Flow Rate & Capacity Analysis

Review

- I= R x T for complex flows
- Process flow graphs and charts
- Flow unit dimensions & conversion factors
- Scaling in I = R x T
- Capacity req't estimation
- Flow time efficiency and improvement

Process Flow Graph

- Documents operations
- Where do you draw the boundary?
- Nodes <=> operations
- Arcs <=> precedence

Process Flow Charts

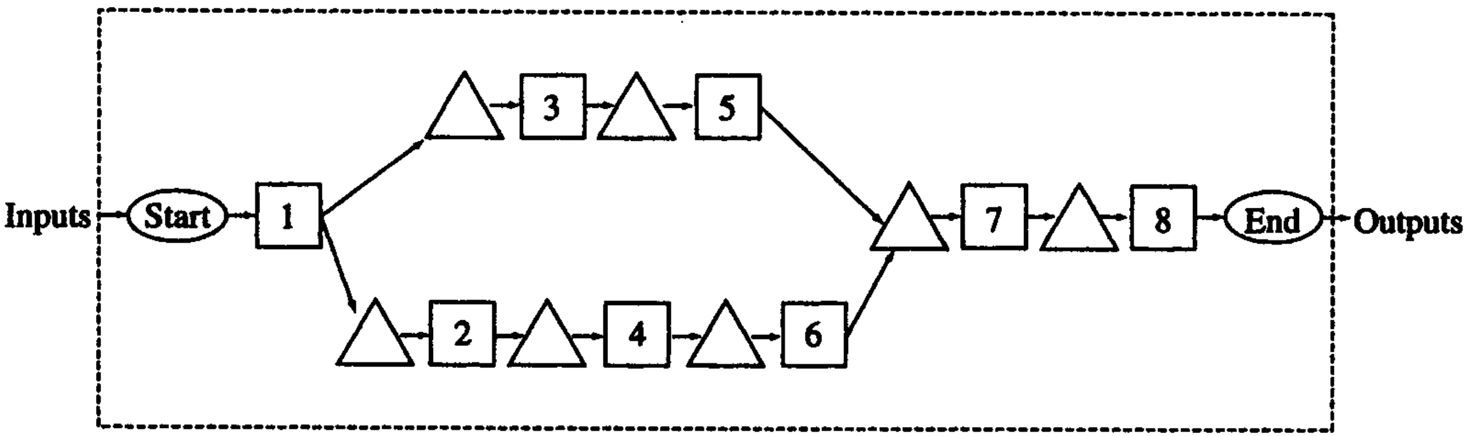


FIGURE 4.1 Process Flow Chart for MBPF, Inc.

We will refer to this as a process flow ***graph*** rather than a process flow ***chart***, because this shows only the structure of the flows, and not the detailed operation information.

Operation	Details of Operation Present Proposed	Operation	Transport	Inspection	Delay	Storage	Distance (ft)	Quantity	Time	Notes
1	Separate								10	Create two flow units
	Transport base							1		Subpath for base flow unit
	Base punch butter									
2	Punch the Base							1	30	
	Transport base							1		
	Base form buffer									
4	Form the Base							1	6	
	Transport base							1		
	Base subassemble buffer									
6	Subassemble Base							1	13	
	Transport to Assemble buffer							1		End subpath for base flow unit
	Transport Roof							1		Subpath for roof flow unit
	Roof punch buffer									
3	Punch roof							1	22	
	Tranport roof							1		
	Roof form buffer									
5	Form roof							1	12	
	Transport to Assemble buffer							1		End subpath for roof flow unit
	Assemble Buffer									
7	Assemble							1	10	
	Transport to Inspect							1		
	Inspect Buffer									
8	Inspect							1	36	

Today

- Modeling details
- Issues in estimating process capacity requirements and maximizing process efficiency
- Fundamental problem of terminology
- Process utilization and improvement

What if only one punch?

