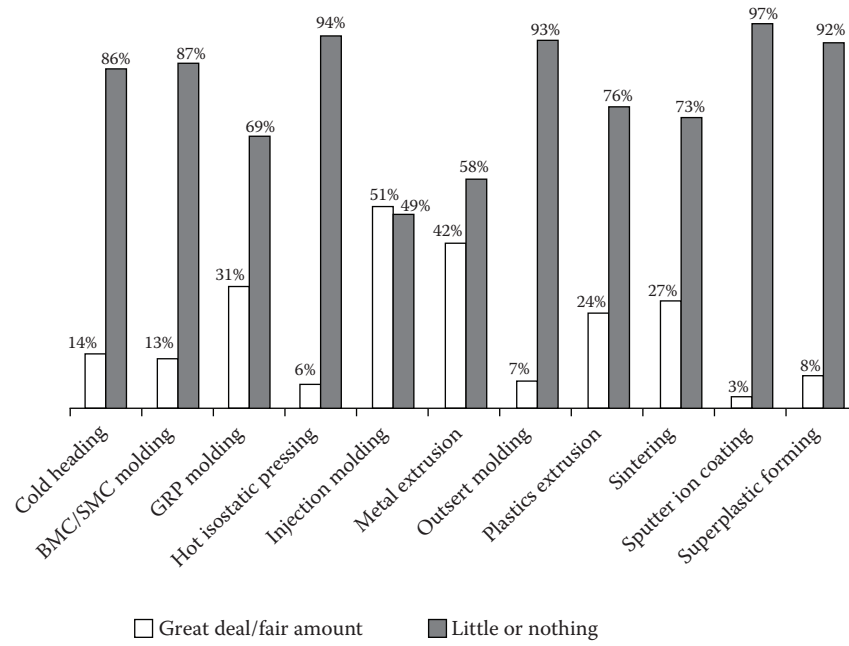


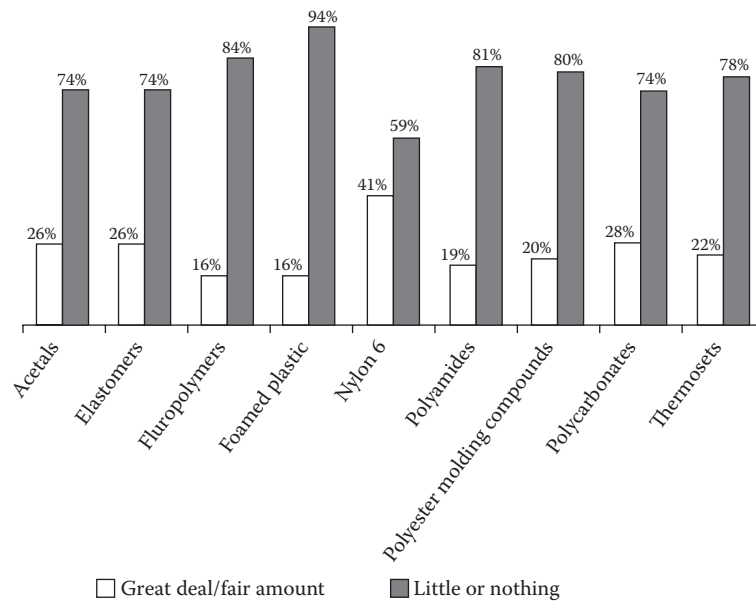
**FIGURE 2.1**

Survey of designers' knowledge of manufacturing processes. (Adapted from Bishop, R. *Huge Gaps in Designers' Knowledge Revealed*, Eureka, October 1985.)



**FIGURE 2.2**

Survey of designers' knowledge of polymer materials. (Adapted from Bishop, R. *Huge Gaps in Designers' Knowledge Revealed*, Eureka, October 1985.)



**FIGURE 2.3**

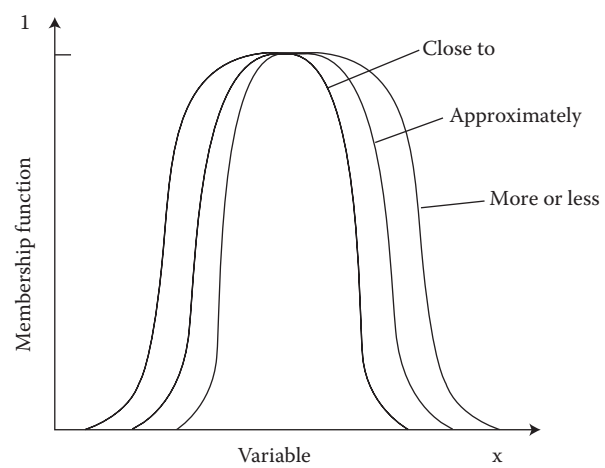
Compatibility between processes and materials.

