The “A” is for Analyze

May 10, 2016
Orange Empire ASQ
Larry Bartkus

DMAIC is a data-driven quality strategy used to improve processes. It is an integral part of a Six Sigma initiative, but in general can be implemented as a standalone quality improvement procedure or as part of other process improvement initiatives such as lean.

The DMAIC process easily lends itself to the project approach to quality improvement encouraged and promoted by Juran.
http://www.slideshare.net/Sixsigmacentral/powerpoint-presentation-3746094

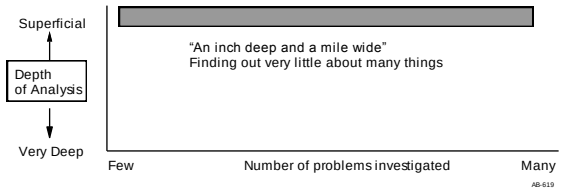
Excerpted from *The Certified Quality Engineer Handbook, Third Edition*, ed. Connie M. Borror, ASQ Quality Press, 2009, pp. 321–332.

Description

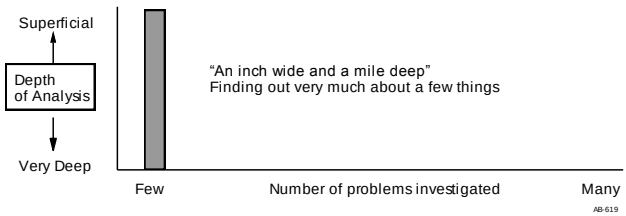
- "… Six Sigma is a quality program that, when all is said and done , improves your customer's experience, lowers your costs, and builds better leaders." Jack Welch CEO GE
- Six Sigma is a proven set of tools and tactics used for process improvement, reduction of defects, and improved quality
- Six Sigma uses data and statistical analysis to zero in on root causes
- Six Sigma can be applied to any process

American Society for Quality ASQ

- **Conventional Problem Solving**



- **Quality Improvement Problem Solving**



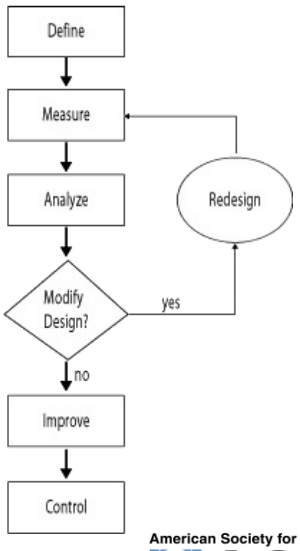
American Society for Quality ASQ

Origin of the DMAIC Process

The DMAIC Process evolved out of the Six Sigma Program. Six Sigma was first introduced by Motorola in 1986. It was a statistics based approach to reduce variation in electronic manufacturing. It was later made very popular by G.E. And received worldwide acceptance . The American Society for Quality (ASQ) adopted this methodology and offers certification in Green Belt, Black Belt and Master Black Belt.

DMAIC is an acronym for the five phases that make up the process:

- **Define** the problem, improvement activity, opportunity for improvement, the project goals, and customer (internal and external) requirements.
- **Measure** process performance.
- **Analyze** the process to determine root causes of variation, poor performance (defects).
- **Improve** process performance by addressing and eliminating the root causes.
- **Control** the improved process and future process performance.



The DMAIC Method

- **Define**
  - **What is it? Describe the problem.**
- **Measure**
  - **Where is it? What levels?**
- **Analyze**
  - **What's causing it to be that way? Look for the Root Cause.**
- **Improve**
  - **How can we make it better?**
- **Control**
  - **How do we keep it from going back to where it was? Lock it in.**