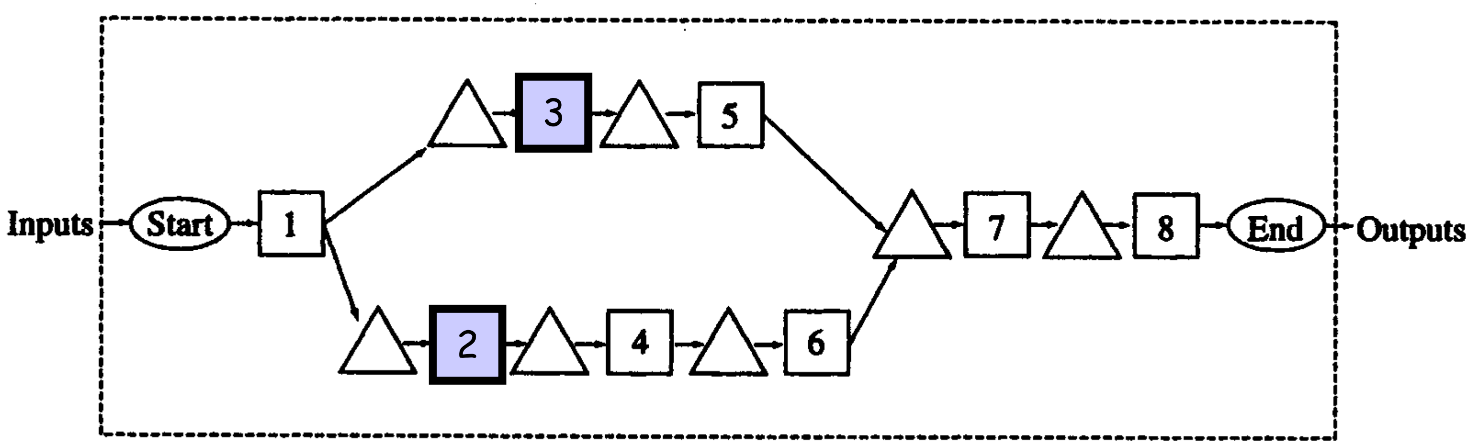


FIGURE 4.1 Process Flow Chart for MBPF, Inc.

