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Process Capability

Understanding Capability and Performance Indexes.

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“Process Capability”; Understanding Capability and Performance **Indexes**.

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Introduction

Process capability is a critical concept in quality control, helping businesses determine how well their processes can produce output within specified limits. In simple terms, it tells us how consistent and reliable a process is in meeting product specifications. By analyzing the variation in a process, we can see whether it consistently delivers products or services within the desired range, or if it needs improvement.

Several statistical indexes are used to measure process capability, including **Cp**, **Cpk**, **Pp**, **Ppk**, and **Cpm**. Each index serves a specific purpose in understanding different aspects of process performance. This article will explain each of these indexes, their importance, and how to interpret their values in layman's terms.

Key Process Capability Indexes

1. Cp

Process Capability Index

Cp is a simple measure that tells us how much of the specification range the process is using. It assumes that the process is centered within the specification limits, which may not always be true in practice. Essentially, Cp answers the question: *Can this process potentially fit within the specification limits if perfectly centered?*

Formula for Cp:

$$Cp = \frac{USL - LSL}{6\sigma}$$

USL: Upper Specification Limit

LSL: Lower Specification Limit

σ: Process standard deviation (a measure of variation)

Interpretation: Higher Cp values indicate a more capable process. A Cp value less than 1 means the process cannot fit within the specification limits, while a Cp value greater than 1 means the process variation is within the limits.

2. Cpk

Process Capability Index with Centering

Cpk takes the concept of Cp one step further by considering whether the process is centered between the specification limits. This is important because even if a process has a high Cp, if it's not centered, it might produce defects.

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Formula for Cpk:

$$Cpk = \min\left(\frac{USL - \mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}\right)$$

μ: Process mean (average)

Interpretation: Cpk values measure how close the process is to the mean and how consistent it is. A Cpk less than 1 indicates that part of the process output is likely to fall outside the specification limits. A Cpk greater than 1 means the process is producing mostly within the limits.

3. Pp

Preliminary Process Capability Index

Pp is similar to Cp but is used for short-term studies or preliminary assessments. It looks at the overall process variation over a short period.

Formula for Pp:

$$Pp = \frac{USL - LSL}{6\sigma_{overall}}$$

σ (overall): Standard deviation based on short-term data

Interpretation: A high Pp value means the process is capable in the short term. However, like Cp, it doesn't account for whether the process is centered.

4. Ppk

Preliminary Process Capability Index with Centering

Ppk is the long-term version of Cpk, using the overall standard deviation. It assesses both the process's centering and its variability.

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Formula for Ppk:

$$Ppk = \min\left(\frac{USL - \mu}{3\sigma_{overall}}, \frac{\mu - LSL}{3\sigma_{overall}}\right)$$

Interpretation: Like Cpk, Ppk measures how well the process meets specifications, but it focuses on long-term data. A Ppk less than 1 indicates the process has a high probability of producing defects.

5. Cpm

Taguchi Capability Index

Cpm is a more advanced index that incorporates the idea of a target. It penalizes deviations from a target value, even if they are within the specification limits.

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Formula for Cpm:

$$Cpm = \frac{USL - LSL}{6\sqrt{\sigma^2 + (\mu - T)^2}}$$

T: Target value for the process

Interpretation: Cpm is useful when hitting a target is important, even if the product is within the specification limits. A higher Cpm means the process is both consistent and close to the target value.

Differences Between the Indexes

- **Cp vs. Cpk**: Cp only looks at variation (the spread of the data) and assumes the process is perfectly centered. Cpk, on the other hand, also takes into account how far off-center the process is, giving a more realistic picture.
- **Pp vs. Ppk**: Pp and Ppk are used for preliminary studies, but Ppk adds the centering aspect just like Cpk. Pp focuses on short-term variation, while Ppk is for long-term analysis.
- **Cpm**: This is the only index that focuses on how well the process hits a specific target, making it more suitable for processes where being close to a target is crucial.

