------|
| 1 | L1 | L1 | L1 | L1 | 42 | 43 | 43 | 42.7 | 35.0 |
| 2 | L1 | L1 | L2 | L2 | 103 | 105 | 106 | 104.7 | 38.6 |
| 3 | L1 | L2 | L1 | L2 | 101 | 99 | 106 | 102.0 | 34.6 |
| 4 | L1 | L2 | L2 | L1 | 102 | 100 | 104 | 102.0 | 37.2 |
| 5 | L2 | L1 | L1 | L2 | 51 | 51 | 53 | 51.7 | 33.6 |
| 6 | L2 | L1 | L2 | L1 | 33 | 33 | 34 | 33.3 | 32.8 |
| 7 | L2 | L2 | L1 | L1 | 67 | 66 | 64 | 65.7 | 34.5 |
| 8 | L2 | L2 | L2 | L2 | 115 | 113 | 120 | 116.0 | 35.7 |
| <p>L8 Alias Structure for 2-way interactions: $A \times B = C \times D$ $A \times C = B \times D$ $A \times D = B \times C$ We can only estimate one interaction from each pair.</p> | | | | | | | | | |
| <p>$S/N = \text{Log}_{10} (\text{Mean } (O1^2, O2^2, O3^2) / \text{Std Dev } (O1, O2, O3))$</p> | | | | | | | | | |



The Experimentation Process –With Example- cont.

- ***Assign factors and locate interactions taking into consideration the degree of difficulty:*** If we know that Arm Tension has no interaction effects with other factors, and the elevator is the most difficult factor to change followed by Arm Tension, then we can assign A to Elevator, B to Arm Tension, C to Ball Seat, and D to Fixed Tension.
- ***Conduct the experimental runs:*** For each of the 8 experimental combinations, run the experiment and record observations for the three Operators.

The Experimentation Process –With Example- cont.

- **Analyze and interpret results:** Using the Averages and Signal to Noise (S/N) ratios, we can see that the closest to target come from experiments 3 and 4 with an identical average of 102. However, we take experiment 4 since the S/N ratio is larger. Therefore, Factor A (Elevator) and D (Fixed Tension) should be set at the low levels (L1), while B (Arm Tension) and C (Ball Seat) should be set at the high level (L2).
- **Conduct confirmation experiment:** Setup the catapult according to the optimum conditions and run the experiment to verify results