Gantt Chart

Punch base first

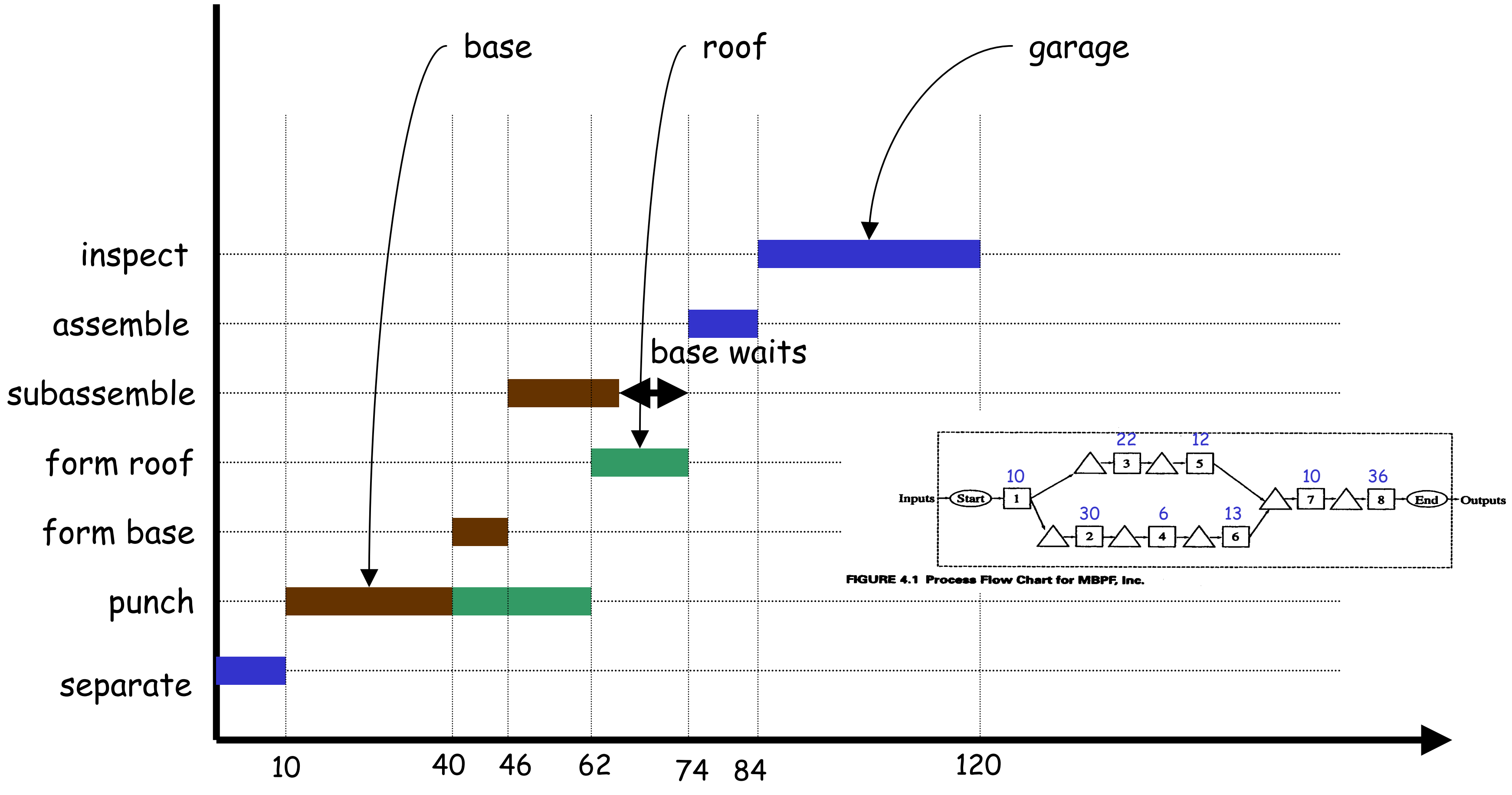


FIGURE 4.1 Process Flow Chart for MBPF, Inc.