American Society for Quality ASQ

The DMAIC Method - Analyze

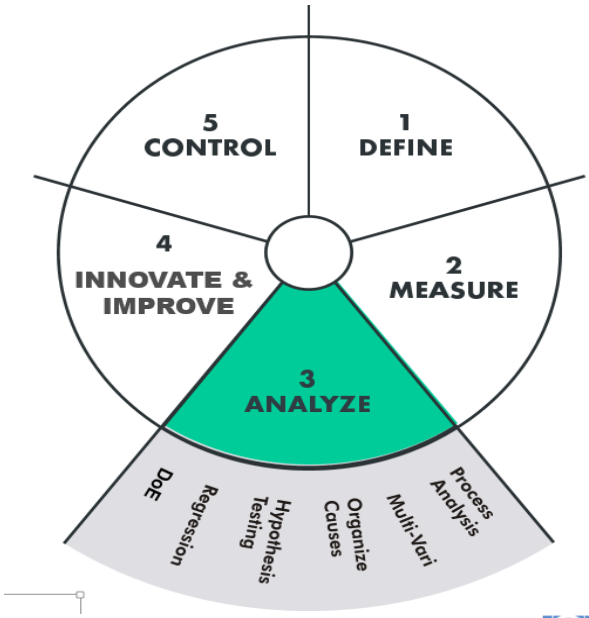
- **Goal**
  - Identify deep root causes and confirm them with data
- **Output**
  - A theory that has been tested and confirmed

Tools

- Process Analysis
- Multi-Vari Chart
- Organize Causes
- Cause & Effect Diagram
- Hypothesis Testing
- Regression
- Design of Experments

The purpose of the Analyze Phase is to determine the root causes of defects or problems. It asks the question: "Why is it there?"

American Society for Quality ASQ



Cause & Effect Diagram

PURPOSE

The Fishbone Diagram can identify many possible causes for an effect or problem. It can be used to structure a brainstorming session. It immediately sorts ideas into useful categories.

When to use a Fishbone Diagram:

- **When identifying possible causes for a problem.**
- **Especially when a team's thinking tends to fall into ruts.**

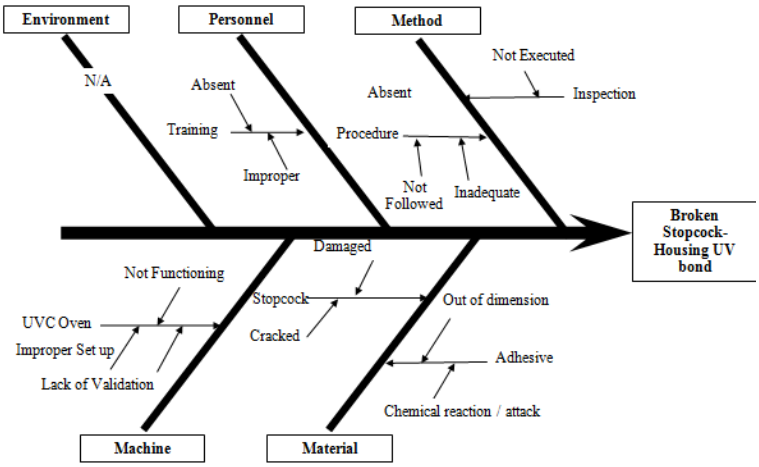
Also called: Cause–and–Effect Diagram, Ishikawa Diagram

Variations: Cause enumeration diagram, process fishbone, time–delay fishbone, CEDAC (cause–and–effect diagram with the addition of cards), desired–result fishbone, reverse fishbone diagram

Typical questions this tool answers:

- **What are the problem causes and how can I group those?**
- **Of all the causes evaluated, which are most likely to be our root cause?**

Cause & Effect Diagram



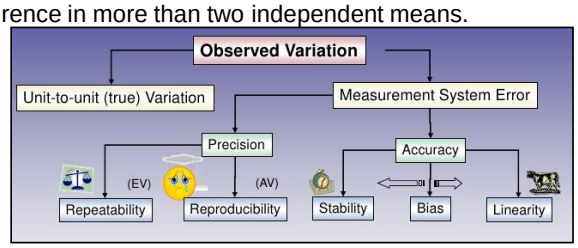
American Society for Quality ASQ

Multi-Vari Chart

PURPOSE

Components of variation studies can be used to identify which factors contribute the most to the variation in products or processes. This tool is most appropriate when the factors are of the categorical type. Since all products and processes have some sort of variability, it is important to distinguish which are controllable or not.