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Acceptable Index Measures

Table summarizing acceptable values for the capability indexes:

Index: Cp, Cpk, Pp, Ppk	Process Capability	Interpretation
< 1.0	Poor	The process is not capable of meeting specification limits.
= 1.0	Marginal	The process just meets specification limits but allows little room for error.
≥ 1.33	Good	The process is consistently within specification limits.
≥ 1.67	Excellent	The process is highly capable and produces very few defects.
≥ 2.0	World-class	The process exceeds expectations and produces virtually no defects.

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Process Capability: A Field Goal Kicker Analogy

An easy way to understand process capability is by comparing it to a field goal kicker in football. The goal posts"Process".

Imagine a Kicker is soo consistent that their kicks rarely deviate from center. Vs. a Kicker who's variation is so erratic that only occasional balls get through the uprights.

If those two Kicker's attempt 100 field goals each, their results would form two different distributions. The first kickers distribution will fit between the specification limits or goal posts, but the second kicker's distribution would have such wide variation that only some fraction of kicks are between the uprights.

- **Cp (Potential Capability)** This represents the kicker's overall ability to kick the ball between the uprights consistently. A high Cp would mean the kicks are consistently between the goal posts**.**
- **Cpk (Actual Capability)** This is a more realistic measure of the kicker's ability because it also considers whether the kicks are on target. A high Cpk means the kicker not only has consistency that keeps kicks between the uprights, but also kicks the ball down the middle most of the time.
- **Pp (Preliminary Capability)**: If the kicker is new and you're observing their kicks over a few practices, you would calculate Pp to see their general consistency in the short term.
- **Ppk (Long-term Capability)**: Over an entire season, you would assess the kicker's long-term ability to kick between the uprights, accounting for all the variables, like wind and pressure. Ppk would tell you how often the kicker was on target.
- **Cpm (Target Capability)**: If you care not just about getting the ball between the posts but hitting the exact middle, Cpm would measure how often the kicker hits the dead center.

Process Capability Quiz

What does Cp measure in process capability?

A. Process Centering
B. Potential Process Capability
C. Long-Term Variability
D. Target Deviation

Answer:

B. Potential process capability.

Cp measures how much of the specification range the process uses, assuming the process is centered.

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Which index measures both process centering and capability?

A. Cp
B. Pp
C. Cpk
D. Cpm

Answer:

C. Cpk.

Cpk accounts for both the process's capability and its centering between specification limits.

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What does a Cp value of less than 1 indicate?

A. The Process is World-Class
B. The process cannot fit within the specification limits.
C. The process is perfectly centered.
D. The process is stable.

Answer:
B. The process cannot fit within the specification limits..

A Cp value less than 1 means the process variation is too wide for the specification limits.

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Which index is used to determine performance relative to target?

A. Cp
B. Pp
C. Cpm
D. Cpk

Answer:

C. Cpm

Cpm accounts for how far the process is from the target, not just whether it is within specification limits.

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What does Ppk stand for?

A. Process performance index
B. Preliminary process capability index with centering
C. Process potential index
D. Process penalty index

Answer:

B. Preliminary process capability index with centering

Ppk is the preliminary index that also considers whether the process is centered.

If a kicker can consistently kick the ball between the goal posts but to the left or right of center, which index is most relevant?

A. Cp
B. Cpk
C. Pp
D. Cpm

Answer:

B. Cpk

Cpk considers how well the process (or kicker) is centered between limits (the goalposts).

What does a Cpk value of greater than 1.33 indicate?

A. The process needs improvement.
B. The process is not capable.
C. The process is capable of consistently meeting specifications.
D. The process is poorly centered.

Answer:

C. The process is capable of consistently meeting specifications.

A Cpk value greater than 1.33 means the process is performing well and consistently with specifications.

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In process capability, what does σ represent?

A. Mean
B. Standard deviation
C. Specification limit
D. Target

Answer:

B. Standard deviation

σ (sigma) represent standard deviation, a measure of process variation.

Which index is specifically concerned with a process meeting a target?

A. Cp
B. Cpk
C. Pp
D. Ppk
E. Cpm

Answer:

E. Cpm

Cpm accounts for how far the process is from the target, not just whether it is within specification limits.

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A process with a Ppk value of 0.75 is likely to produce:

A. Many defects
B. Few defects
C. Consisten results
D. World-class results

Answer:

A. Many Defects

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