

Collaborative Engineering

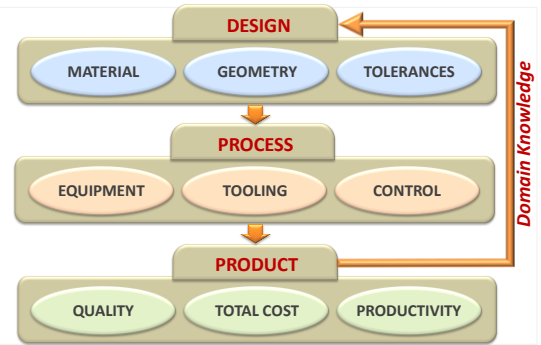
Manufacturing Process Selection



- ◆ Machining and CNC
- ◆ Casting and Foundry
- ◆ Metal Working
- ◆ Rapid Manufacturing
- ◆ Surface Finishing

OrthoCAD Lab, I.I.T. Bombay

Product - Process Relationship



Process Selection for a Given Product Design

Conformance to specified requirements
(manufactured product is the same as the desired part)



Compatibility between part design and process
(low cost of obtaining the desired quality and productivity)

Factors in Process Selection

- Material-process suitability
- Part shape complexity: external and internal
- Part size: overall length
- Wall thickness and uniformity
- Dimensional tolerances
- Surface finish / roughness
- Order quantity and batch size
- Tooling and manufacturing lead time



Selected Manufacturing Processes

- **Material Removal:** Machining to create a specific shape
 - Turning, Milling, 5-axis CNC Machining
- **Liquid Shaping:** Molten metal poured into shaped mold cavity
 - Investment casting, Injection molding
- **Metal Working:** Plastic deformation of a material into desired shape
 - Forging, Extrusion, Deep drawing
- **Layered Manufacturing:** Addition of material into free form shape
 - Selective Laser Sintering
- **Surface Engineering**
 - Grinding and Plasma spraying

Machining: Turning

Equipment



Applications



Process Capabilities

Materials	SS, Ti, Cu
Part shape	Cylindrical
Part size	10-1000 mm
Thickness	0.5 - 50 mm
Tolerance	± 0.025 mm
Surface finish	0.5 - 3 mm
Quantity	1-1000
Lead time	Days

Process Parameters

Spindle speed	
Feed Rate:	Roughness
Depth of cut:	Vibration
Tool:	HSS, Carbide, CHSS

Machining: Milling

Equipment



Applications



Process Capabilities

Materials SS, Ti, Cu
 Part shape Limited complex
 Part size 1 - 3000 mm
 Thickness 1 - 1000 mm
 Tolerance ± 0.025 mm
 Surface finish 0.8 - 3 mm
 Quantity 1-1000
 Lead time Days

Process Parameters

Cutting feed (Cf)
 Cutting speed & Spindle speed (Ss)
 Feed rate = Cf x Ss
 Axial depth of cut

Machining: 5-axis CNC Machining Center

Equipment



Applications



Process Capabilities

Materials SS, Ti, Cu
 Part shape Complex 3D
 Part size 0.5 - 10000 mm
 Thickness 0.5 - 1000 mm
 Tolerance 1 - 100 micron
 Surface finish 0.4 - 3 mm
 Quantity 1-1000
 Lead time Weeks

Process Parameters

Computer Code : NC, G
 Axes of machine
 Spindle speed
 Feed Rate: Roughness

Liquid Shaping: Injection Molding

Equipment



Applications



Process Capabilities

Materials Thermoplastics
 Part shape Complex 3D
 Part size $150 \text{ mm}^3 - 2.2 \text{ m}^3$
 Thickness 0.5 - 5 mm
 Tolerance ± 0.2 mm
 Surface finish 0.1 - 0.5 mm
 Quantity 10000-1000000
 Lead time Months

Process Parameters

Clamping force and stroke
 Shot Volume
 Injection pressure
 Platen size

Liquid Shaping: Investment Casting

Equipment



Applications



Process Capabilities

Materials Al, SS, Alloy steel
 Part shape Complex 3D
 Part size 0.5 g - 200 Kg
 Thickness 1.5 - 20 mm
 Tolerance ± 0.125 mm
 Surface finish 1 - 3 mm
 Quantity 10-1000
 Lead time Weeks

Process Parameters

Wax and wax die temp.
 Wax injection pressure
 Firing temperature
 Metal cooling rate

Metal Working: Die Forging

Equipment



Applications



Process Capabilities

Materials AL, Ti, Steel, Alloy
 Part shape Convex 3D
 Part size 25 g - 25 tons
 Thickness 10 - 250 mm
 Tolerance 0.1 - 2 mm
 Quantity 1-10 million
 Lead time Less than casting
 Strength Improved

Process Parameters

Temperature: 100 - 2300 degrees
 Pressure: upto 200 MPA
 Shape: Symmetric, non-symmetric

Metal Working: Extrusion

Equipment



Applications



Process Capabilities

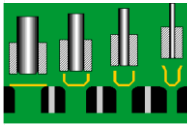
Materials Al, Alloy, Polymer
 Part shape 2.5 D
 Part size 10 - 600 mm (D)
 Thickness 25 - 250 mm
 Tolerance ± 0.2 mm of cross section
 Strength Improved due to strain hardening
 Lead time Less than casting

Process Parameters

Temperature: 350 - 4000 degrees
 Pressure: upto 1000 MPA
 Ram displacement
 Ram speed: 350 mm/s

Metal Working: Deep Drawing

Equipment



Process Capabilities

Materials	Al, Cu, mild steel
Part shape	Cylindrical/ Rect.
Part size	120 mm (D)
Thickness	0.1 to 1.5 mm
Tolerance	± 0.05
Quantity	25,000 to 10,000,000
Lead time	Low

Applications

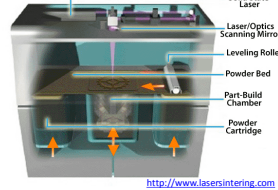


Process Parameters

Sheet thickness	
Drawing force: 250 kN	
Punch diameter	
Steps of drawing	

Layered Manufacturing: Selective Laser Sinter

Equipment



Applications



Process Capabilities

Materials	Powder metal/polymer
Part shape	Complex 3D
Part size	0.15 - 500 mm
Thickness	0.15 - 50 mm
Tolerance	± 0.25 mm
Surface finish	Average
Build Speed	Fast

Process Parameters

Part bed temperature	
Layer thickness	
Energy density	
Green Part strength: binder	

Surface Engineering: Grinding

Equipment



Grinding tool



Process Capabilities

Materials	Al, Brass, SS
Grind length	200 mm
Grind Dia.	230 - 3 mm
Tolerance	0.005 mm
Taper Grind	Upto 30 degrees
Surface finish	0.4 mm

Applications



Process Parameters

Depth of cut (inversely proportional to surface finish)	
Grinding wheel speed; diameter	
Cross feed speed	

Surface Engineering: Plasma Spraying

Equipment



Applications



Process Capabilities

Materials	Co, SS, Ni alloys, Al, Ti, HA coating
Part size (D)	80 - 2000 mm
Thickness	0.05 - 10 mm
Surface finish	0.5 mm
Coating	Uniform, dense
Fatigue life	Improved
Process time	Reduced

Process Parameters

Plasma gas composition	
Flow rate	
Energy input	
Torch Distance and cooling	

SUMMARY

- Process selection affects part quality and cost
- Process selection depends on part design
- Selection parameters