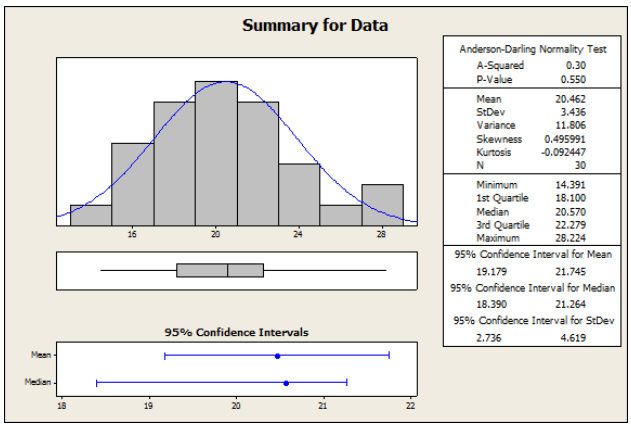
The ANOVA technique is commonly used to summarize the data and to draw conclusions. ANOVA is a test that provides a global assessment of a statistical difference in more than two independent means.



American Society for Quality ASQ

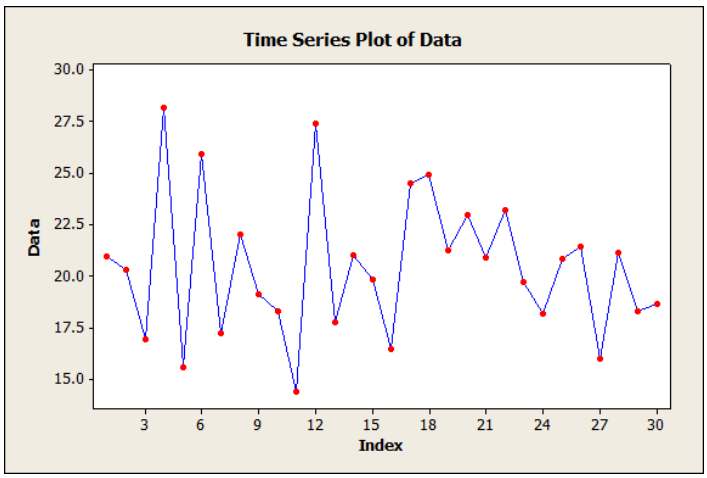
Normal Data for Data Set 1

20.99	16.46
20.32	24.53
16.95	24.95
28.22	21.29
15.61	22.98
25.96	20.91
17.21	23.23
22.05	19.74
19.10	18.21
18.31	20.83
14.39	21.46
27.43	16.00
17.77	21.17
21.02	18.32
19.85	18.63