Gantt Chart

Punch roof first

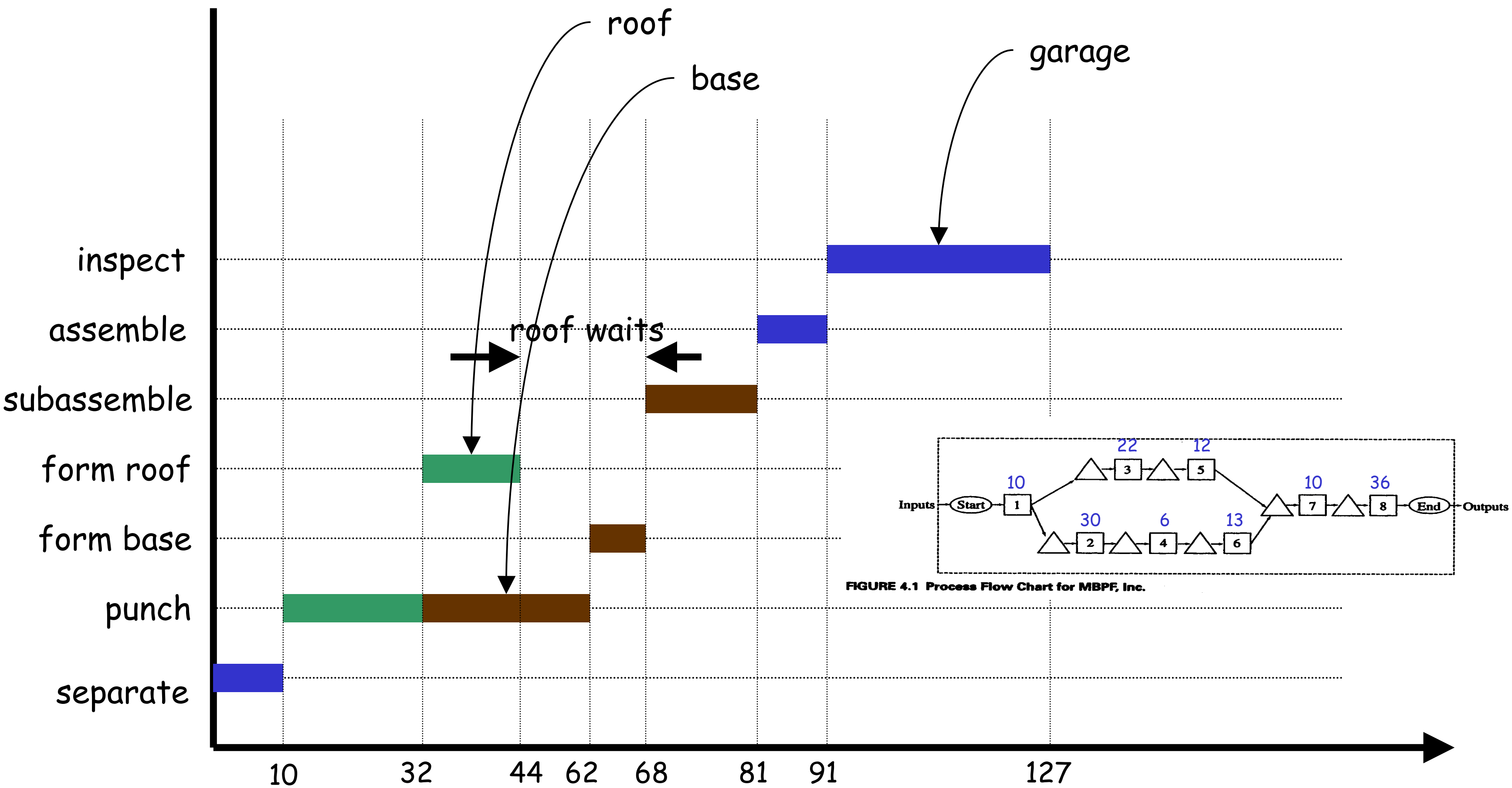


FIGURE 4.1 Process Flow Chart for MBPF, Inc.

