ELEMENTS OF PROBABILISTIC ORDER CONCERNING THE CAPACITY OF A TECHNOLOGICAL PROCESS TO MAKE PIECES WITH FEATURES WITHIN THE ALLOWED TOLERANCE LIMITS

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Abstract:
Quality is a picture of an entity (the production process) obtained by composing the quality characteristics of it. At a time, from a process can result a better-quality product, the problem is that the best products must be achieved constant, and this constitutes the quality assurance. This has like features the quality construction, quality verification, quality guarantee, quality improvement and training for quality.

***Key words**: improving of the processes, capability of the technological process, control process diagram, technical control.*

***JEL classification:** M 11*

1. Improving of the processes

Quality improvement function includes a set of measures resulting from verification and tracking pattern of all quality related activities. Unlike the build quality, which refers to measures taken to ensure quality standards in new products to be realized, improving quality raises the current manufacturing products by redesigning products and processes.

Strategies to improve quality can be product-orientated (aimed at improving product characteristics), process orientated (improving activities participating in the product), or system oriented (to improve the functions of the industrial organization).
Modern practice requires that the improvement to be made, firstly, over the production processes (criterion P), unlike the old approach that refer in particular to improve results (criterion A) (Fig. 1).

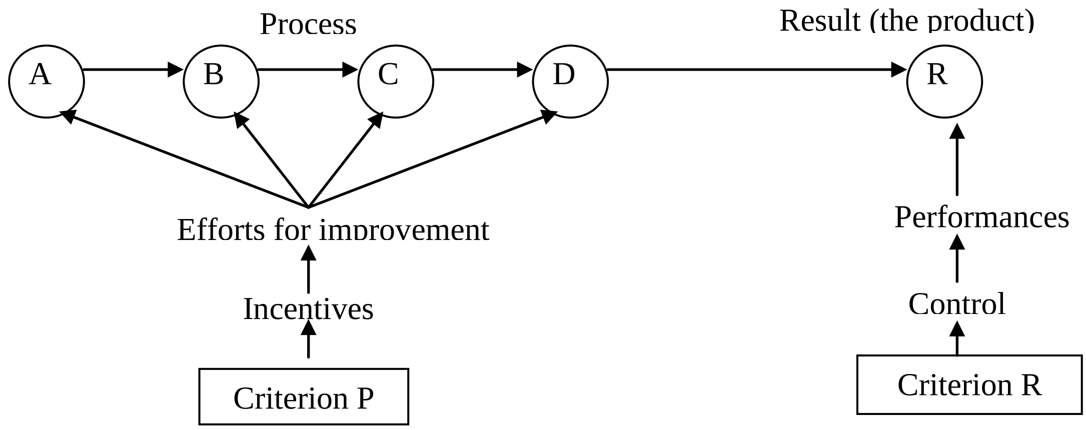

Fig. 1 – Partial improvement strategies

The Japanesse design probabilities are endless, unlimited improvement, while in Western culture prevails the improvement made through innovation. But the company can not introduce an innovation every day. Kaizen requires an infinite number of small efforts that presume today to work a little better than yesterday.

Continuous improvement is necessary because major companies have market leading technologies, or they can purchase if they want, leading to a certain equality between them. But the obsolescence makes that in time to occur differences. In order to keep themselfs competitives, companies, must, from time to time, make innovations and discoveries that may provide a substantial advantage, cut difficult even for the strongest ones. For this reason it tries through small steps, but continue to make improvements to maintain the benefits.

Improving processes involve making improvements to the design and carrying processes.

Improving processes requires:

- Full involvement of managers in this direction. At least once a year should be made an analysis and remind the policy of the company for improving processes. Managers need to monitor the progress of projects and be directly involved in some critical processes;
- Also requires a commitment of all the designers and their knowledge over all phases of the process;
- Is necessary the knowledge of some instruments to improve as statistical methods (ANOVA, EVOP, TAGUCHI) or some heuristic methods;
- Managers must use some methods of recognition for the contribution of the process designers such as: presentation of good company projects to the senior management, the opportunity to participate in congresses abroad, publishing projects, cash prizes or trips;

Improve the running of the processes involves new solutions in processing operations, control, transport and storage.