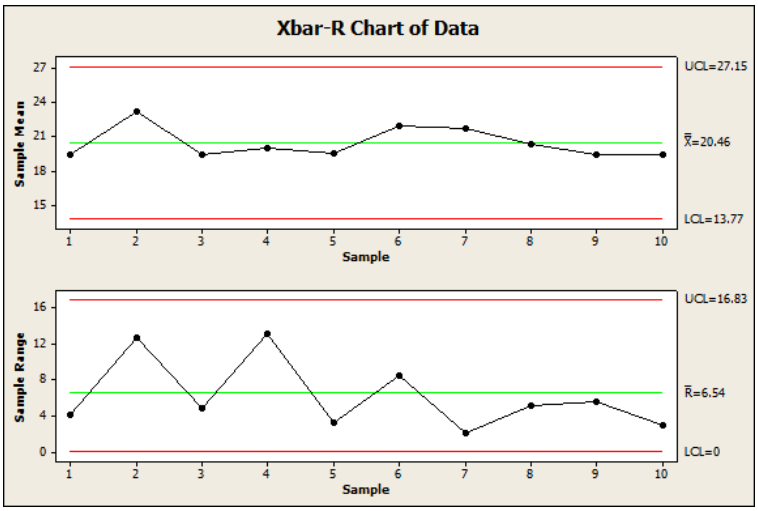
American Society for Quality ASQ

Time Series Plot for Data 1



American Society for Quality ASQ

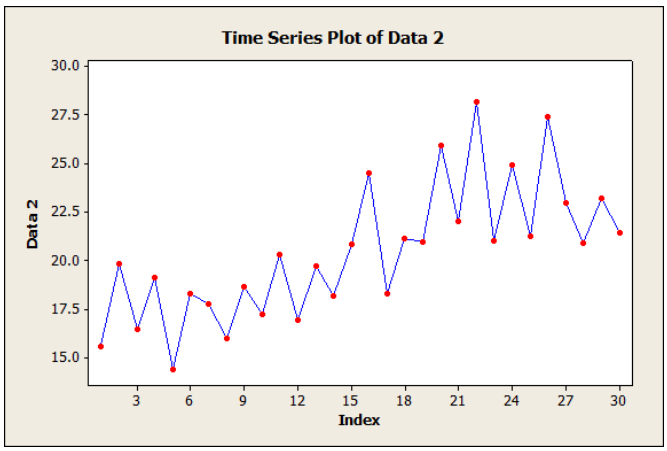
X Bar & R for Data Set 1



American Society for Quality
ASQ

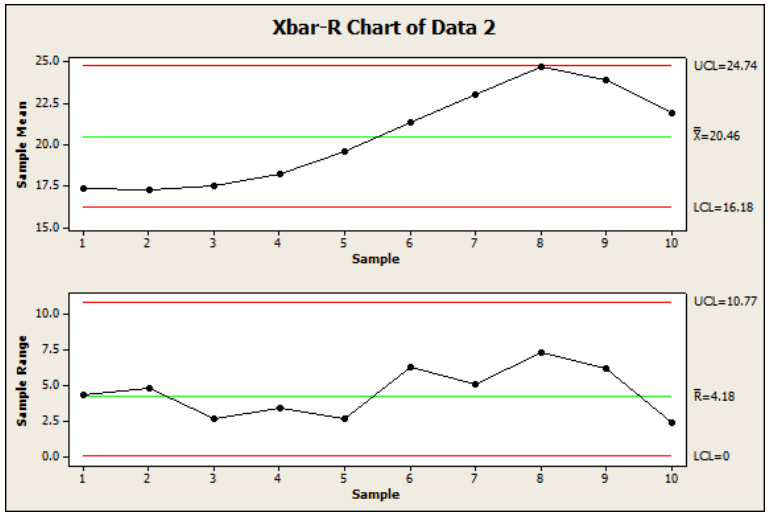
Time Series for Data Set 2

15.61	24.53
19.85	18.32
16.46	21.17
19.10	20.99
14.39	25.96
18.31	22.05
17.77	28.22
16.00	21.02
18.63	24.95
17.21	21.29
20.32	27.43
16.95	22.98
19.74	20.91
18.21	23.23
20.83	21.46



American Society for Quality
ASQ

X Bar & R for Data Set 2



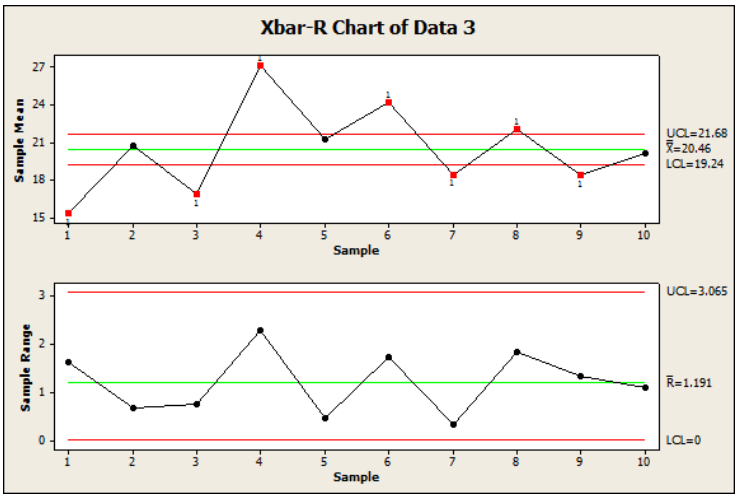
American Society for Quality
ASQ

Time Series Plot for Data 3

16.00	24.53
14.39	24.95
15.61	23.23
20.99	18.32
20.32	18.63
20.91	18.31
16.46	22.05
16.95	22.98
17.21	21.17
27.43	17.77
28.22	18.21
25.96	19.10
21.02	19.85
21.29	19.74
21.46	20.83