	Cast iron	Carbon steel	Alloy steel	Stainless steel	Aluminum and alloys	Copper and alloys	Zinc and alloys	Magnesium and alloys	Titanium and alloys	Nickel and alloys	Refractory metals	Thermoplastics	Thermosets	
Sand casting														Solidification processes
Investment casting														
Die casting														
Injection molding														
Structural foam molding														
Blow molding (ext.)														
Blow molding (inj.)														
Rotational molding														
Impact extrusion														Bulk deformation processes
Cold heading														
Closed die forging														
Powder metal processing														
Hot extrusion														
Rotary swaging														
Machining (from stock)														Material removal processes
ECM														
EDM														
Wire EDM														Profiling
Sheet metal (stamp/bend)														Sheet forming processes
Thermoforming														
Metal spinning														

Normal practice
  Not applicable
  Less common

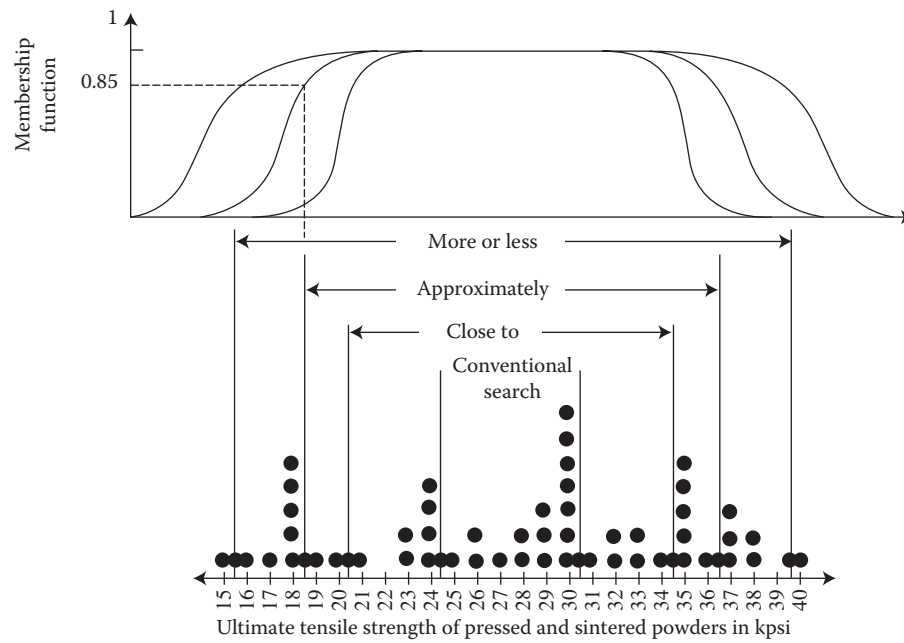
**FIGURE 2.4**

Membership functions for material and process selection.



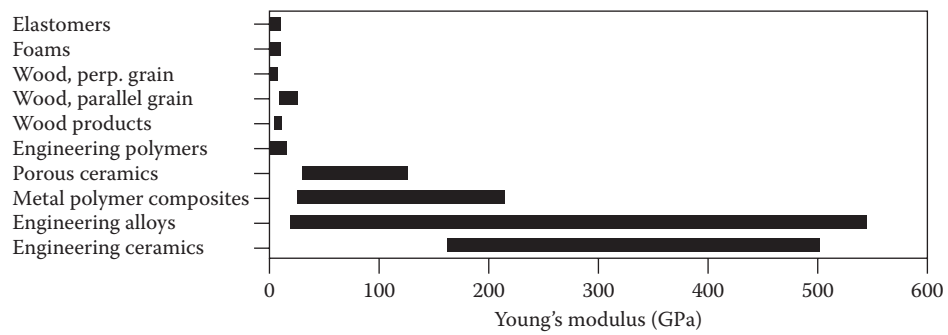
**FIGURE 2.5**

Selection of sintered powder materials by membership function modification. (Adapted from Farris, J. *Selection of Processing Sequences and Materials During Early Product Design*, Ph.D. Thesis, RI, 1992.)



