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Estimating Process Capability: An Example

In this video, you learn how to conduct a capability study.

First, you need to evaluate some assumptions. Two important assumptions for a capability analysis are stability and normality.

In previous videos, you learned that in order to estimate process capability the process must be stable.

The standard capability indices also assume that the process characteristic is normally distributed.

However, a capability analysis can also be conducted for characteristics that are not normally distributed. We discuss capability studies for nonnormal distributions in a future video.

Let's consider an example introduced in the previous lesson, Metal Parts. Recall that you are on a team charged with improving the dimensional conformance of a small metal part. The critical measurement is part thickness. Your goals are to bring the thickness to target and to reduce variability. The target is 40 plus or minus 5 hundredths of an inch (which is about 1 centimeter). These data were collected using rational subgroups over a 25-hour period, but ignore the subgrouping for now.

You have plotted the data using an I and MR chart and have verified that the process is stable. The estimated average is 41.328, which is well above the target.

The lower control limit is 36.388, and the upper control limit is 46.268.

Because these limits give you a range in which you can expect future thickness values to fall, you can expect some parts to fall beyond the upper spec limit.

You have also verified that the distribution of thickness measurements is approximately normal.

The process spread is about the same as the width of the spec limits, so you'd expect C_p to be around 1.0.

The process mean is 41.33, and the target is 40. Because the process is off target, C_{pk} will be less than C_p. You can see that some measurements fall beyond the upper spec.

You conduct a capability analysis and learn that C_p is 0.963 and C_{pk} is 0.707. You also learn that 2.4% of the measurements fell above the upper spec limit. Unless the process mean is shifted to the target, an estimated 1.7% of future product will be out of spec.

Notice that the long-term estimate of the standard deviation was used to calculate the capability indices.

These data were collected using rational subgroups of five parts. We can conduct this same study using both the long-term estimate of the standard deviation and the short-term, within-subgroup estimate. Let's repeat this analysis, but this time using rational subgrouping.

You check stability using an X-bar and R or S chart. As expected, you see that the process is stable.

However, you must use caution when interpreting the control limits.

The control limits on an X-bar and R or S chart are for subgroup means rather than individual values.

So you can't directly compare the control limits to the spec limits, and you shouldn't plot spec limits on an X-bar chart.

We have already checked for the normality of the individual thickness measurements. We learned that the distribution of the raw thickness measurements is approximately normal.

Now we conduct the analysis using estimates of both the short-term and the long-term standard deviation.

The short-term and long-term estimates of sigma are very similar. So the estimates of the capability indices are also similar.

The long-term estimate of the standard deviation, sigma, is often larger than the short-term estimate. This is because the short-term estimate is based on rational subgroups that only include common cause variation.

If the long-term estimate is much larger, you have an indication that there might be undetected special causes of variation in the process.

In this video, you learned how to conduct a capability study to evaluate the ability to meet customer specifications. You also learned about short-term and long-term estimates of capability.

In the next videos, you learn how to calculate these capability indices in JMP. You also learn how to change the labeling of the indices in JMP to P_p and P_{pk} if needed.

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