Statistica in azienda
Statistici in azienda
SIS 2010
Riunione Satellite

QUALITY PROJECT

Improve the process with statistical methods

Francesco Valente – University of Milano-Bicocca
Solving Efeso srl 47, via V. Monti 20123 Milano – Italy

SOLVING EFESO
STRATEGY IN ACTION

STATISTICAL PROCESS CONTROL (SPC)

WHO: Manufacturing centre of furniture hardware and components; it produces and sells worldwide clever solutions for the furniture and kitchen industry.

WHAT: Define an industrial plan for the manufacturing of a new drawer on a quality target of about 200 defective parts per million (PPM).

WHY: To monitor processes, to make sure they do not change, to compare the output of a process with the specification and to understand the possible sources of defects in order to eliminate or control them.

PHASES AND STRATEGIES

1. PROCESS MAPPING
2. QUALITY DEFINITION and QUALITY TARGET
3. ANALISYS OF THE DEFECTS' CAUSES WITH QUALITY FUNCTION DEPLOYMENT (QFD)
4. DEVELOPMENT OF A SIMULATION'S SYSTEM FOR QUALITY EVALUATION
5. FAILURE MODE AND EFFECT ANALYSIS (FMEA)
6. PLAN CORRECTIVE ACTION

Work on actual defectiveness level evaluated by in field measurements and historical data of similar product.

DETAILS ON:

QFD: is based on the philosophy that the 'voice of the customer' drives all company operations.
QFD is well suited to manage the integration of the techniques in the design process with its related matrices and focus on business and customer needs. The function of QFD is to translate the needs of the customer and consumer into product and process design, and through the related matrices of capital, cost and ensure that the 'best choice' of parameters such as functionality, reliability, reproducibility, etc. are met.

FMEA: is focused on preventing process and product problems before they occur, enhancing safety, and increasing customer satisfaction.
It helps us to reduce costs by identifying product and process improvements early in the develop process when changes are relatively easy and inexpensive to make. The result is a more robust process because the need for after-the-fact corrective action and late change crises are reduced or eliminated.

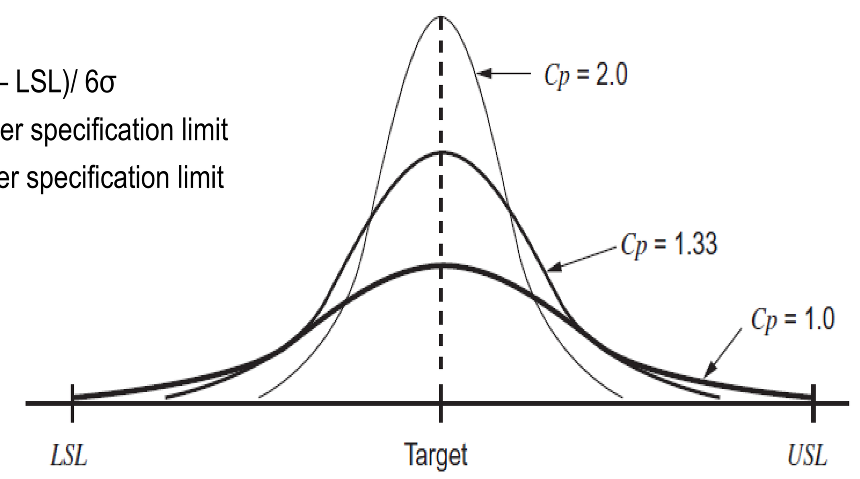
WHAT WE CAN USE? STATISTICAL INSTRUMENTS

- Measurement system
- Sampling
- Basics Statistics (descriptive statistics, statistical distribution)
- Capability analysis
- Control charts

FOCUS ON CAPABILITY INDICES

Capability indices allow to quantify how well a process can produce acceptable product, all conforming product.
The capability indices measure what a process would be capable to do while the Gaussian hypothesis of the process is respected.
They are used by manager or engineer to prioritize needed process improvements.
We can use them to monitor the process, to eliminate scrap, rework and increase customer satisfaction.

C_p = (ULS – LSL)/ 6σ
ULS = Upper specification limit
LSL = Lower specification limit



The distributions of individual values for C_p indices of 1.0, 1.33,and 2.0. A higher C_p index means less nonconforming product.