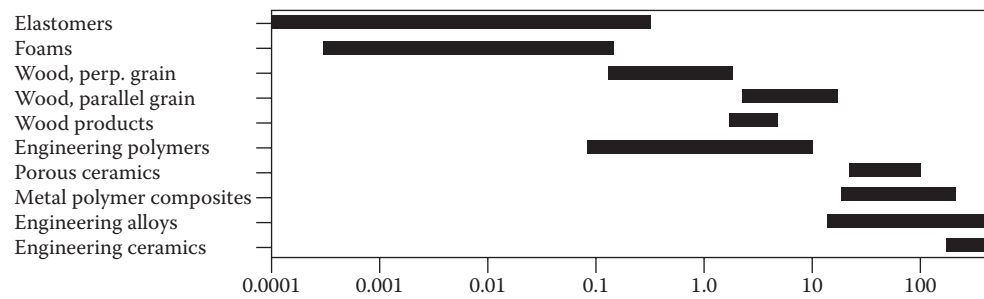
**FIGURE 2.6**

Elastic modulus for classes of materials plotted on linear scales. (Adapted from Dewhurst, P. and Reynolds, C.R. *Journal of Materials Engineering and Performance*, 6(3), 53–62, 1997.)



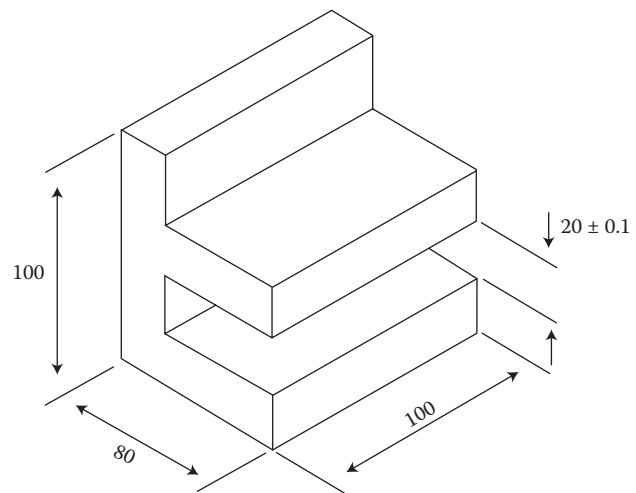
**FIGURE 2.7**

Elastic modulus for classes of materials plotted on logarithmic scales. (Adapted from Dewhurst, P. and Reynolds, C.R. *Journal of Materials Engineering and Performance*, 6(3), 53–62, 1997.)



**FIGURE 2.8**

Oven bracket part.



Dimensions in mm



**FIGURE 2.9**

Process elimination based on four geometric attributes of the part in Figure 2.8.

		Cast iron	Carbon steel	Alloy steel	Stainless steel	Aluminum and alloys	Copper and alloys	Zinc and alloys	Magnesium and alloys	Titanium and alloys	Nickel and alloys	Refractory metals	Thermoplastics	Thermosets		
1. Depression ..... Yes																
2. Uniform wall ..... Yes																
3. Uniform cross section ..... Yes																
4. Axis of rotation ..... No																
Sand casting															Solidification processes	
Investment casting																
Die casting																
Injection molding																
Structural foam molding																
3	Blow molding (ext.)															
3	Blow molding (inj.)															
3	Rotational molding															
3	Impact extrusion														Bulk deformation processes	
3	Cold heading															
Closed die forging																
Powder metal processing																
Hot extrusion																
1, 2, 3, 4	Rotary swaging															
Machining (from stock)															Material removal processes	
ECM																
EDM																
Wire EDM															Profiling	
Sheet metal (stamp/bend)																
3	Thermoforming														Sheet forming processes	
1, 3, 4	Metal spinning															

Normal practice
  Not applicable

Less common

**FIGURE 2.10**

Process elimination based on further four attributes of the part in Figure 2.8.

