Introduction

Define

Process

Experiment

Design of Experiment

System

Design

History of Design of Experiment

Ronald Fisher – Agricultural Era

A methodology for designing experiments was proposed in his innovative book The Design of Experiments (1935). Fisher work was in the agricultural applications

Box and Wilson – Industrial Era

The development of response surface methodology RSM (1951). DOE in industrial applications is different in two features; immediacy and sequentiality

Genichi Taguchi – Robust Parameter Design

(1980-1990) Making process insensitive to environmental factors; making products insensitive to variation transmitted from the components.

General Era

(1990- ..) Statistical DOE is successfully used in many areas of science and engineering, business, financial, government operations and medical sectors.

History of Design of Experiment

DOE examples from the industry

- Characterizing of process
- Optimizing of a process
- Designing a product
- Formulating a product

History of Design of Experiment

Three Basic Principles for DOE:

- Randomization
- Replication
- Blocking

Randomization

Randomization is a process that assigns research participants by chance, rather than by choice. This means both the allocation of the experimental material and the order in which individual runs or trials of experiment are to be performed are randomly determined.

Why?

Because statistical methods require that the observation or errors be independently distributed random variables.

History of Design of Experiment

Bias

The difference between the average or expected value of a distribution, and the true value. It can often be estimated and/or eliminated by calibration to a reference standard

Precision

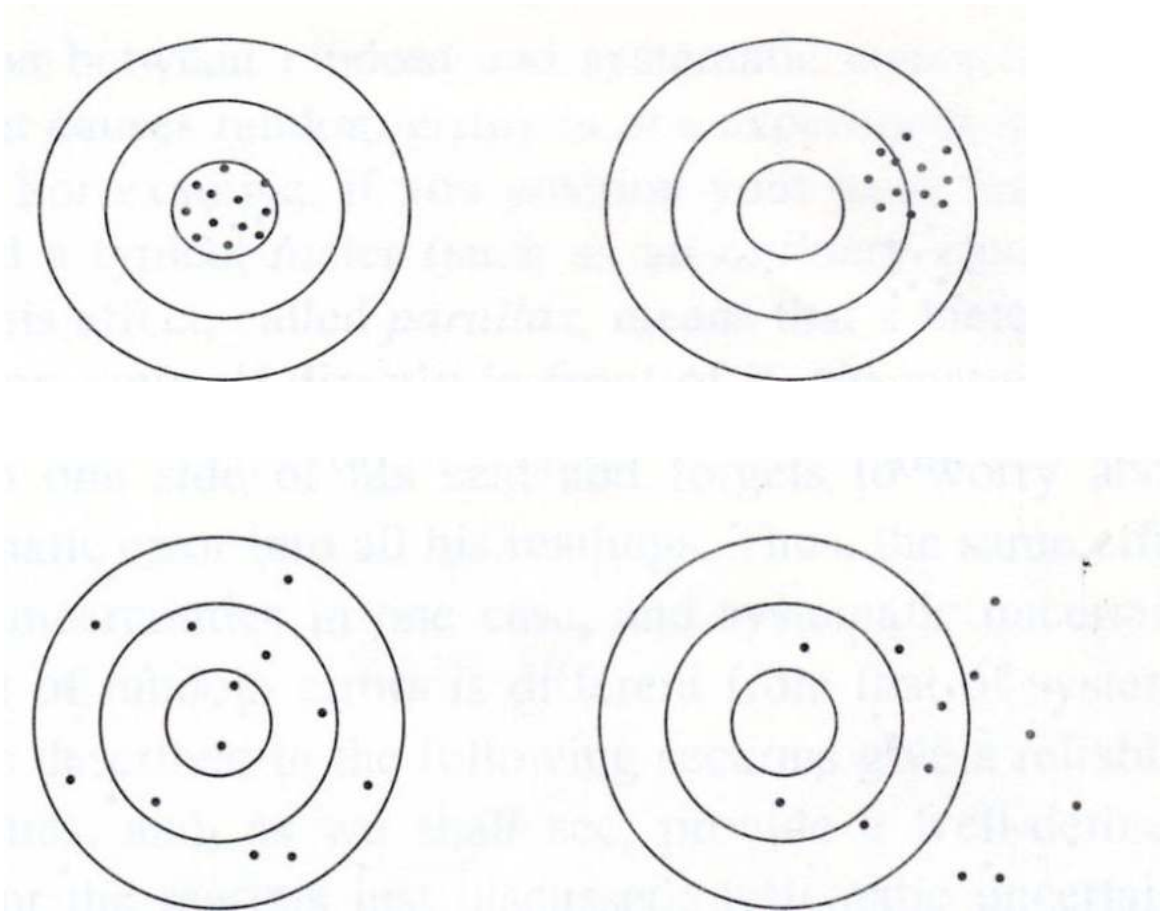
The variability of a measurement process around its average value.