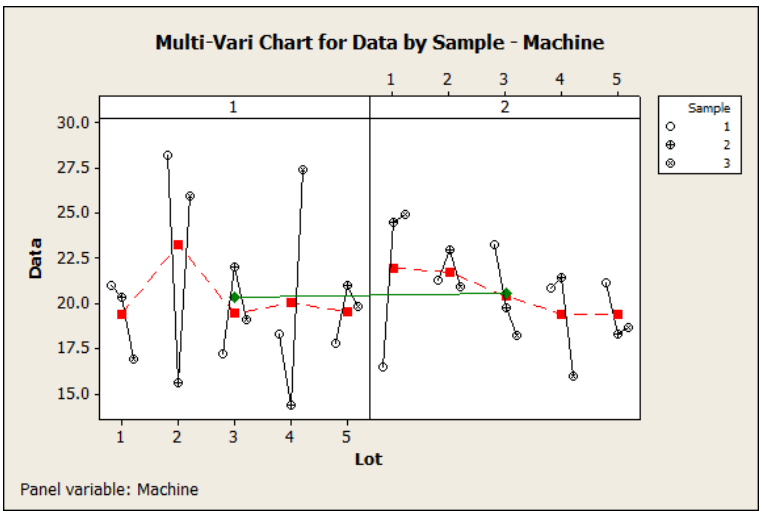
American Society for Quality
ASQ

X Bar & R for Data Set 3



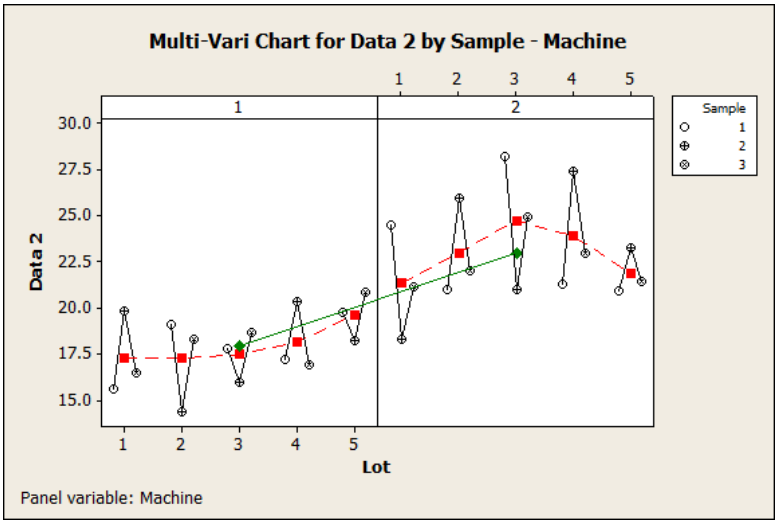
American Society for Quality ASQ

Multi-Vari Chart for Data Set 1



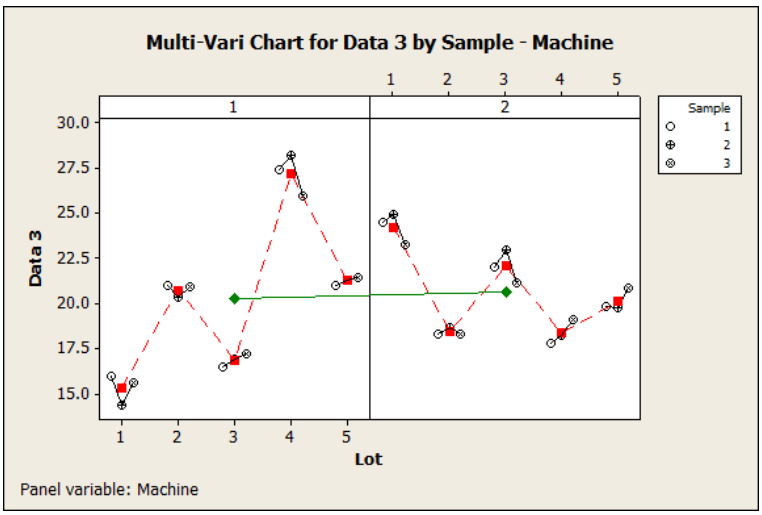
American Society for Quality ASQ

Multi-Vari Chart for Data Set 2



American Society for Quality ASQ

Multi-Vari Chart for Data Set 3



American Society for Quality ASQ

Hypothesis Testing

PURPOSE

A hypothesis test is a statistical test that is used to determine whether there is enough evidence in a sample of data to infer that a certain condition is true for the entire population. It is important to determine the criteria for the test and the required sample size before you collect the data.