Specialists say that to improve the production process are necessary four phases:

1) Define the improving program – stages of process, the knowledge used in each stage, costs involved, customer needs;
2) Identification process – input into the process, its stages, outputs, control parameters, the process boundaries, parameter values, decission taken, the basic objectives to be achieved;
3) Improving the process – are asked questions like: what goes right or not, how can a phenomenon can be prevented. Are analyzed the requirements for each stage, the instruments used, is checking whether the processes are under control, whether the maintenance and storage methods are appropriate;
4) Preparing the documentation for the process – are required procedures for making changes to documentation;

In an attempt to obtain an excellent manufacturing are recommended some new solutions for quality improvement processes as:

- Design improvements – this involves assessing the quality and setting targets;
- Systematic research into the problem – for this purpose spot anomalies throughout the processes and assess their frequency;
- Systematic research into the causes – for this can be used, for example „ Tree failure”;
- Propose corrective actions and testing them;
- By identyfying ways of action can develop working instructions to give confidence that the solution is practical;

There are four possible states in which to find a process (Fig.2).

- Ideal – when the process has capability and is controlled;

- Transition („the treshold”) – it is under control, but has no capability;
- Unstable („at the edge od chaos”) – it has capability, but is not under control;
- Chaos – it does not have capability and is out of control;

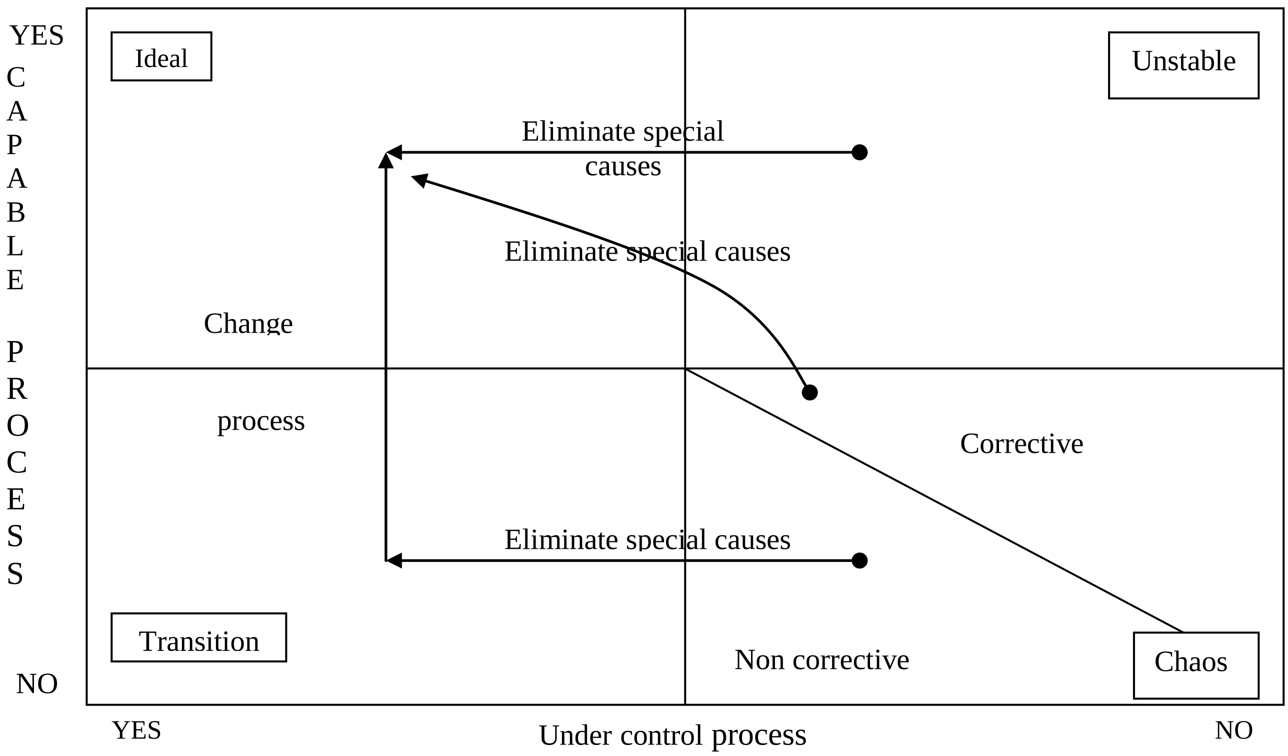

Fig. 2 – Process control chart

As can be seen, reaching the ideal state is achieved by removing the special causes or by changing the process.

To change the transitional process can be applied statistical methods (ANOVA, EVOP, TAGUCHI), to detect factors affecting important quality characteristics. To improve the unstable process may apply also statistical methods to detect and eliminate the causes of variability. A process in a state of chaos can be analyzed on the basis of control charts with which to detect special causes of variability. After removal of these cases the process may be perfectly capable and can enter the ideal state. But if the process is under control, but the results are inconsistent, then it means that is transitive and should be changed.