Accuracy

The variability of a measurement process around the true value.

In metrology, the difference between precision and accuracy is that measures of precision are not affected by bias, whereas accuracy measures degrade as bias increases.

History of Design of Experiment



History of Design of Experiment

Replication

Independent repeat of each factor combination.

It has two important properties ; It allows the experimenter to obtain an estimate of the experimenter error and more precise estimate of true mean response for one of factor levels in the experiment.

$$\text{Replication} \neq \text{Repeated Measurements}$$

Blocking

A design technique used to improve precision with which comparisons among the factors of interests are made.

History of Design of Experiment

Nuisance Factors

Factors that may influence the experimental response but in which we not directly interested

Blocking is used to reduce or eliminate the variability transmitted from the nuisance factors

History of Design of Experiment

Guidelines for DOE

- Recognition of and statement of the problem
- Selection of response variable
- Choice of factors, levels, and ranges
- Choice of experimental design
- Performing the experiment
- Statistical analysis of the data
- Conclusion and recommendations

History of Design of Experiment

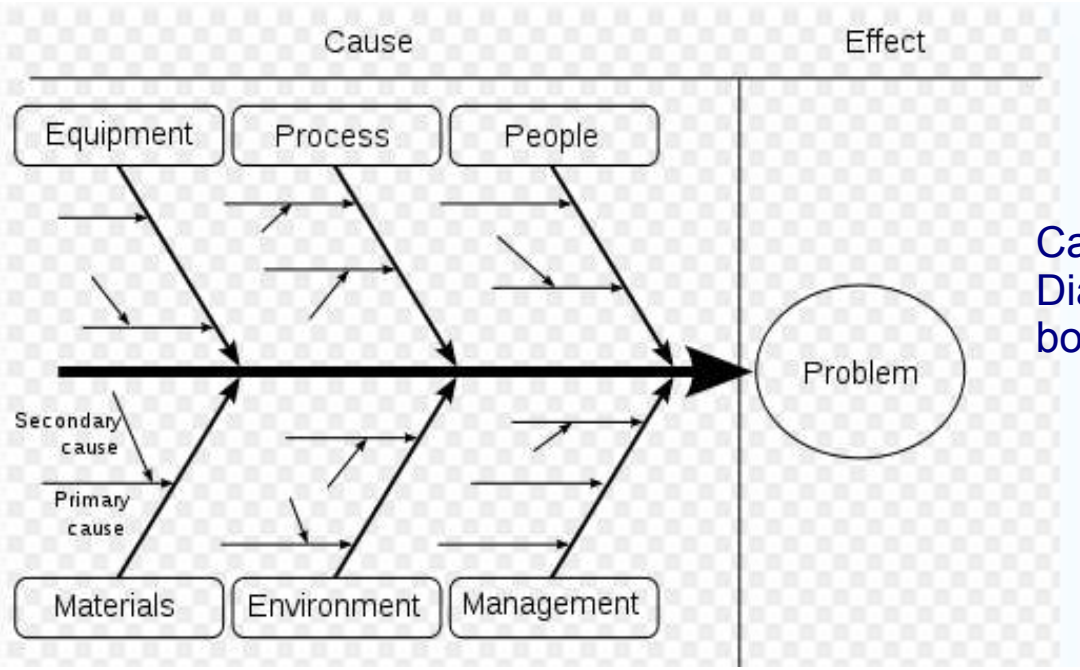
Recognition of and statement of the problem

- (Characterization, Optimization, Confirmation Discovery, Stability)

Selection of response variable

Choice of factors, levels, and ranges

Pre-experimental Planning



Cause-and-effect Diagram or Fish-bone Diagram

History of Design of Experiment

Choice of experimental design

(Sample size, run order, levels of randomization and blocking)

Performing the experiment

(Monitor the experiment carefully, use trial runs first!)

Statistical analysis of the data

(use the appropriate software package)

Conclusion and recommendations

(Graphical methods usually used to present the results)