DEPARTMENT OF AEROSPACE ENGINEERING
19MEE304 Total Quality Management

Topic: Measures of Central Tendency and Dispersion in Quality Management

1. Introduction to Central Tendency and Dispersion

- **Central Tendency:** Describes the center or average of a dataset.
- **Dispersion:** Measures how data points spread around the central value.
- **Importance in Quality Management:**
  - ✅ Helps monitor process stability.
  - ✅ Identifies variations in production.
  - ✅ Supports Six Sigma and Statistical Process Control (SPC).

2. Measures of Central Tendency

A. Mean (Arithmetic Average)

- Formula:

$$\bar{X} = \frac{\sum X_i}{N}$$

Where:

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- $\bar{X}$ = Mean
- X_i = Each value in dataset
- N = Total number of values

- **Example in Quality Control:**
  - Measuring the **average weight** of packaged products in a factory.
  - **Issue:** Affected by extreme values (outliers).

B. Median (Middle Value)

- Definition: The central value when data is arranged in ascending order.
- **Formula:**
  - **If N is odd:** Median = Middle value.
  - **If N is even:** Median = Average of two middle values.
- **Example in Quality Control:**
  - Median time taken to **resolve customer complaints** in a service industry.
  - **Advantage:** Not affected by extreme values.

C. Mode (Most Frequent Value)

- Definition: The value that appears most frequently in a dataset.
- **Example in Quality Control:**
  - Most common **defect type** in a manufacturing unit.
  - Used in Pareto Analysis (80/20 Rule).

3. Measures of Dispersion (Variability in Data)

A. Range (Simplest Measure of Dispersion)

- Formula:

$$\text{Range} = \text{Maximum Value} - \text{Minimum Value}$$

- **Example:**
  - Measuring the **variation in diameter** of machine-produced bolts.
  - **Limitation:** Does not show distribution of values.

B. Variance (σ2\sigma^2σ2)

- Definition: Measures how data deviates from the mean.
- **Formula:**

$$\sigma^2 = \frac{\sum (X_i - \bar{X})^2}{N}$$

Where:

- X_i = Each value
- $\bar{X}$ = Mean
- N = Total values

Example in Quality Control:

- **Variance in the thickness of aircraft components** ensures consistency.

C. Standard Deviation (σ\sigmaσ)

- Definition: Square root of variance; measures spread of data.
- **Formula:**

$$\sigma = \sqrt{\sigma^2}$$

- **Importance in Quality Management:**
  - ✅ Helps in setting **control limits** in SPC.
  - ✅ Determines **process capability** in Six Sigma.
  - ✅ **Smaller standard deviation** = Better quality consistency.
- **Example:**
  - Monitoring the **standard deviation of assembly line errors** in an automobile plant.

D. Coefficient of Variation (CV)

- Definition: Standard deviation relative to the mean.
- **Formula:**

$$CV = \frac{\sigma}{\bar{X}} \times 100$$

- **Example:**
  - Comparing **product weight variation** across different factories.

4. Statistical Tools Using Central Tendency & Dispersion

Tool	Purpose	Example
Control Charts ($\bar{X}$ & R Charts)	Monitor process stability	Track weight of pharmaceutical tablets
Process Capability Index (Cpk)	Measure process performance	Determine machine accuracy in aerospace manufacturing
Histogram	Visualize data distribution	Analyze customer satisfaction survey scores

5. Industry Applications

📌 Case Study 1: Quality Control in Semiconductor Manufacturing

- **Issue:** Variations in **silicon wafer thickness** affected chip performance.
- **Solution:** Used **Mean & Standard Deviation** to set control limits.
- **Outcome:** Reduced defects by **30%**, improving yield.

📌 Case Study 2: Automotive Industry (Toyota)

- Used **Six Sigma principles** to analyze variation in **engine part sizes**.
- Applied **Standard Deviation & Process Capability Analysis**.
- **Result:** 99.9997% defect-free production achieved.

6. Challenges in Using Central Tendency & Dispersion

🚧 **Outliers Impacting the Mean** → Use Median for accuracy.
🚧 **Skewed Data Distribution** → Use Mode for better insights.
🚧 **Misinterpretation of Variability** → Always combine Range, Variance & Standard Deviation.

🔷 **Solution:**
✔ Use **Control Charts & SPC methods** to monitor variations.
✔ Implement **AI-driven real-time monitoring** in manufacturing.

7. Conclusion

- **Central tendency & dispersion are crucial in quality management.**
- **Understanding data spread ensures process control & consistency.**
- **Industry leaders use these measures in SPC, Six Sigma, and defect prevention.**
- **Adopting AI & automation enhances statistical analysis for quality improvement.**