Technological process capability

Capability is the ability of a technological process to achieve parts with features within the tolerances limits allowed.

As is known, the technological process consists of a sequence of operations and every operation should be performed with a certain tolerance dimension (Fig.3). effect dimension is between $X_N - \frac{T}{2}$ and $X_N + \frac{T}{2}$ in case when the tolerance is symmetric (generally between $X_N - T_j$ and $X_N + T_s$, where T_j and T_s are the upper and lower tolerance).

Theoretically, by checking a lot to a certain operation, the probability to exist a dimenssion on the interval ($x_N - \frac{T}{2}$ and $x_N + \frac{T}{2}$) fallows a normal distribution (Fig.4).

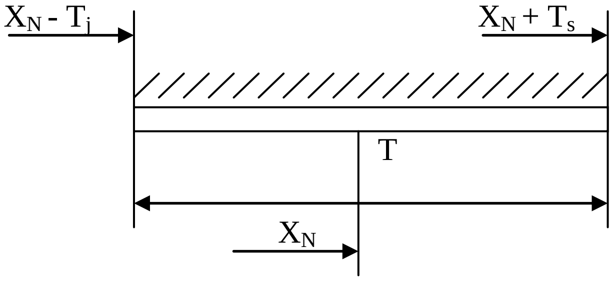

Fig. 3 – Measurement process

The distribution is characterized by a central value $\bar{x}$ and through a dispersion σ. Normal distribution has the property that on a range of 6σ there are approximately 99,99% of the values, so basically the entire population.

Compatibility of an operation is expressed by the relation:

$$C = \frac{6\sigma}{T}$$

The probability that the measured value to be found within the limits (-∞, x), therefore not exceed x, is:

$$p = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{x} e^{\frac{-(x-x)^2}{2\sigma^2}} dx,$$

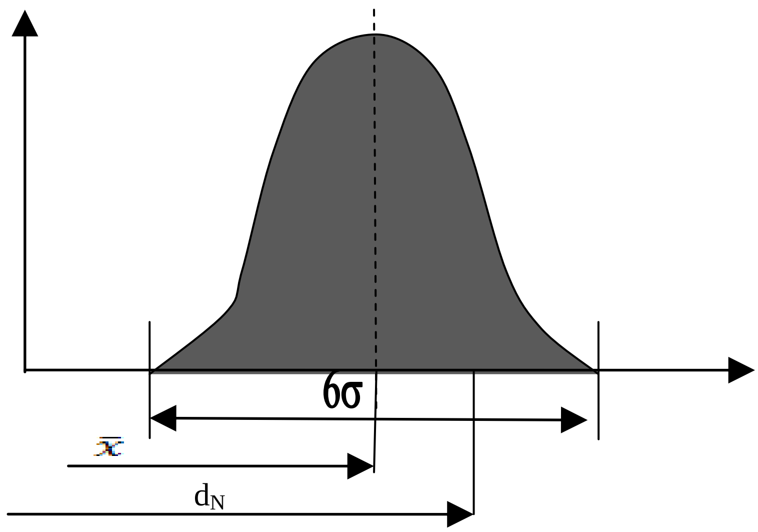

Fig.4 – Normal distribution of values

In this way, for an operation it can calculate the probability of obtaing good parts. Between theoretical and actual situation are however differences; is happening that the good parts fallow a distribution other than normal.

Therefore must be verified whether the actual distribution is normal or other. Even for the second case the values x and σ are sufficient for providing guidance on corrective actions.

If the actual distribution is normal, the fallowing situations are possible:

1. The process is decentreded (fig. 5)

In case (a) the upper and lower limits have the range within the permitted limits:

$$\bar{x} + 3\sigma \leq x_N + T_s ;$$
$$\bar{x} - 3\sigma \geq x_N - T_j ;$$

In this operation, the machine is capable and achieves the prescriptions, if: $\frac{6\sigma}{T} < 1$ (practical the value should be between 0,6 and 0,8). In case (b) real limits exceed those prescribed, namely:

$$\bar{x} + 3\sigma \geq x_N + T_s ;$$
$$\bar{x} - 3\sigma \leq x_N - T_j ;$$

In this case the tolerance is exceeded $\frac{6\sigma}{T} > 1$ and it must be taken measures to eliminate the decentratrion.