5. Regular cross section .....	No	Cast iron	Carbon steel	Alloy steel	Stainless steel	Aluminum and alloys	Copper and alloys	Zinc and alloys	Magnesium and alloys	Titanium and alloys	Nickel and alloys	Refractory metals	Thermoplastics	Thermosets	
6. Captured cavity .....	No														
7. Enclosed cavity .....	No														
8. Draft free .....	Yes														
8	Sand casting														Solidification processes
8	Investment casting														
8	Die casting														
8	Injection molding														
8	Structural foam molding														
6, 8	Blow molding (ext.)														
6, 8	Blow molding (inj.)														
7, 8	Rotational molding														
	Impact extrusion														Bulk deformation processes
	Cold heading														
8	Closed die forging														
	Powder metal processing														
	Hot extrusion														
8	Rotary swaging														
	Machining (from stock)														Material removal processes
8	ECM														
8	EDM														
	Wire EDM														Profiling
8	Sheet metal (stamp/bend)														Sheet forming processes
8	Thermoforming														
8	Metal spinning														

Normal practice

Not applicable

Less common

**FIGURE 2.11**

Final process selection based on geometric attributes of the part in Figure 2.8.

All shape attributes	Cast iron	Carbon steel	Alloy steel	Stainless steel	Aluminum and alloys	Copper and alloys	Zinc and alloys	Magnesium and alloys	Titanium and alloys	Nickel and alloys	Refractory metals	Thermoplastics	Thermosets	
Sand casting														Solidification processes
Investment casting														
Die casting														
Injection molding														
Structural foam molding														
Blow molding (ext.)														
Blow molding (inj.)														
Rotational molding														
Impact extrusion														Bulk deformation processes
Cold heading														
Closed die forging														
Powder metal processing														
Hot extrusion														
Rotary swaging														
Machining (from stock)														Material removal processes
ECM														
EDM														
Wire EDM														Profiling
Sheet metal (stamp/bend)														Sheet forming processes
Thermoforming														
Metal spinning														

Normal practice
  Not applicable
  Less common

**FIGURE 2.12**

Final selection based on process/material combinations of the part shown in Figure 2.8.

All shape attributes plus material requirement	Cast iron	Carbon steel	Alloy steel	Stainless steel	Aluminum and alloys	Copper and alloys	Zinc and alloys	Magnesium and alloys	Titanium and alloys	Nickel and alloys	Refractory metals	Thermoplastics	Thermosets	
Sand casting														Solidification processes
Investment casting														
Die casting														
Injection molding														
Structural foam molding														
Blow molding (ext.)														
Blow molding (inj.)														
Rotational molding														
Impact extrusion														Bulk deformation processes
Cold heading														
Closed die forging														
Powder metal processing														
Hot extrusion														
Rotary swaging														
Machining (from stock)														Material removal processes
ECM														
EDM														
Wire EDM														Profiling
Sheet metal (stamp/bend)														Sheet forming processes
Thermoforming														
Metal spinning														

Normal practice
  Not applicable
  Less common

FIGURE 2.13

General description of proposed part.

The screenshot displays the 'DFM Concurrent Costing 1.1' software window. The interface is divided into several sections:

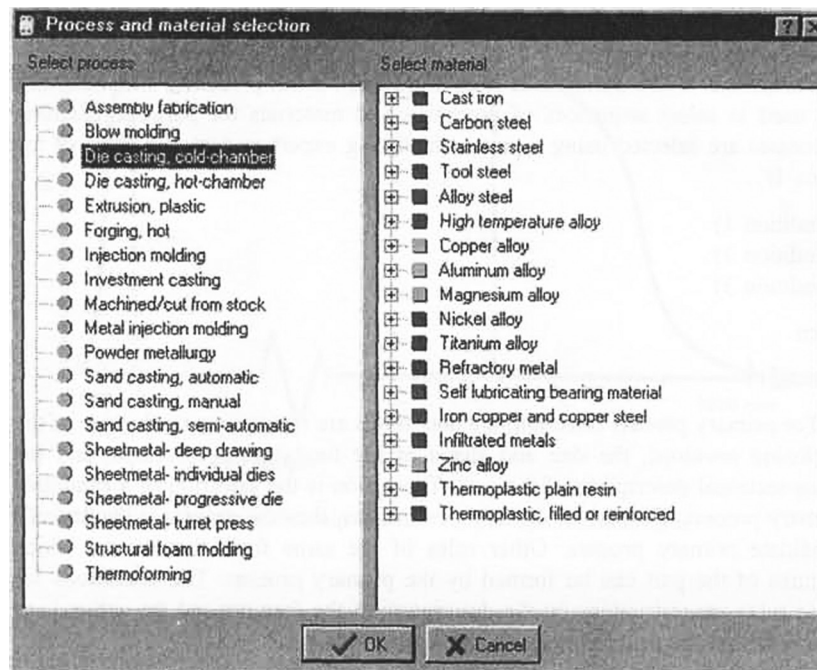
- Part Information:** Fields for 'Part name' (Sample), 'Part number' (12345), and 'Life volume' (100000).
- Envelope shape:** A row of icons representing different part geometries, with a cylinder icon selected.
- Approximate envelope dimensions, in:** Input fields for '1' (diameter), '0.1' (average thickness), and '3' (height).
- Forming direction:** A diagram showing a cylinder with a vertical arrow and a coordinate system with X, Y, and Z axes.
- Cost per part, \$:** A table comparing 'Previous' and 'Current' costs for various categories.
- Tooling investment:** Fields for 'Previous' (0) and 'Current' (0) tooling investment.