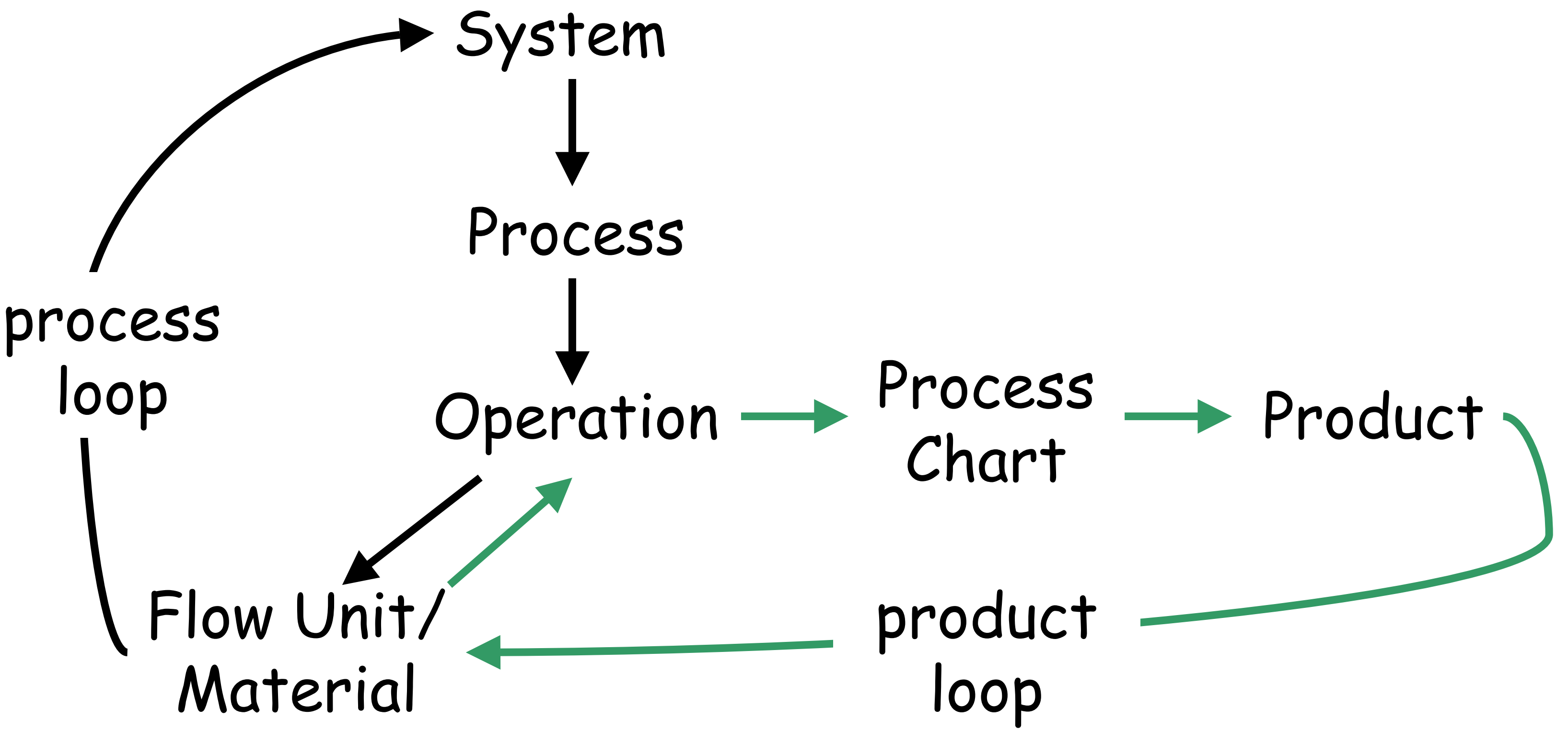
Example 4.4

- $I = RT$ is based on a "system boundary" and I is all the units in the boundary
- If you draw the boundary so it includes *only* the buffer, you get

$$I_b = RT_b$$

- That's why theoretical flow time is added to the "buffer" time

Circular Definitions



Terminology

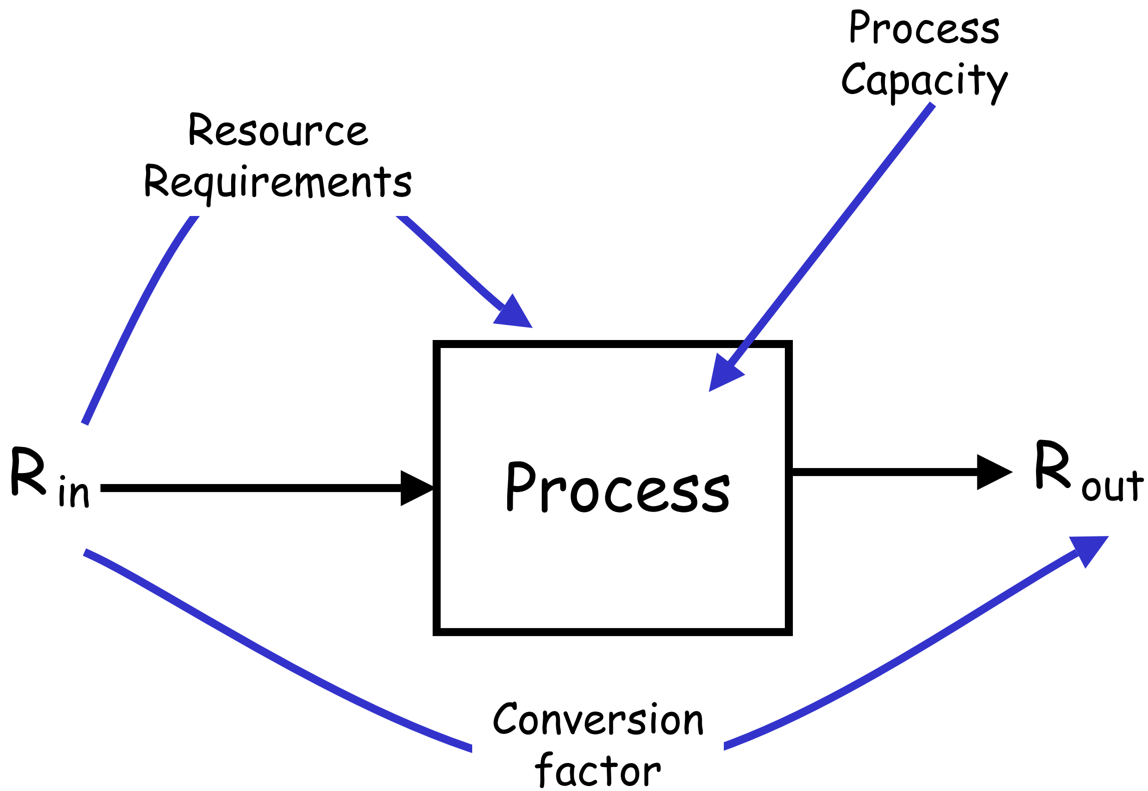
- Flow units: get moved between *operations*; note that while conservation of material holds at an operation, conservation of "flow unit" may ***not*** hold. E.g., raw material enters the process on a pallet, is converted into blanks, and leaves in totes

