Module 1:

Topic 2: Process Flow Diagram / Process Metrics

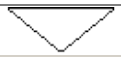
1. Process and Process Flow Diagram

1.1. What is a process?

A process is a collection of tasks, connected by flows of goods and information that transform various inputs into more valuable outputs. To describe a process we often use a **process flow diagram**.

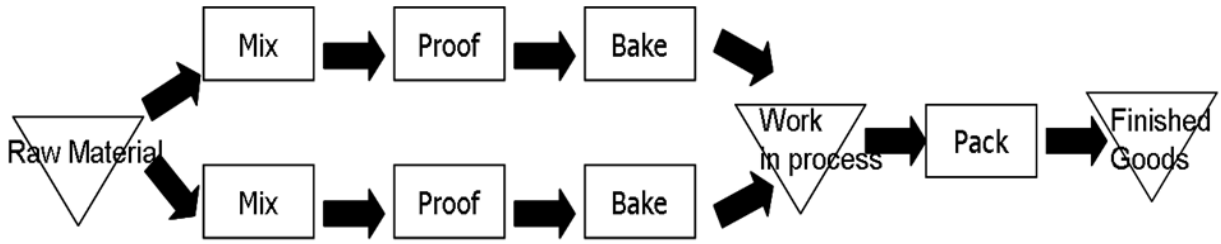
1.2. Process flow management

A business process is often modeled as a network of activities (i.e., tasks, operations, machines, etc) performed by resources that transform inputs into outputs. Process flow management is set of managerial policies that specify how a process should be operated and which resources should be allocated over time to the activities. The process network of activities and buffers is called a **process flow diagram (PFD)** that conveniently presents the major elements of an operation system. We represent each activity with a box, each buffer, or storage area for inventory, with a triangle and mark the direction of flow units with arrows.

	Tasks or operations (Machine, station, etc)
	Storage areas, Buffers, Queues (Waiting lines), etc
	Flows of materials

Example 1: Process Flow Diagram

Let's consider the process of baking bread a bakery. The bakery produces one type of bread, operating two parallel baking lines. Each line is equipped with a mixer, a proofer and an oven. There is a single packaging line fed by the two baking lines. A single raw material inventory buffer feeds the two lines. After baking is completed on either of the bread-baking lines the loaves feed a single work-in-process buffer; followed directly by a packaging activity step. When packaging is completed, the finished products feed into a single storage area (a finished-goods buffer) until trucks arrive to pick them up for delivery. Draw a PFD for this process.



2. Process Metrics

We already learned about "Productivity" in the previous topic, as the simplest tool to measure the performance of a process. However, there are some other important major metrics we need to know to accurately measure the performance of a process.

2.1. Work In Process (WIP)

Units that have entered the process but have not left the process (i.e., not yet completed)
Note: There are two types of WIP:

- Raw materials (WIP in front of the first task)
- Buffer inventory (WIP between tasks)

2.2. Finished goods inventory

Units that have been completed.

2.3. Arrival rate (AR) or Input rate (IR)

The number of incoming units to be processed per unit of time (e.g., 12 units/hr). You can measure it at the beginning of the process.
In Example 1, you can measure how many raw materials are coming in front of mixers.

2.4. Output rate (OR)

The number of units produced per unit of time (e.g., 12 units/hr). You can measure it at the end of the process.
In Example 1, you can measure how many finished goods are being produced after the packaging operation.

2.5. Capacity (CAP)

Potential (maximum) rate of output. Usually units of output per unit of time (e.g., 10 units/min)
Capacity is measured for a task (i.e., operation, station) or an entire process.

2.6. Throughput time (TP) = Flow time = Manufacturing lead time

The average time for a unit to move through an entire process.
TP = waiting time (at the storage area)+ transfer time (to move from one station to the other station) + processing time.

2.7. Cycle time (CT)

Time between completions of consecutive units (e.g., 4 min/unit).

2.8. Bottleneck (BN)

The factor which limits production. For example, a machine is too slow in a process, and items pile up in front of this machine.

2.9. Resource (labor, machine, work station, entire process) utilization or capacity utilization
Utilization measures how effectively resources are used to produce products.

Utilization =

[Time resource is “productive” or “busy”] / [Time resource is available] =

[# of units actually produced by resource in time period] / [Resource capacity during time period]

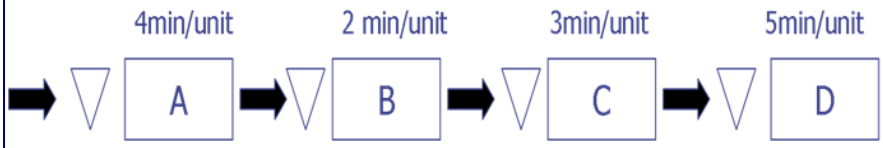
Note that "Capacity" is the potential (maximum) rate of output that can be different from the actual number of units produced.

Example 2: Utilization
There are two workers and each worker is available for 8 hours. If they are working only for 7 hours what is the capacity utilization?

Example 3: Utilization
The company A can produce 800 desks per shift. On a certain day the company produced only 700 desks per shift. What is the capacity utilization on that day?

3. PFD and Process Metrics

Example 4: Process Metrics
Consider the following process flow diagram. Cycle time of each task is given in the diagram.



- All times constant, negligible transfer time between stations
- Arrival rate (input rate) = 1 unit/5min = 12 units/hr

Find:
a. Hourly capacity of each station
b. Hourly capacity of processes
c. Bottleneck operation
d. Cycle time of process
e. Output rate
f. Throughput time
g. Station utilization for each station
h. Average station utilization
i. What is the throughput time if the line is mechanically paced? (Assume each station is the same distance in length on the line)

a.

b.

NOTE:
CAP of Process = CAP of BN

c.

Answer:

d.

NOTE:
CT of Process = CT of BN

e.

f.

NOTE:

	Station								
	A		B		C		D		TP Time (min)
unit	in	out	in	out	in	out	in	out	
1	0	4	4	6	6	9	9	14	
2	5	9	9	11	11	14	14	19	
3	10	14	14	16	16	19	19	24	
4	15	19	19	21	21	24	24	29	
5	20	24	24	26	26	29	29	34	

g.

Answer:

Station Utilization = [Capacity of the process] / [Capacity of a station]

or

Station Utilization = [Cycle time of a station] / [Cycle time of the process]

h.