Process Capability Indices

As you learned in the previous video, the most commonly used capability indices are C_p, C_{pl}, C_{pu}, and C_{pk}. Let's see how these indices are calculated.

The C_p index is the ratio of the width of the spec limits to the width of the distribution of the process characteristic.

If the process characteristic is normally distributed, approximately 99.73% of all observations fall within plus or minus 3 standard deviations of the mean. Because of this, the process spread is defined as 6 standard deviations.

Notice that this formula doesn't include information about process centering. In other words, C_p doesn't include information about the center of the process, estimated by X-bar, relative to the spec limits.

Note that we use x-bar and s rather than mu and sigma in the formulas throughout this lesson. This is because mu and sigma are usually unknown and are estimated from the data. In an upcoming video, you see how to compute capability indices for short-term and long-term estimates of sigma.

Each of these processes has a C_p of 1.0, even though two of the processes are off-center.

This also means that a process could be centered outside of the spec limits but still have a reasonable value for C_p.

Both of these processes, which have means outside the spec limits, also have a C_p of 1.0. For these examples, it's clear that C_p is an inadequate measure of the capability of processes that are off target.

Because the C_p index assumes that the process is centered, this index is also called the potential process capability. It is a measure of what the capability could be, if the process were on target.

Let's look at the other capability indices that take into consideration the centering of the distribution.

C_{pl} is used to examine the ability of a process to meet the lower spec limit. This is used when only a lower spec limit exists.

Likewise, C_{pu} is used to examine the ability to meet the upper spec limit, or when only an upper spec limit exists.

C_{pk} is simply the minimum of C_{pl} and C_{pu}. You can examine your distribution and see which spec limit is closer to the mean.

If the lower spec limit is closer, C_{pk} will equal C_{pl}.

If the upper spec limit is closer to the mean, C_{pk} will equal C_{pu}.

In this example, the mean is closer to the upper spec, so C_{pk} will equal C_{pu}.

If the process is perfectly centered within the spec limits, C_p and the C_{pk} will be the same.

If the process is not centered, C_{pk} will be smaller than C_p.

And, if the center of the distribution is outside the spec limits, C_{pk} will be negative. In this example, C_p is 1.0 but C_{pk} is -0.77.

Let's take a look at how these indices are calculated using a simple example. For this process, the lower specification limit is 27, the target is 30, and the upper specification limit is 33.

The process mean is 31, and the standard deviation is 1.0. We can see that the distribution is not centered on the target.

Here are the four indices. C_p is 1.0. The spread of the process is the same as the width of the specification limits.

The process is shifted toward the upper specification limit, so C_{pl} is 1.33 and C_{pu} is 0.66. So C_{pk} is the same as C_{pu}. C_{pk} is 0.66.

What do we consider good values for C_p and C_{pk}?

If the distribution is perfectly centered and the process spread equals the width of the spec limits, both C_p and C_{pk} will be 1.0. But, as you will see, this will result in some out of spec, or nonconforming, product.

This process is also perfectly centered, but the specification limits are 6 standard deviations from the mean. The nonconformance rate for this process will be very low. Here, both C_p and C_{pk} are 2.0.

There are many guidelines for acceptable values depending on the industry, the specific company, the specific division of the company, or specific quality standards. A barely capable process is considered to have a C_{pk} of 1.0. Some guidelines require a minimum C_{pk} value of 1.33.

Some companies require a C_p of at least 2.0 and C_{pk} of at least 1.5.

In this video, you learned how to compute C_p, C_{pl}, C_{pu}, and C_{pk}. In future videos, we focus on C_p and C_{pk}.

In the next video, you learn how to estimate the standard deviation used to calculate these capability indices.

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