STEPS FOR CAPABILITY STUDY:

1. Select Critical Parameters: established from drawings, inspection instruction, work instruction. Critical parameters are usually correlated to product fit and / or function.
2. Collect Data: a data collection system need to be established to assure the appropriate data is collected. It is preferable to collect at least 60 data values for each critical parameter.
3. Establish Control over the Process: a distinction between product and process should be made. Process capability indices are always performed using the critical parameters of the product. Their calculation is dependent on the statistical control of the process that can be studied using control charts.
4. Analyze Process Data: a normal distribution is required, we must prove that.
5. Analyze Sources of Variation.
6. Establish process Monitoring System: a routine process control technique should be employed to assure that the process remains stable.

		DIAMETER (ø)								
SUPPLIER	DIMENSION (øxl)	μ	σ	USL	LSL	Cp	CPU	CPL	CPK	PPM
A	3,65 x 5,5	3,68	0,003	3,68	3,63	2,470	-0,126	5,067	-0,126	647.454
A	6,04 x 5,0	6,03	0,011	6,06	6,02	0,621	0,894	0,348	0,348	151.811
G	6,04 x 5,0	6,04	0,011	6,06	6,02	0,585	0,611	0,560	0,560	79.907
G	5,80 x 5,5	5,77	0,009	5,80	5,76	0,750	1,008	0,492	0,492	71.087
		LENGTH (l)								
SUPPLIER	DIMENSION (øxl)	μ	σ	USL	LSL	Cp	CPU	CPL	CPK	PPM
A	3,65 x 5,5	5,47	0,013	5,50	5,46	0,523	0,830	0,217	0,217	263.795
A	6,04 x 5,0	5,00	0,012	5,00	5,46	-6,520	-0,097	-12,943	-12,943	1.613.981
G	6,04 x 5,0	4,97	0,014	5,00	5,46	-5,654	0,651	-11,959	-11,959	1.025.440
G	5,80 x 5,5	5,49	0,020	5,52	5,45	0,588	0,530	0,645	0,530	82.443

Example of a capability study on a drawer's component a "roller".

PROCESS CAPABILITY RELATED TO Parts Per Million (PPM)

Many process capability indices C_p , C_{pk} may be expressed in terms of parts per Million by using the standard normal distribution tables.

CONVERTING C_p to PPM

- Calculate the Z-score = 3 C_p

The Z-score in the Z percentage point from the standard normal distribution tables. C_p , C_{pk} assumes that the process data follows a normal distribution.

- Use the Z-score to find the Z-score curve area value in the standard normal table
- Convert the Z-score curve area to PPM : (1 – Z-Score curve Area)*2*10^6

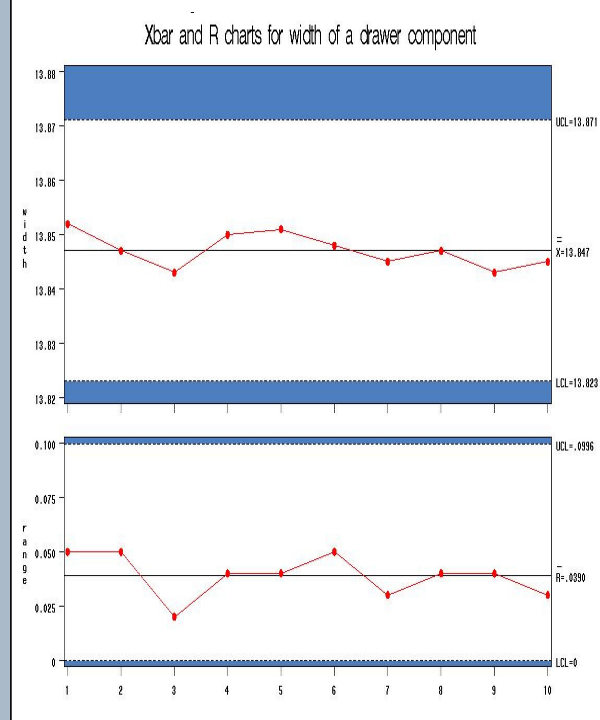
C_p VS. PPM			
C_p	Z-SCORE	% NONCONFORMING	PPM
0,50	1,50	13,36	133.614
0,65	1,95	5,12	51.176
0,85	2,55	1,08	10.772
0,95	2,85	0,44	4.371
1,05	3,15	0,16	1.632
1,15	3,45	0,06	560
1,24	3,72	0,02	199
1,33	3,99	0,01	66
1,42	4,26	0,00	20

Process capability should be revaluated periodically to assure that the process mean has not shifted and that the process variation has not increased. We work under the assumptions that data are distributed normally, and the performance measure data reflects statistical control when plotted on a control chart.