A hypothesis test examines two opposing hypotheses about a population: the null hypothesis and the alternative hypothesis. The null hypothesis is the statement being tested. Usually the null hypothesis is a statement of "no effect" or "no difference". The alternative hypothesis is the statement you want to be able to conclude is true.

CONSIDERATIONS

A common misconception is that statistical hypothesis tests are designed to select the more likely of two hypotheses. Instead, a test will remain with the null hypothesis until there is enough evidence (data) to support the alternative hypothesis.

American Society for Quality ASQ

Hypothesis Testing

Differences In	Hypothesis Test	Purpose
Averages	*t*-test	Compare two group averages
	Paired *t*-test	Compare two group averages when data is paired
	ANOVA (Analysis of Variance)	Compare two or more group averages
Variances	Test of Homogeneity of Variance	Compare two or more group variances
Proportions	Chi-Square test	Compare two or more group proportions
	1-Proportion test	Compare one proportion to a prescribed boundary
	2-Proportion test	Compare two group proportions

American Society for Quality ASQ

Regression Analysis

PURPOSE

The linear regression method studies the relationship between a response variable, Y (dependent), and single explanatory variables, X (independent). This tool allows the user to do the following:

To predict the value of the response variable, for specific values of the explanatory variables.

To predict (at a stated level of confidence) the range of values in which the response is expected to lie given specific values for the explanatory variables.

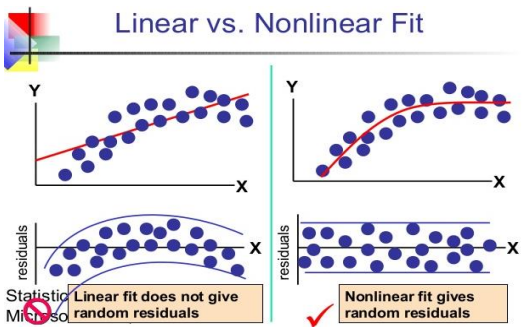
To estimate the direction and degree of association between the response variable and an explanatory variable (although such association does not imply causation). Such information might be used, for example, to determine the effect of changing a factor such as temperature on process yield, while other factors are held constant.

American Society for Quality ASQ

CONSIDERATIONS

Linear regression analysis consists of more than just fitting a linear line through a cloud of data points. It consists of 3 stages – (1) analyzing the correlation and directionality of the data, (2) estimating the model, i.e., fitting the line, and (3) evaluating the validity and usefulness of the model.

There are 3 major uses for regression analysis – (1) causal analysis, (2) forecasting an effect, (3) trend forecasting.



American Society for Quality ASQ

Design of Experiments

PURPOSE

Design of Experiments (DOE) consists of planned trials where numerous input variables are set to predefined levels and one or more response variables are observed. This tool can provide information on how process variables affect and interact with the process performance.

Applications of Design of Experiments (or Experimental Design):

- Determine the process variable settings that change several performance characteristics
- Screen out the important process variables from a large set of potential variables.
- Determine a mathematical model that confirms the effects of the root cause(s) on the symptoms

American Society for Quality ASQ

CONSIDERATIONS: PLANNING, CONDUCTING & ANALYZING AN EXPERIMENT

The practical steps needed for planning and conducting an experiment include: recognizing the goal of the experiment, choice of factors, choice of response, choice of the design, analysis and then drawing conclusions.

- Recognition and statement of the problem
- Choice of factors, levels, and ranges
- Selection of the response variable(s)
- Choice of design
- Conducting the experiment
- Statistical analysis
- Drawing conclusions, and making recommendations