Cost per part, \$	Previous	Current
material	0.00	0.00
setup	0.00	0.00
process	0.00	0.00
piece part	0.00	0.00
tooling	0.00	0.00
total	0.00	0.00

Tooling investment	Previous	Current
	0	0

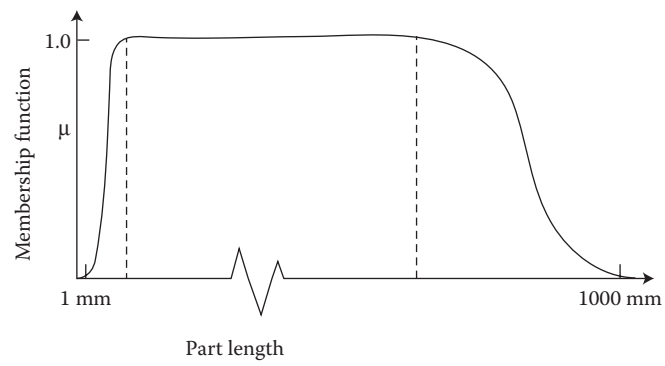
**FIGURE 2.14**

Material classes compatible with cold-chamber die casting.



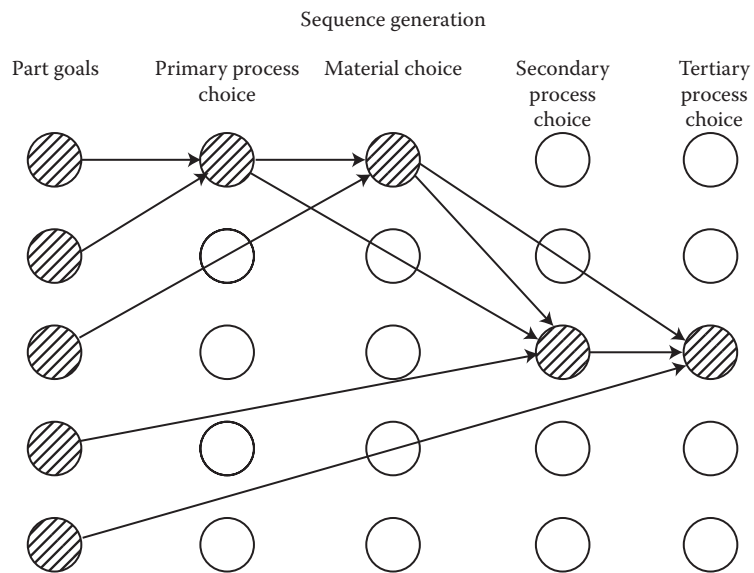
**FIGURE 2.15**

Example of membership function for process selection rules.



**FIGURE 2.16**

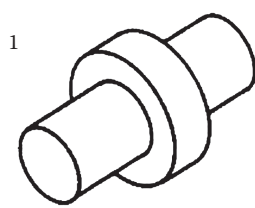
Procedure for processing sequence selection.



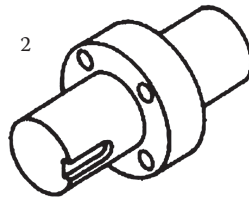


**FIGURE 2.17**

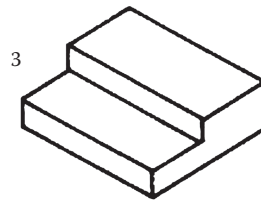
Seven basic categories of machines' component parts. (Adapted from PERA, *Survey of Machining Requirements in Industry*, PERA, Melton Mowbray, UK.)