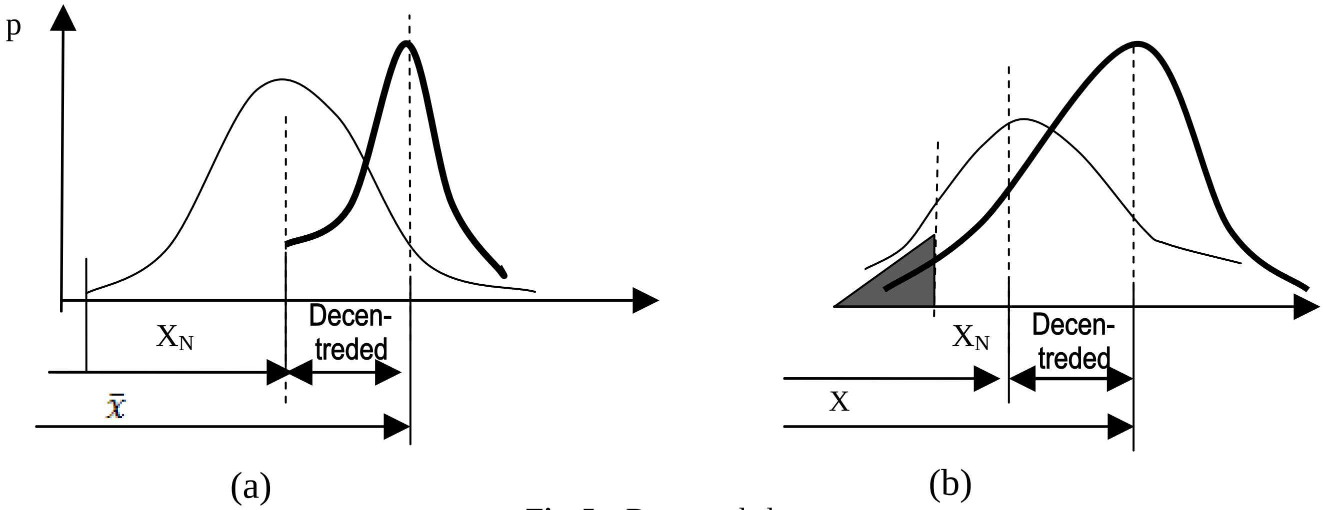

Fig. 5 – Decentreded processes

2. Process is centered (Fig. 6)

In case (a) the real limits fall within prescribed limits.

In case (b) the real limits exceed the prescribed limits, and the shaded area represents the defective fraction.

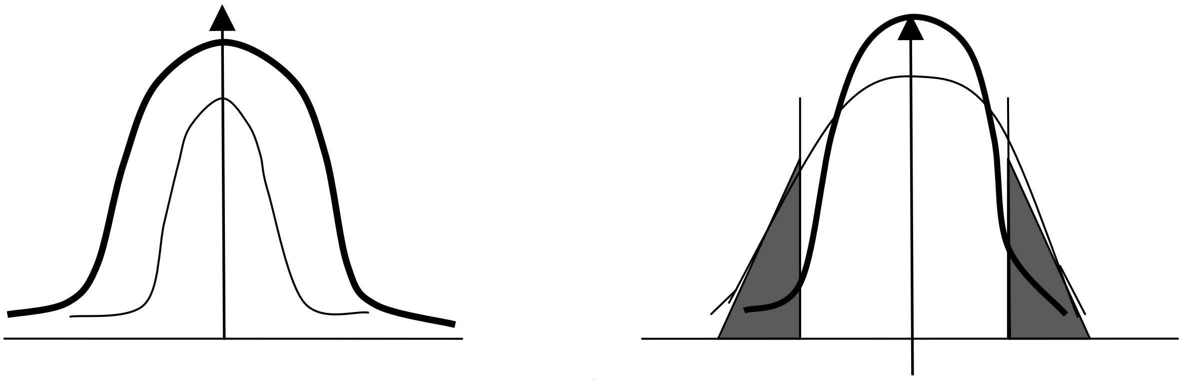

Fig. 6 – Centered processes

Is to note that the actual distribution varies over time. Analyses performed at different time shows that the distribution is not centered, but by self-control they can center (the analyse of capability is made with the distribution at t_f moment).

Basically, to calculate capability must be determined the posibility to obtain the best pieces in an operation. The process involves the fallowing steps :
from zero series are extracted from hourly time for a period of n_1 hours (n_1 ~ 6) a number of n_2 pieces (n_2 ~ 5). The data are centralized in a table (table 1).

