8.6 Process planning and quality

Name: _____ Class: _____ Date: _____ **Total: 16 marks**

KEY WORDS process capability • statistical process control

Objective

Judge a process against its specification with C_p and C_{pk}, estimate the scrap rate, and set the limits of an $\bar{x}$ control chart.

1 Key knowledge and worked examples

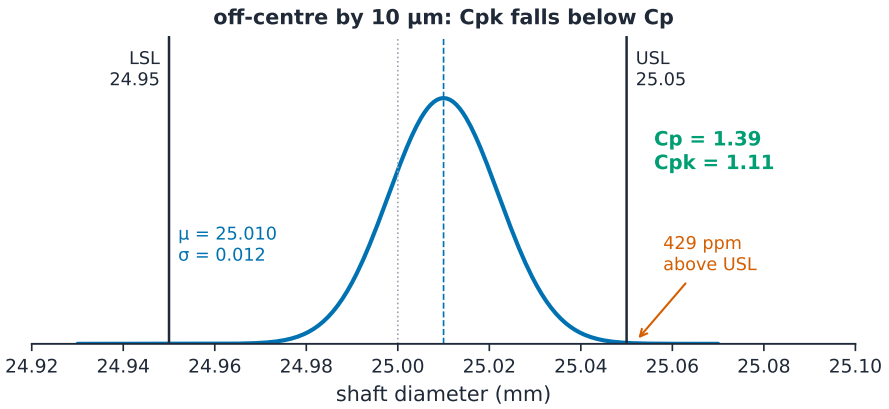
■ Capability and control

- **Process capability** : $C_p = (USL - LSL)/6\sigma$ (does the spread fit?) and $C_{pk} = \min(USL - \mu,\ \mu - LSL)/3\sigma$ (is it centred?).
- Out-of-spec fraction from $z = (\text{limit} - \mu)/\sigma$ and the normal table.
- **Statistical process control** : an $\bar{x}$ chart with limits $\mu \pm 3\sigma/\sqrt{n}$ shows when the process has changed.

■ Worked example. The bearing seat

Specification 25.00 ± 0.05 mm; grinder at $\mu = 25.010$, $\sigma = 0.012$ mm.

- $C_p = (USL - LSL)/6\sigma = 0.10/0.072 = \mathbf{1.39}$.
- $C_{pk} = (USL - \mu)/3\sigma = 0.040/0.036 = \mathbf{1.11}$.
- Above the USL $z = 3.33$: about 429 ppm. Re-centred, $C_{pk} = 1.39$ and only 31 ppm in total.



2 Practice

A pin is specified 12.00 ± 0.03 mm; the lathe runs at $\mu = 12.006$ mm, $\sigma = 0.008$ mm. Normal tail areas: $z = 3.0$: 0.00135; $z = 3.75$: 0.0000884; $z = 4.5$: 0.0000034.

2.1 Find C_p and C_{pk} (two decimals). [4]

2.2 Find the parts per million above the USL and below the LSL. [3]

2.3 Set the $\bar{x}$ chart limits for samples of $n = 4$ (three decimals, mm). [3]

3 Exam-style questions

3.1 The lathe is re-centred to 12.000 mm. Find the new C_{pk} and the total ppm out of specification. The customer demands $C_{pk} \geq 1.33$: what σ is needed, and what would you change to get it? [6]

Solutions

2.1

- $C_p = (USL - LSL)/6\sigma = 0.06/0.048 = \mathbf{1.25}$.
- $C_{pk} = (USL - \mu)/3\sigma = (12.030 - 12.006)/0.024 = \mathbf{1.00}$.

2.2

- Above: $z = (USL - \mu)/\sigma = (12.030 - 12.006)/0.008 = 3.0$, tail 0.00135: **1350** ppm.
- Below: $z = (\mu - LSL)/\sigma = (12.006 - 11.970)/0.008 = 4.5$: **3.4** ppm.

2.3

- $\mu \pm 3\sigma/\sqrt{n} = 12.006 \pm 3 \times 0.008/2 = 12.006 \pm 0.012$: **11.994** to **12.018** mm.

3.1

- Centred: $C_{pk} = C_p = \mathbf{1.25}$.
- Each side $z = 0.03/0.008 = 3.75$: total $2 \times 88.4 = \mathbf{177}$ ppm.
- $C_{pk} = 0.03/3\sigma \geq 1.33$ gives $\sigma \leq 0.03/4 = \mathbf{0.0075}$ mm.
- Reduce the spread: a stiffer set-up, a sharper or more stable tool, temperature control, or a finishing pass.