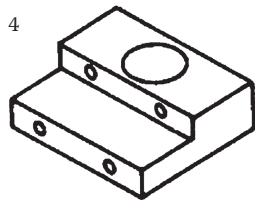
Primary rotational



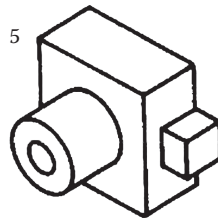
Primary rotational  
with secondary



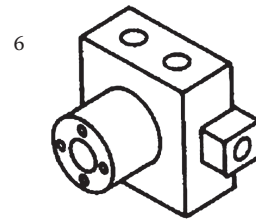
Primary planar



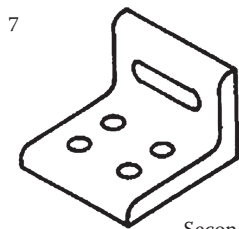
Primary planar  
with secondary



Primary planar  
and primary rotational



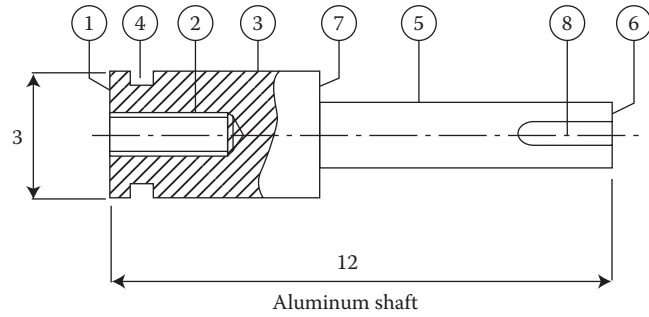
Primary planar  
and primary rotational  
with secondary



Secondary

**FIGURE 2.18**

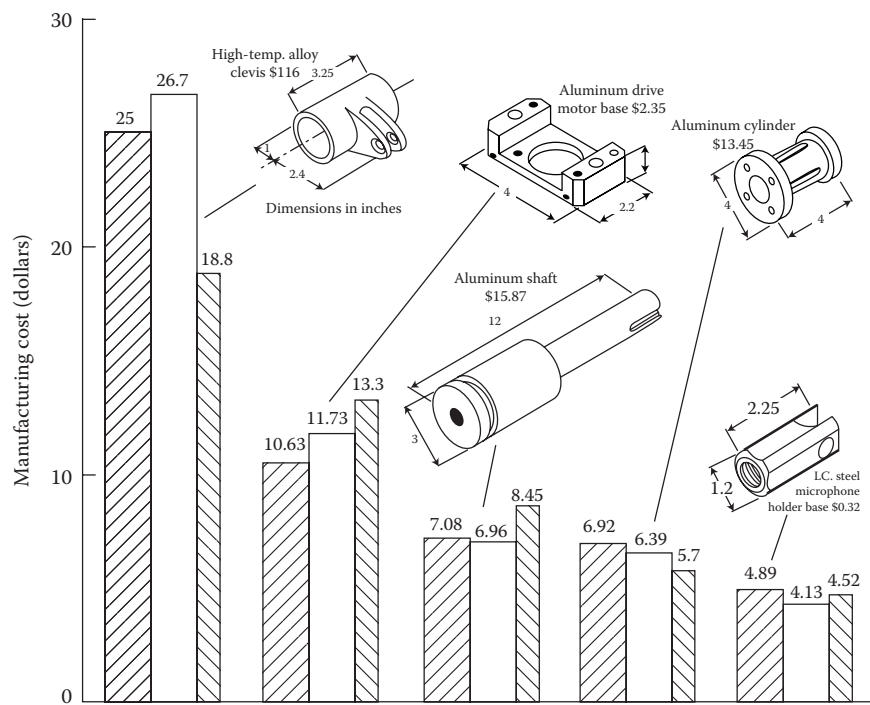
Category 2 part—rotational with secondary features.



