DEPARTMENT OF AEROSPACE ENGINEERING
19MEE304 Total Quality Management

Topic: Population and Sample in Quality Management

1. Introduction

- **Population:** The entire set of items, individuals, or data points relevant to a study.
- **Sample:** A subset of the population selected for analysis.
- **Importance in Quality Management:**
  - ✅ Sampling allows for quality assessment without testing every unit.
  - ✅ Helps in statistical process control (SPC) and Six Sigma.
  - ✅ Reduces costs and time in large-scale quality inspections.

2. Definition and Key Differences

Aspect	Population	Sample
Definition	Entire set of data or items	A subset of the population
Size	Large (can be infinite)	Small (manageable size)
Cost & Time	Expensive & time-consuming	Cost-effective & quick
Accuracy	Highly accurate	May contain sampling errors
Example	All manufactured bolts in a factory	100 randomly selected bolts for inspection

3. Types of Population in Quality Control

A. Finite Population

- A limited number of elements.
- **Example:** Total **number of cars produced** in a factory in one month.

B. Infinite Population

- A continuously growing or uncountable set.
- **Example: Real-time sensor data** collected in an industrial IoT system.

C. Target Population vs. Accessible Population

- **Target Population:** The ideal set for study (e.g., all smartphones produced globally).
- **Accessible Population:** The practical set available for sampling (e.g., phones from a specific factory).

4. Types of Sampling Methods

A. Probability Sampling (Random Selection)

- Each unit has an equal chance of selection.
- **Used in Six Sigma & SPC.**

1. Simple Random Sampling (SRS)

- Every item is chosen randomly.
- **Example:** Selecting **50 bolts randomly** from a batch of 1000 for inspection.

2. Stratified Sampling

- Divides population into **homogeneous groups** and selects samples from each.
- **Example:** Sampling **defective and non-defective items** separately in a factory.

3. Systematic Sampling

- Every kthk^{th}kth item is selected.
- **Example:** Inspecting **every 10th product** in an assembly line.

4. Cluster Sampling

- Divides population into clusters and selects random clusters for analysis.
- **Example:** Choosing **5 warehouses** randomly to inspect inventory accuracy.

B. Non-Probability Sampling (Non-Random Selection)

- Used when random selection isn’t possible.

1. Convenience Sampling

- Selecting items based on accessibility.
- **Example:** Testing the **first 100 products** off the production line.

2. Judgmental Sampling

- Selecting items based on expert judgment.
- **Example:** A quality engineer selecting **high-risk components** for detailed analysis.

3. Quota Sampling

- Sampling based on pre-defined criteria.
- **Example:** Ensuring **equal sampling** from different machine operators.

4. Snowball Sampling

- Used when population is hard to reach.
- **Example:** Identifying **rare defects** in high-end aerospace manufacturing.

5. Population and Sample in Statistical Process Control (SPC)

SPC Tool	Application in Population & Sampling
Control Charts	Uses sample data to monitor production processes
Process Capability (Cp, Cpk)	Determines if a process meets specifications
Acceptance Sampling	Inspects a batch based on sampled items
Hypothesis Testing	Draws conclusions about population quality based on a sample

6. Case Studies and Industrial Examples

📌 Case Study 1: Sampling in Pharmaceutical Industry

- **Problem:** Testing every tablet for potency is impractical.
- **Solution:** Used **stratified random sampling** to test samples from each batch.
- **Result:** Ensured regulatory compliance without 100% testing.

📌 Case Study 2: Automotive Quality Control (Toyota)

- Toyota uses **systematic sampling** to check engine parts every 50 units.
- **Outcome:** Reduced defect rates by 40% through SPC sampling techniques.

7. Challenges in Sampling for Quality Management

🚧 **Sampling Bias** → Can lead to incorrect conclusions.
🚧 **Non-Representative Sample** → Affects reliability of SPC.
🚧 **High Variability** → Requires larger sample sizes for accuracy.

🔷 **Solution:**
✔ Use **appropriate sampling techniques** based on process needs.
✔ Apply **AI-based real-time quality inspection** to reduce bias.

8. Conclusion

- **Sampling is a crucial tool** in quality management.
- **Proper sampling techniques ensure accuracy and efficiency.**
- **Industries use statistical methods** like SPC and Six Sigma for quality improvement.
- **Future trends** involve AI-based **predictive sampling** for real-time quality monitoring.