American Society for Quality ASQ

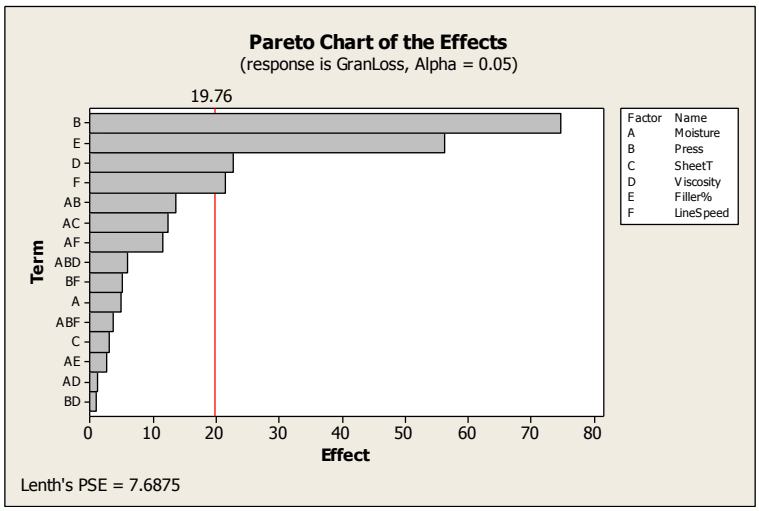
Design of Experiments

- An experimental design is an organized approach to solving a problem. The problem is usually expressed as one or more questions requiring an answer. These questions can be related to machinery, human effects, materials, environmental conditions; basically any factor that could have an impact on a process.
- Factors for the study are determined and the experiment is designed to use as the guideline for gathering and analyzing data.
- Remember the only goal of an experiment is an answer to a question.

"To determine what happens with a process when you interfere with it, you have to interfere with it, not passively observe it." –George E.P. Box

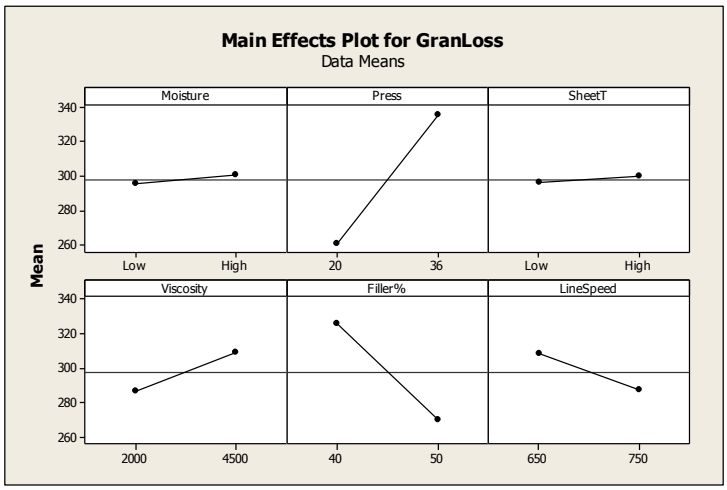
American Society for Quality ASQ

Design of Experiments



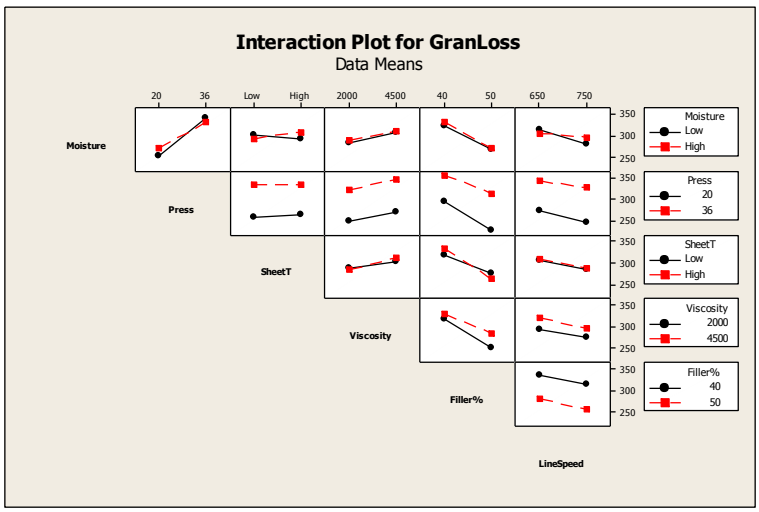
American Society for Quality ASQ

Design of Experiments



American Society for Quality
ASQ

Design of Experiments



American Society for Quality
ASQ

Thanks!

Thank You for Your Time and Attention !

- Uncle Larry