Machine	Feature	Operations
Horizontal band saw	–	Cut off workpiece
CNC lathe	1	Finish face
	2	Center drill, drill, tap
	3	Finish turn
	4	Groove
	–	Reclamp
	5	Rough and finish turn
	6	Finish face
Vertical miller	7	Finish face
	8	End mill keyway

**FIGURE 2.19**

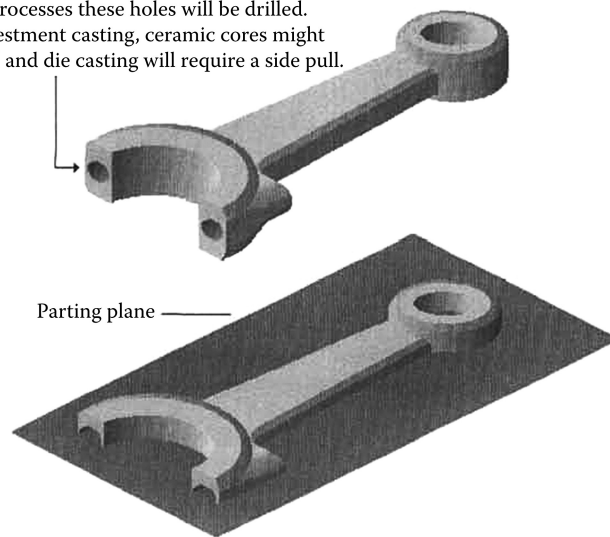
Comparison of machining cost estimates. The cost indicated next to each part drawing is the material cost for the part, ▨, detailed analysis; □, estimate; ▩, initial estimate.



**FIGURE 2.20**

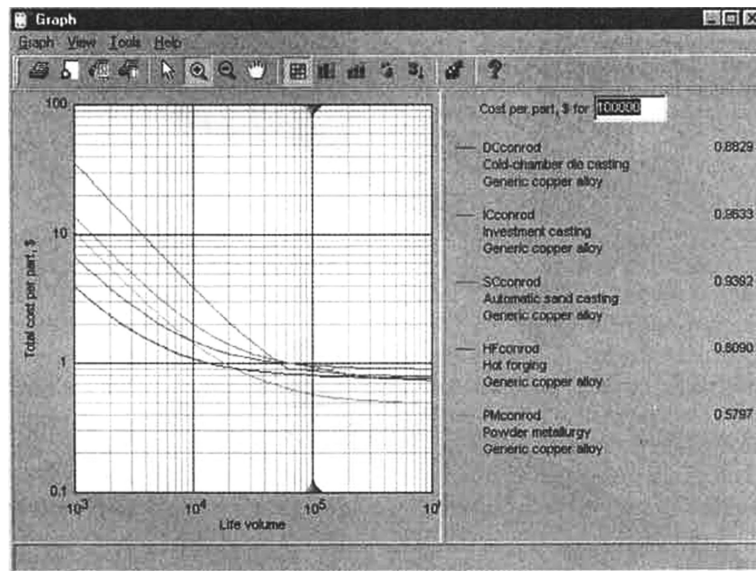
Connecting rod.

For sand casting, hot forging or powder metal processes these holes will be drilled.  
For investment casting, ceramic cores might be used and die casting will require a side pull.



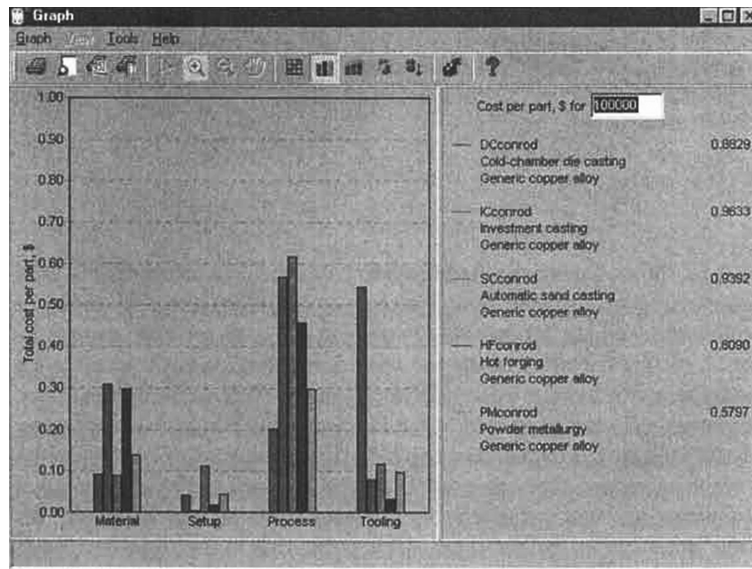
**FIGURE 2.21**

Connecting rod costs for different processes and production volumes.