Terminology

- Flow unit conversion: when the units of measure for the flow units leaving an operation are not the same as the units of measure for the flow units entering the operation (NIB*)
- Flow unit conversion factor:
  output flow units/input flow unit (dimensionless) (NIB)

* NIB = "not in book"

Information Requirements



Defining Process Capacity

- ***Different from text!***
- Not all flow units entering a process are the same
- Capacity should *not* be expressed in terms of maximum rate at which flow units can enter the process, because the mix may vary over time

Example

- Two products, *A* & B, requiring 1 hour and 2 hours, respectively of machine time.
- Product mix today is 4 *A* and 2 B, or a rate of 6 “flow units”, requiring 8 hours.
- Can I achieve 6 flow units tomorrow, if all I make is B?

Resolution

- Process capacity: the amount of process time available per unit of scheduled time, hrs/hr, e.g.
- Operation process requirement: the amount of *process* time required per *flow unit* entering the process, hrs/unit, e.g.

Unit Loads

- I don't like the authors' use of this term
- "Unit load" has a conventional definition, in material handling
- Their "unit load" is simply the operation time, or the sum of operation times assigned to a resource

Theoretical Capacity

- I see no benefit to thinking of a process as having a different "theoretical capacity" for every product/flow unit (process view)
- The book's "theoretical capacity" is really the product (flow unit) "run rate" for that process (product view)

Capacity Required

- It is straightforward to compute, for a given process, the total amount of capacity required for a given set of products with given rates
- ReqCap = Sum(ProdRate x OpProcReqt)

Capacity Utilization

- Utilization =
  CapReq/TheoreticalCap

- E.g., supposed the plan rate for a product is 10 units/hr, and each unit requires 5 minutes of process time. Utilization is $(10 \times 5)/60 = 0.83$

Factors Affecting Process Capacity

- "Uncontrollable" factors (in the short run
  - breakdowns, preventive maintenance
- "Controllable" factors
  - setup/changeover, starvation (no waiting job), blocking, no operator

for a given R, increasing lot sizes *reduces* utilization, because of setups.

Process Availability

- Different from text!
- Availability =
  scheduled time - uncontrollable losses

- Product mix has no effect on availability, unless it impacts maintenance requirements

Effective Capacity

- Is simply
  theoretical capacity x availability

- E.g., if there is one machine, and its availability is 90%*, then the effective capacity is 54 minutes/hour

*e.g., 10% is the historical average time lost to breakdowns and maintenance

Improving Theoretical Capacity

- Section 5.6 is misleading--capacity is determined by resources, not by operation “recipes”
- Increasing capacity requires adding resources, or using the resources for longer periods of time (overtime, two shifts, e.g.)

Improving Flow Rates

- Increase theoretical capacity
- Reduce availability losses
- Reduce operation process requirements at bottleneck processes, e.g., by reducing setup times, increasing yields, or improving run rates
- Reduce schedule or material related idle time on bottleneck processes

Summary

- Circular definitions
- Flow unit conversion
- Process capacity, availability, and utilization
- Improving capacity vs improving throughput

At this point, you should be able to

- Use terminology correctly
- Use I = RT
- Develop a process flow graph for a simple process
- Develop a process flow chart for a simple scenario
- Calculate flow time efficiency
- Determine process capacity, availability, & utilization
- Identify opportunities for improving flowtime and flow rates for simple scenarios