Capability: sample sizes

Reminder
Process capability studies have become very fashionable in recent times, due to the simplicity of both the concept and the metric; 1.6 = good, 1.3 = acceptable, 1.0 = go back and improve. However I always try and persuade quality professionals to speak in terms of numbers of defects per million rather than Pp and Ppk, as defective ppm is the true measure of quality. We must also remember that unless the process is in statistical control and normally distributed, point estimates for Pp and Ppk are worthless; seek help.

Point estimates

We calculate a statistic from a sample size, in order to predict the unknown parameter of the whole population. For example: we calculate an average for a control chart, hoping it is close to the true process average, so we can decide if any action is required. A statistic like xbar is known as a *point estimate,* and most of us have been guilty of placing too much reliance on such numbers. If we have an insufficient sample size the *point estimate* may be very different from the true process parameter. We must learn to make decisions, not based on *point estimates*, but on the *confidence intervals* around that estimate.

n = ƒ{s, αβ, c}

The fundamental relationship between a statistic and its sample size is:

Sample size =
ƒ { variability of the process, confidence we want in the statistic, change we are trying to detect}

Methods of deciding on a sample size for capability studies
Here are three approaches to estimating a sample size

1. Pre-defined:
   In the 1980s, the sample size for a capability study was defined by each company based on their experience. Some companies were happy with 30 samples. Other companies required 120 samples.

2. Looking at the resulting confidence intervals and adjusting the sample size to suit:
   More recently, with Minitab release 16 providing confidence intervals around a capability index, process engineers would measure (say 50) samples, calculate the index and decide if the interval was sufficiently narrow for them to make a good decision.

For example: If a critical customer parameter had been specified at a Pp of 1.3 and the point estimate using 30 samples for the Pp = 1.40 with a confidence interval of [1.25 - 1.52], the engineer would hope the process meets the requirement, but would measure extra samples to get that proof. Perhaps by taking another 25 samples the new estimate becomes Pp = 1.38 with a CI of [1.31 to 1.44], so providing evidence that the process meets the required specification.

3. Deciding on the width of confidence intervals required prior to the study:
Pp: … to estimate a sample size, with 90% confidence, to limit the confidence intervals around the point estimate of Pp to within 10%, we can use the following equation:

$$n = \frac{1}{2}\left(\frac{z_{\alpha/2}}{\delta}\right)^2$$ where

$z_{\alpha/2}$ comes from z tables (90% conf) and will be 1.645 (if α = 0.9, $\alpha/2$ = 0.45, therefore z = 1.645)
δ is the confidence interval % 0.10

$$n = \frac{1}{2}\left(\frac{1.645}{0.10}\right)^2 = 135$$

Ppk: … to estimate a sample size, with 80% confidence, to limit the confidence intervals to within 10% of its value, and we expect the Ppk $\approx$ 1.6

$$n \approx \frac{1}{2}\left(\frac{z_{\alpha/2}}{\delta}\right)^2\left(\frac{1}{9Ppk^2} + \frac{1}{2}\right) = \frac{1}{2}\left(\frac{1.285}{.1}\right)^2\left(\frac{1}{9\times 1.6^2} + \frac{1}{2}\right) = 45$$

Formulae used in 3. are taken from:
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