Inspection and Quality Control

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Outline

• Need for Inspection and Quality Control
• Modes of Inspection
  • Accuracy Testing of Machine Tools
  • Part / Product inspection
  • Process Quality Control
• Basics of Metrology
  • Definitions
  • Metrology Instruments.
Inspection

Watchdog of a Manufacturing Process

Product cost = Material + Production + Inspection

Cost of inspection is Significantly High.
Inspection Process is mostly manual.
Inspection Process

Objective

• Assess Conformity with Design Specifications
• Improve Product Quality and Reliability

Constraints on Inspection

• Product Volume
• Product Cost
• Product Functional Performance
Global Manufacturing Scenario

Challenges

• Miniaturization
• High Precision and Accuracy
• High Productivity and Reliability
• Shortest Time to market
• Quick Turn-around
Machining Accuracy

Machining accuracy capability (µm)

- 0.1 mm
- 1 µm
- 1 nm
- 1 Å

Graph showing the evolution of machining accuracy from 1940 to 2000:

- Normal machining (1940-1980)
- Precision machining (1960-2000)

Applications:
- Turning and milling machines
- Grinding machines
- CNC machines
- Lapping and honing machines
- Jig boring and grinding machines
- Step and repeat cameras
- Optical lens grinding machines
- Precision grinding machines
- Super-finishing machines
- Diamond grinding machines
- High-precision mask aligners
- Ultra-precision diamond turning machines
- Diffraction grating ruling engines
- Free abrasive machining
- Electron beam lithography
- Soft X-ray lithography
- Ion beam machining
- STM/AFM molecular manipulation

Ref: Taniguchi
Cost – Tolerance relation

![Graph showing the relationship between relative cost and tolerance for different operations like Grinding, Reaming, and Turning. The graph plots relative cost against tolerance (in.).]
Production Time - Surface Finish
Stages in Product - Process Inspection

Product Development

- Part Production and Inspection
- Assembly Testing
- Prototype Testing
  - Kinematic (No load) Testing
  - Performance Testing
- Roll Out

Process Monitoring

- Process inspection and control
Modes of Inspection

• Accuracy Testing of Machine Tools
• Part / Product inspection
• Process Quality Control
Accuracy Testing of Machine Tools

Objective

• To Test kinematic and Geometric accuracy of Machine Tool
  • Alignment, Location, Orientation errors between Spindle, Slides, Tool/ work Holders
• Certification, Maintenance tasks, History
Configuration of CNC Machine

Gantry type
3- Axis CNC Milling Machine

X - Y - Z
5 – Axis CNC Milling Machine

X - Y - Z - B - C
Precision Machine Tools

Desirable Characteristics

- Accurate running Spindle
- Perpendicularity of Spindle with Table
- Straightness of slides (axes)
- Parallelism between axes
- Location accuracy of axes
- Angularity errors between Axes
3 Axis CNC Machine Tool

Axes : X, Y, Z

Geometric errors per axis

Location error : 1
Straightness errors : 2
Angular errors : 3

Total no of errors for machine : 18
Geometric Errors for Y axis
Geometric Errors for 3 axis CNC
Straightness Error of Z axis - EXZ
Testing Straightness - Linear axis
Location Errors – Y axis
Straightness Errors – Y axis
Tool Path with Geometric Errors
Part Inspection

• Dimensional Tolerance

• Geometric Tolerance
  • Form
  • Orientation
  • Location
  • Position

• Surface Finish
  • Topography
Part with Dimensional Tolerances

[Diagram of a part with dimensional tolerances.
Dimensions: 80 +0.1, 39.8 - 0.007, 20 g6 - 0.020]
Part with Geometric Tolerances

A

80.25

B

C

A - B

// 0.02 C

- 0.007

0.070

2.020

⊥ 0.1 A

C

© 0.002 A - B
Basics of Metrology
Precision and Accuracy

Both accurate and precise

Precise, but not accurate

Accurate, but not precise

Neither accurate nor precise