Examples of Precision Machine Design

ME EN 7960 – Precision Machine Design
Topic 1

Definition

- A precision machine device is defined as a piece of equipment with one or more moving parts whose accuracy determines the quality of the device
- Examples of precision machine devices include:
  - Machine Tools
    - Milling Machines
    - Lathes
    - Grinders
    - Laser Cutter
    - WaterJets
    - Non-traditional machines (EDM, ECM, …)
  - Coordinate Measuring Machines
  - Production Equipment
    - Presses
  - Mechanical watches
  - Etc…

Traditional Machine Tools – Vertical Machining Center

Source: Mazak

Source: Precision Design Lab

- 3 linear axes (typical)
- 1-5 rotary axes (optional)
- 1-30 kW spindle power (typical)
- 0-10,000 rpm spindle speed (typical)
- > $50,000

3D parts (non-symmetrical)

Traditional Machine Tools - Lathe

Source: Hardinge

- 2 linear axes + 1 rotary axis (typical)
- 1-2 rotary axes (optional)
- 1-15 kW spindle power (typical)
- 0-6,000 rpm spindle speed (typical)
- > $25,000

3D parts (rotationally symmetric)

3D parts (rotationally symmetric) with off-axis features (requires 2nd spindle)

Traditional Machine Tools – Surface Grinder

Source: Jung GmbH


Source: THK

2D parts (flat or profiled)

- 3 linear axes + 1 rotary axis (typical)
- 1- 2 rotary axes (optional)
- 5-15 kW spindle power (typical)
- 800-4,000 rpm spindle speed (typical)
- > $20,000

Traditional Machine Tools – Circular Grinder

Source: Studer GmbH


Source: Crowder Supply

3D parts (rotationally symmetric)

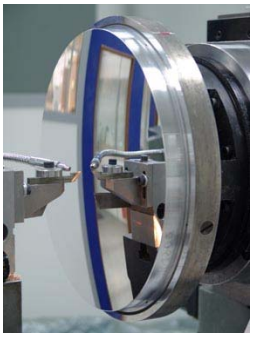
- 2 linear axes + 2 rotary axes (typical)
- 5-10 kW spindle power (typical)
- 800-4,000 rpm spindle speed (typical)
- > $25,000

New Machine Tools – Diamond Turning

Source: Precitech

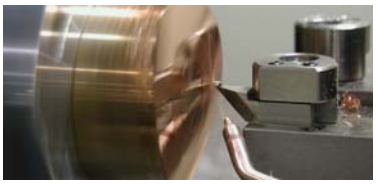
- 2 linear axes (typical)
- 1-15 kW spindle power (typical)
- 0-7,500 rpm spindle speed (typical)
- > $150,000

3D parts (rotationally symmetric)



Source: Savimex

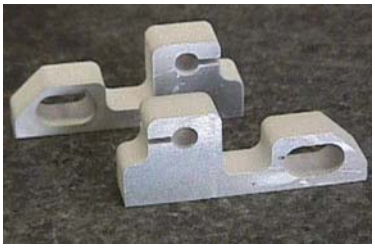
3D parts (asymmetric) with fast tool servo (optional)

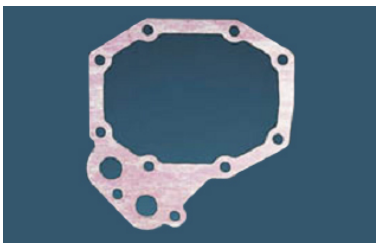


Source: Precitech

New Machine Tools - WaterJet

Source: OMAX

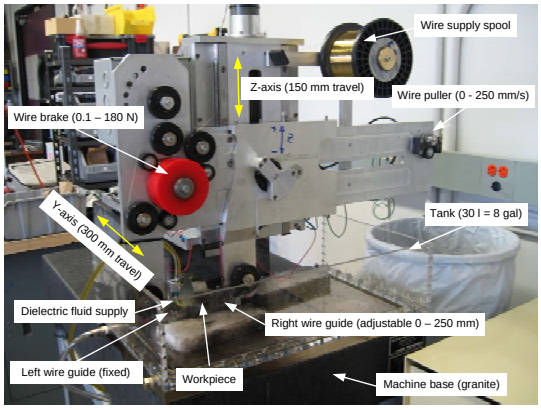




- 2 linear axes (typical)
- Pump power (15-40 kW)
- > $20,000

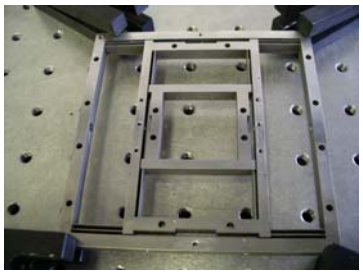
2D parts (from flat stock material)

