DEPARTMENT OF AEROSPACE ENGINEERING
19MEE304 Total Quality Management

Topic: Process Capability

1. Introduction to Process Capability

- **Definition:** Process capability measures how well a process can produce products within specified limits.
- **Purpose:** Determines whether a process is capable of consistently meeting customer requirements.
- **Key Idea:** A capable process produces **minimal defects** and operates within control limits.

2. Key Process Capability Metrics

a. Process Capability Index (Cp)

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

- **Formula:**
- **Interpretation:**
  - **Cp > 1:** Process is capable.
  - **Cp < 1:** Process is not capable (needs improvement).
  - **Cp = 1:** Process just meets specifications.
- **Limitation:** Does not consider process centering.

b. Process Performance Index (Cpk)

- **Formula:**

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

- **Key Difference from Cp:** Cpk considers whether the process is centered within limits.
- **Interpretation:**
  - **Cpk > 1.33:** Highly capable process.
  - **Cpk between 1 and 1.33:** Acceptable process.
  - **Cpk < 1:** Poor process performance.

c. Pp and Ppk (Process Performance Indices)

- **Used for short-term analysis** when the process is **not yet stable**.
- Similar to Cp and Cpk but accounts for **overall variation**, not just short-term variation.

3. Steps to Determine Process Capability

1. **Collect data** from the process (measurements of product dimensions, weight, etc.).
2. **Calculate the process mean (μ) and standard deviation (σ).**
3. **Identify specification limits (USL & LSL) from customer requirements.**
4. **Compute Cp and Cpk to analyze capability.**
5. **Interpret results and take corrective action if needed.**

4. Industry Applications of Process Capability

1. Automotive Industry (Toyota, Ford, Tesla)

- **Application:** Ensuring **engine cylinder diameter is within tolerance**.
- **Metric Used:** Cpk > 1.33 to meet precision requirements.
- **Impact:** Reduces rework, ensures smooth engine performance.

2. Semiconductor Industry (Intel, TSMC, AMD)

- **Application:** Controlling **wafer thickness uniformity**.
- **Metric Used:** Cp > 2.0 for high precision.
- **Impact:** Improves yield in chip manufacturing.

3. Pharmaceutical Industry (Pfizer, Johnson & Johnson)

- **Application:** Maintaining **tablet weight and composition accuracy**.
- **Metric Used:** Cpk > 1.5 for regulatory compliance.
- **Impact:** Ensures drug efficacy and patient safety.

4. Aerospace Industry (Boeing, Airbus, SpaceX)

- **Application:** Checking **tolerances in aircraft fuselage assembly**.
- **Metric Used:** Cp > 1.67 for safety-critical components.
- **Impact:** Reduces failure risk in flight operations.

5. Food Industry (Coca-Cola, Nestlé, PepsiCo)

- **Application:** Ensuring **uniform fill levels in beverage bottles**.
- **Metric Used:** Cpk > 1.33 to prevent underfilling.
- **Impact:** Maintains product consistency and reduces waste.

5. Improving Process Capability

- **Reduce variation** using Six Sigma methods.
- **Use Statistical Process Control (SPC)** for real-time monitoring.
- **Improve machine precision** through maintenance and calibration.
- **Optimize production parameters** using Design of Experiments (DOE).

6. Conclusion

- **Cp and Cpk** are key metrics for assessing manufacturing quality.
- Higher values indicate **better process stability and consistency**.
- Process capability analysis helps industries **reduce defects, improve efficiency, and meet customer expectations**.