Statistical Quality Control

and the Rise of International Manufacturing Competition

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Basics as shown illustrated by the piston of a brake caliper

Variable data

Design spec, tolerance

Brake caliper, power supply, . . . you name it. Measure! Length, voltage, temperature, weight . . . inexpensive digital tools available.

Figure 14-9: Anatomy of a single-piston, floating-caliper disc brake.

Typical Single Piston Floating Caliper Assembly

AA1Car.com
Mass Production

Make hundreds of thousands of pistons perhaps

Volume and quality both goals

Lack of quality has many downsides

Recalls, wasted money, lawsuits, lost customers . . .

What does quality mean here?

Item within specification

Typically: diameter +/- tolerance. Here 1.510 +/- .005”

Metric #1: #defects per million items  dpm

Reality:

Measure all diameters of all pistons.

A Normal Distribution results

all the time. There is always variation. (key point). For my piston assume the average is 1.510” = μ and the standard deviation σ = .0025

How does quality relate to this news?
The area in yellow, in the tails is equal to approximately \(0.045\). This means of course that \(95.42\%\) of the items are being manufactured correctly. Or an equivalent defect rate of \(45,800\) per million... hmmm.

**Background: history of US Mass production**

- **Ford** assembly line for Model T
  
  [https://safeshare.tv/x/ShbgywazCZ](https://safeshare.tv/x/ShbgywazCZ)

- **Electrical industry** 1920s, 30s
  
  AT&T Western Electric Wire!

- **Walter Shewart, W. Edwards Deming**
  
  *Sampling* as a way to measure quality
  
  *Central Limit Theorem* an important underlying fact
  
  Increasing quality as a goal
  
  Management philosophies tied to statistical methods. Eventually
  
  *Deming’s 14 points of Management*

- **WWII** manufacturing capacity a key element in eventual victory

- **Postwar**
By the late 1960s, Hal Spierlach, an accountant working for Lee Iaccoca at Ford, estimated the cost of nonconformance was 20-40% of revenues”, perhaps $2500 per car. Lessons forgotten.

Meanwhile, **Japanese industrial capability grew post WWII.** Deming taken very seriously. Became global players in electronics and cars thanks in part to sound management practices that included Deming’s philosophies. Meanwhile Ford was losing millions per day by the early 80s. And *market share* it would never regain.

**The Shewhart Cycle**

- Collect data samples regularly in the factory
- Study, conjecture possible paths to improvement
- Carefully implement changes
- Collect more data, evaluate

Also:

- Study *failures* methodically
- Fishbone diagrams

**Control Charts - Everyday Statistics on the Assembly Line**

Two charts: $\bar{x}$, $R$ charts for samples relating to *mean* and *standard deviation* of the process

- Take samples daily (shift if possible). Often just 5.
- Compute averages, plot
- Watch the plot. Holler if key events observed
- Trends, drifts, outstanding events
  
  *If needed, stop the line!*

A visual, intuitive understanding of statistics is involved
Back to our pistons

We would like to lower the defect rate. This can be achieved by lowering variation $\sigma$ which will decrease the area in the tails and hence the defect rate.

Suppose thru communication, training, analysis and feedback we decrease $\sigma$ to .0016. Then the area in the tails is now about .002 so 99.8% of our pistons are acceptable and .2% defective, which translates into 2000 defects per million, about 1/22 nd of what we had! This came about by reducing variation from .0025 to .0016. Consistency is worth something!!

A process is often described by its sigma level. This is defined as how many units of standard deviation lie in between the design specs, over 2.

In our case, since the design specs are 1.505 to 1.1515 and $\sigma$ to .0016. So the sigma level is about 3.1 ($0.005/0.0016$)

The higher the sigma level the better.

In the 1990s, Motorola, a major manufacturer of computer chips, was said to have achieved a 6 sigma level. This corresponded to only a few defects per bilion.

Who This Material Appeals To

Measuring, sampling, variation, control charts: manufacturing personnel

Underlying mathematics of Control Charts: statistics students

The mathematics of normal distributions: AP Calc students (see reference below)

Strategies for improving quality: management students

Conclusion

Statistical Quality Control has, and will continue to play an important role in manufacturing, which in turn plays an important role in the economy of a region or country. Different aspects of it can interest and challenge a variety of students and allow them to relate their mathematical studies. The notions of sampling and variation are important, in one way or another, to almost everyone.

References


“Nummi” This American Life. Chicago Public Radio. See podcast at


(General Motors plant in Freemont CA which became the home of the joint Toyota-GM project)