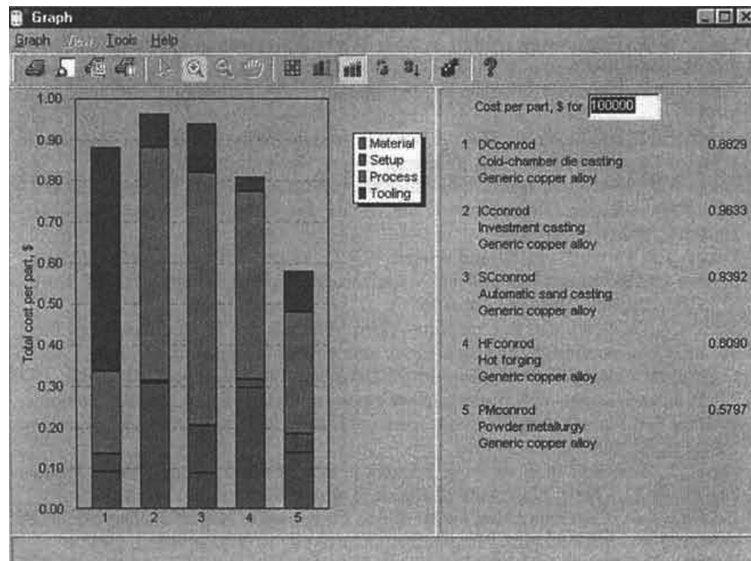
**FIGURE 2.22**

Cost breakdown for production volume of 100,000.



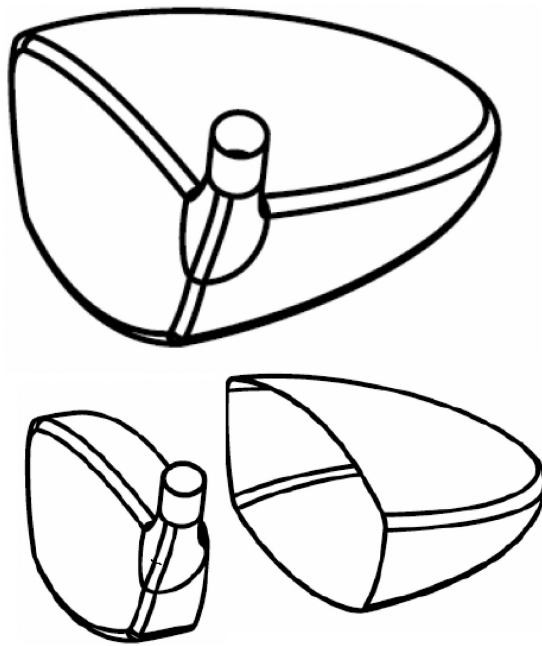
**FIGURE 2.23**

Cost comparisons for production volume of 100,000.



**FIGURE 2.24**

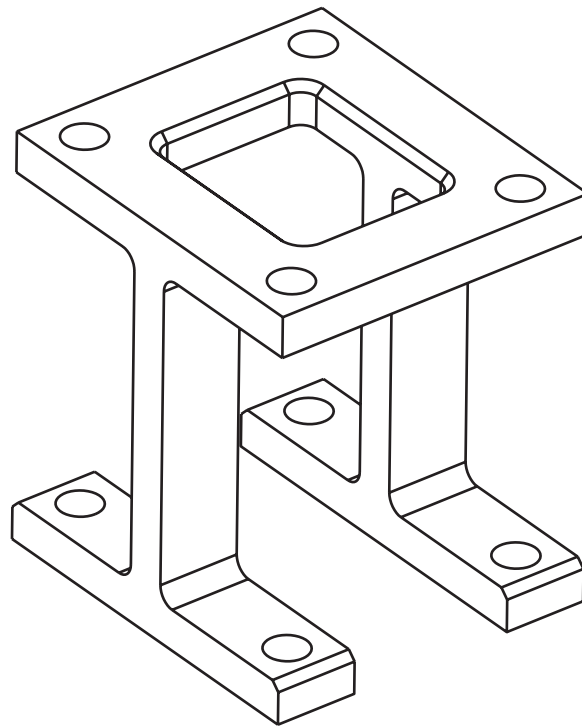
Hollow metal golf driver head construction.





**FIGURE 2.25**

Electrical instrument support platform.



**FIGURE 2.26**

Rotor housing.