New Machine Tools – Wire –Electro Discharge Machine



Source: Precision Design Lab

2D parts from flat stock

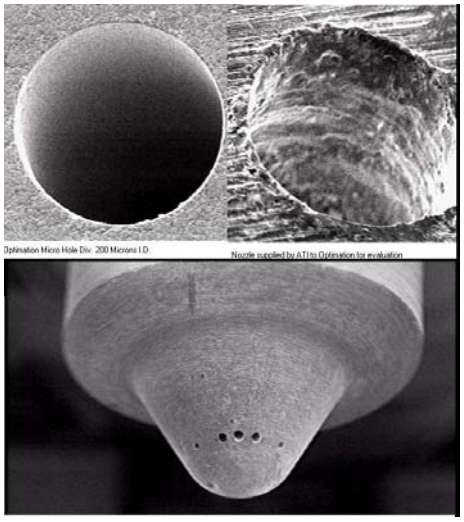


Source: Precision Design Lab

- 2 linear axes (typical)
- 4 linear + rotary axes (optional)
- 1-10 kW power supply (typical)
- > $100,000

New Machine Tools – Sinker Electro-Discharge Machine

Source: Charmilles



Source: Optimation

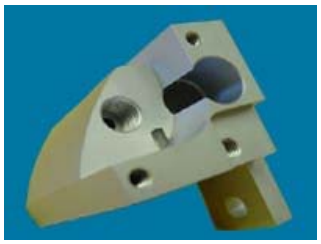
- 2D or 3D parts (from flat stock material)
- 3 linear axes (typical)
- 0-5 kW power supply
- > $80,000

New Machine Tools – Electro Chemical Machining

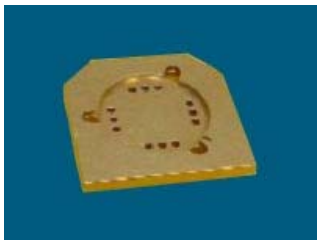
Source: Ultra Systems Ltd.

- 1 linear axes (typical)
- 3 linear + rotary axes (optional)
- 1-10 kW power supply (typical)
- > $100,000

3D parts



2D parts



Coordinate Measuring Systems

Specifications

Model No.		QM-Measure 333	QM-Measure 353
Measuring range	X-axis	12" (300mm)	12" (300mm)
	Y-axis	12" (300mm)	20" (500mm)
	Z-axis	12" (300mm)	12" (300mm)
Length standard		Precision linear encoder	
Resolution		.00002" (0.0005mm)	
Accuracy (20°C ± 1°C)*		E = (3.0 + 4L/1000)µm R = 4.0µm (.00016")	
Guide method		Air bearing for each axis	
Clamping method		Clamping screw	
Fine feeding device		Optional (.4" / 10mm stroke)	
Z-axis balance		Counterweight	
Measuring table		Granite sub-plate	
Machine stand		Optional	
Workpiece loading		Maximum height: 16.14" (410mm) Maximum mass: 66 lbs. (30kg)	
Air Pressure		51PSI or 0.35MPa	
Air consumption		50L/min. (in normal state) or 1.8CFM	
Dimensions (QM-Measure)	Width	32.48" (825mm)	32.48" (825mm)
	Depth	27.17" (690mm)	35.04" (890mm)
	Height	52.95" (1345mm)	53.54" (1360mm)
Mass**	QM-Measure	286 lbs. (130 kg)	374 lbs. (170 kg)
	QM-Data 300	2.6 lbs. (1.2 kg)	2.6 lbs. (1.2 kg)

Source: Mitutoyo

Performance Criteria

Precision Devices are rated according to:

- Manufacturing Capability
  - Accuracy
  - Resolution
  - Repeatability
- Ability to provide motion
  - Number of axes (complexity of machined geometry)
  - Speed (determines the manufacturing time)
  - Travel (determines the part size)
- Ability to provide energy required for manufacturing processes
  - Spindle power (machining centers, lathe, grinder, etc.)
  - Laser power (laser cutters)
  - Pump pressure (WaterJet)
  - Voltage, Current, Frequency (EDM, ECM)

Performance Limiting Criteria

- Most machines create geometry by selectively removing material.
- The amount and location of the material removed is a function of the amount and location of the energy transmitted from the tool (machine) to the work piece.
- The location of the energy transmission is rarely controlled directly but indirectly at remote measurement points.
- As a result, the created geometry will always deviate from the perfect shape.
- The amount of this deviation can be defined as the achievable precision of both the machine and the process.