ABOUT CONTROL CHARTS

- **ROLE**: control charts enables operators to monitor key process variables and adjust the process when it changes, before it goes out of control and produces a bad product.
- **USED TO** get a real-time view of the process. When a failure occurs in the process, the control charts will signal a change. By quickly reacting to the signal, the team can work to find the root cause of the failure in order to eliminate it.
- **TYPES OF CHARTS**: We choose the average and range (Xbar and R) control chart. We use variable control charts when the characteristic of interest is measured on a continuous scale.
The Xbar chart to monitor process mean and the R chart to monitor process variability. The X and R charts assume that, under stability, X ~ NID(μ,σ).

- **RECCOMENDED**:
→ It is a good practice to periodically review and, if necessary, update the control chart design. With the constant control of the process an out-of-control signal does not require the production to be stopped but an investigation.
→ We need an out-of-control action procedures for a successful real-time implementation of control charts, to describe in cases of rule violation, what specific investigatory, and other actions will be taken process operators.

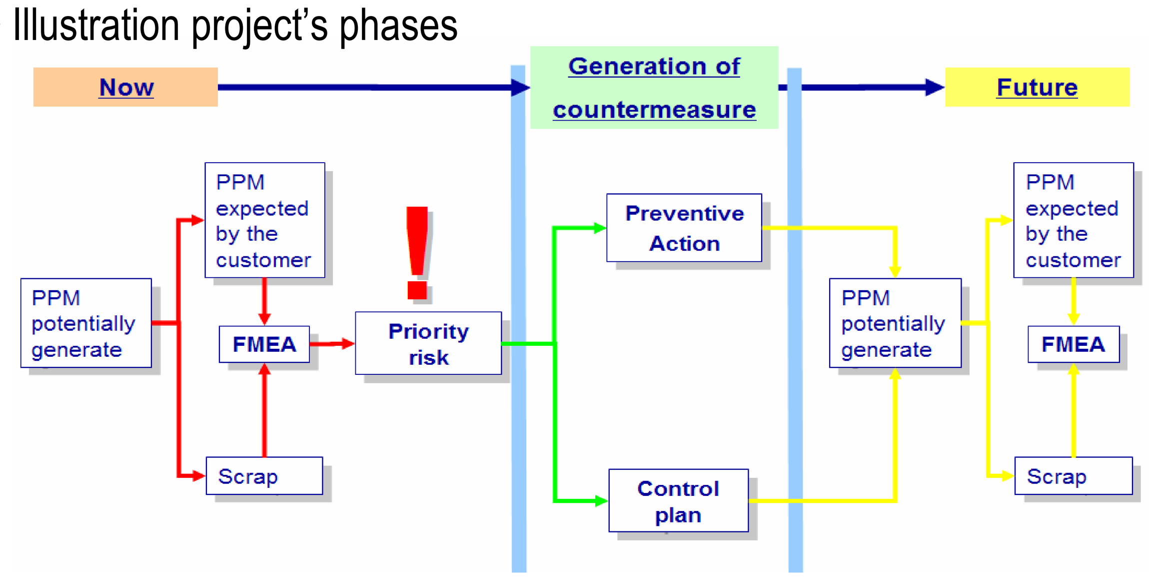


When causes are found we need take permanent corrective improve the process.

Example of control charts used to process control of a drawer component. Note that the Xbar and R charts are in control, indicating that the within-subgroup variability is constant over time.

RESULTS

- Illustration project's phases



- We need internal control : Optical control for the most critical causes of defects and SPC for others.
- Supplier approval of capability target for machinery and part of product.
- Improve process capability with set-up procedure definition and maintenance.

REFERENCES

Bossert, James L. (1991), Quality function deployment: a practitioner's approach, ASQC Quality Press.

Di Forrest, W. Breyfogle (1999), Implementing six sigma: smarter solutions using statistical methods, Wiley, 791, 90.

Montgomery, Douglas C. (2009), Statistical Quality Control: A Modern Introduction (6 ed.), Hoboken, New Jersey: John Wiley & Sons, 23.

Joglekar, Anand M. (2003), Statistical methods for six sigma. *In R&D and Manufacturing* , John Wiley & Sons.

R.E. McDermott, R.j.Mikulak, R. Beauregard (2009), The basic of Fmea (2 ed.) Taylor & Francis Group, LLC.