Synoptic table for capability calculation

Table 1

Selection	Hour	Data				$\sum x$	$\bar{x}$	R
		1	2	...	n_2			
1								
2								
3								
...								
n_2								

x represents arithmetic average of the measured values, and *R* amplitude.

$$\bar{x} = \frac{\sum x_i}{n_2}; R = x_M - x_m$$

x_M is the maximum value observed, and x_m is the minimum value;

1. Calculate the statistical parameters:
2. $\bar{\bar{x}} = \frac{\sum \bar{x}}{n_1}$; $\bar{R} \frac{\sum R}{n_1}$ and results σ= $\frac{\bar{R}}{d_2}$, where d_2 is a conversion factor.

Real curve parameters are $x_{max} = \bar{\bar{x}} + 3σ$ and $x_{max} = \bar{\bar{x}} - 3σ$;

3. check that the data in Table 1 meet the normal distribution;
4. calculate the probability to obtain a correct operation.

In case where $x_{max} > T_s$ and $x_{min} < T_j$ is to calculate the reduced variable of the normal distribution:

$$z_s = \frac{T_s + \bar{\bar{x}}}{σ} \text{ and } z_j = \frac{T_j - \bar{\bar{x}}}{σ}$$

and then from a table with a normal distribution is determined the probability that the value to enter in the upper limit (p_s)and the probability to enter in the lower limit (p_i). The probability to achieve a correct aopration is p~ max. (p_s p_i), and the probability to make a scrap operation is $q = 1 - p$.

In this way is analyzed the capability of an operation. In case where the entire process is fallowed, he is able if all the operations have$0{,}6 < C < 0{,}8$. The probability of achieving the appropriate pieces is :

$$p = p_i \cdot p_2 \cdot \ldots\ldots \cdot p_i$$

As an extension, we can compute the probability that an assembly is correct in case where is known the probability of parts is correct :

$$p_a = (1 - p_r)^n ,$$

where n is the number of parts from the assembly.

Previous considerations were related only to the influence of machine tools on process capability. But we have to take into account also the influence of workers on the process, the series of manufacturing, materials, environment.

Studies shows that 80% of defects occur in manufacturing, mainly due to capability. Other factors occur also such as training, fatigue, things that can be fixed, but the variability of the process is a natural phenomenon.

Moments to calculate the capability :

a) before start the manufacturing in series, to demonstrate the correctness of the technological process elaborated (the way of avaluation was previously exposed) ;
b) during fabrication, to analyze the efforts that are made to obtain appropriate plots and making successive adjustments. The analysis of capability during fabrication is different from the fabrication control. For this extract more samples of five pieces and we fallow the arithmetic average $\bar{\bar{x}}$ and the amplitude$\bar{R}$. For the control of the process the values are on a chart and assigns the limits L_{cs}, L_{ci}, L'_{cs}, according standards, the goal being elimination of the systematic deviations. For the analysis of the capability is necessary to determine in what measure the variations in time of the process are able to generate pieces within the tolerance area, while respecting prescribed AQL values. The limits are set for $\bar{x}$ at $\pm 1{,}5\sigma$ for centered processes and at $\pm(1{,}25 \ldots 1{,}45)\sigma$ for decentred processes;
c) at the completion of execution, to reveal how the final control evaluate the quality of the lot, the analysis is performed on samples from 30 to 50 pieces.

To improve the technological processes must be considered even since the organization of the production the fallowing aspects:

- Completion of the equipments with suitable SDV construction to give greater independence to the parameters which are determining the capabilty of fabrication such as attention or skills;
- Introduction in the machine tools of the control and adjustment elements, stroke limitations to release the worker to check the accuracy of processing;
- Introduction of additional processing operations such as amendments after cutting, extra-finish after correction precision punching after simple punching;
- Transfer processing on high precision machines: drills in coordinates, lathes and precision mills;
- Transition to higher forms of order in the processing process: control program sequentially, numerically order.

In parallel, is working to improve technical control by:

- Adopting of new control technologies: control the process, multidimensional control statistical control;

- Preventive inspection to be made over machine tools precision used in the process and also over the SDV's;
- Introduction of special selection operations performed with automatic and sorting control machines, in case where we have mass production;

Capability increases if the tolerances are in the upper limits. Since this is not possible, there is a reserve in calculating the size chains. Today they are calculated by the assembly, but, if it were to use quadratic programming or statistics, could widen the tolerances to some dimensions, without affecting the tolerance required for assembly.

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