Quality Engineering

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Course Topics

- Introduction
- History Perspective on Quality
- Deming’s 14 Points
- Taguchi’s View of Quality
- Statistical Fundamentals
- Conceptual Framework for Statistical Process Control
- Statistical Basis for Shewhart Control Charts
- Construction and Interpretation of Shewhart Control Charts
- Computer Workshops
- Rational Sampling
- Process Capability
- Variation of Assemblies
- Control Charts for Individuals
- Control Charts for Attribute Data
- Case Studies
- Other topics for graduate credit
Text

Statistical Quality Design and Control, Contemporary Concepts and Methods, Macmillan (Prentice-Hall), Richard E. DeVor, T. H. “Phil” Chang, John W. Sutherland

Grade Determination (grad. credit % in parentheses)

25% Homework (20%)
15% Computer Workshops (10%)
25% Midterm Exam (25%)
35% Final (35%)
Extra Assignments (10%)

Grade Breakdown
Class GPA: approx. 3.0 - grad. students graded separately
Web-based Materials

• the course web site can be accessed from:
  http://www.me.mtu.edu/~jwsuther

• At the web-site, the following materials may be retrieved:
  - Course notes
  - Homeworks
  - listing of assignment results for both on- and off-campus students
  - other

• For listing of assignment results we need a 3 digit codeword
Is Quality Important?

- Met with corporate executives from over 100 companies

- Identified issues of concern:
  - Quality
  - Efficient use of resources (people, inventory, etc.)
  - Faster time to market
  - Costs

- Quality???
  6 sigma, ISO 9000, warranty costs, customer voice, etc.
Assignment

• Read Chapters 1 and 2

• Problems:

• Graduate Credit:
A “Quality” Case Study

*BigTop Balloon’s* yearly production is 100M (about 80,000 balloons/day)

They sell their product in packets of 100 balloons

Cost of production of each packet is $2 -- thus yearly cost of production $2M

The *BigTop Balloon* company has been receiving many complaints lately about the quality of their products.
First Approach

- Management’s initial reaction: hire inspectors for 100% testing
Examining the Proposed Approach

• Upon doing the math -- the expense of 100% testing comes out to be $20M

Assuming:
- Each inspector will look at 2000 balloons a week
- 2000 balloons/wk * 50 wks = 100,000 balloons/year
- Total inspectors required -- 1000
- Pay inspectors $20,000/year
- Total cost of inspection $20m

• Thus, 100% testing -- to ensure that only quality balloons reach the customer, is too expensive
Acceptance Sampling

Process

Batch of Parts

“small” sample

Some Sampling Insp. Method

Decision to Accept / Reject Batch

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Quality Engineering (MEEM 4650 / 5650)
Dept. of Mechanical Engineering - Engineering Mechanics
Michigan Technological University
Second Approach

• Decide to test 100 balloons per day (out of 80,000) using a moderately priced testing machine

• Testing Criteria -- for a day’s sample of 100 balloons
  # bad balloons \leq 1 --- Accept day’s production
  # bad balloons \geq 2 --- Reject day’s production

• How effective is this sampling plan?
• What can we conclude about the Quality Level of the production?
• Cost?
OC Curve

• We want to draw a graph called an Operating Characteristic (OC) Curve

• It plots Probability of Acceptance vs. Fraction Defective.

• Take a single part at random.
  Probability that it is defective: p - fraction defective
  Probability that it is non-defective: 1-p

• Such a probability situation (only two outcomes -- binomial distribution)
Binomial Distribution

• What if we have two parts? What is probability of (D, D)?
  (D, N)?
  (N, D)?
  (N, N)?

• Summarizing
  - For a Sample Size of n
  - Fraction defective of p

Probability of d defectives in a group of n parts:

\[ \text{prob}(d) = \binom{n}{d} p^d (1 - p)^{n-d} \]
Back to our OC Curve

• For our example: the sample size \( n = 100 \), and the cutoff value for defectives is \( c=1 \) (if we get 1 or less defectives, we accept the batch).

• So, we are concerned about the probability of getting either \( d=0 \) or \( d=1 \) defectives in the sample.

• What value to use for \( p \)?
  We do not know the actual quality (\( p \) value - fraction defective) of the parts we are producing, so we need to check what happens for a few different \( p \) values.
More on our OC Curve

- What if $p=0$? (There are no defectives in the batch). The probability of getting either $d=0$ or $d=1$

\[
\text{Prob}(d=0) = \binom{100}{0}(0.00)^0(1.00)^{100} = 1.00
\]

So, when the fraction defective is 0, the probability of us accepting the batch is 1.00.

- When $p = 0.01$, check for $d=0$ and $d=1$

\[
\text{Prob}(d=0) = \binom{100}{0}(0.01)^0(0.99)^{100} = \]

\[
\text{Prob}(d=1) = \binom{100}{1}(0.01)^1(0.99)^{99} = \]

Probability of acceptance = $X + X = X$. 
Displaying the OC Curve

- $n = 50 ; c = 0$
- $n = 100 ; c = 1$
- $n = 200 ; c = 2$
More on OC Curves

Seemingly, we are willing to accept 1% of the production as defective (initial plan was n=100, c=1). A *perfect* OC curve for this would appear as follows:

To approach perfection, need larger and larger values for n. With increasing n, the sampling cost increases.
Let’s Look at the Cost

![Diagram showing the relationship between cost and quality, with lines for Defective Cost, Inspection Cost, and Total Cost, and an optimal quality level.](image-url)
Fundamental Flaws with this Philosophy

- Focus is on product control (not process control)
  - Emphasis: find and remove defective parts so that the customer never gets them.
  - The process remains unchanged -- the faults producing the defective products still exist
- We are willing to tolerate some level of defective parts.

This course will focus on the modern quality philosophy
- Emphasis: improving the process by removing faults. As faults are removed, quality improves & production rate increases & costs reduce.