

Introduction to Bioprocess Engineering

SQBI2513

Basic process flow diagram

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Definition

- What is process flow sheet?
 - A diagram that is normally generated by software to represent the process of a manufacturing plant.
 - Symbols are used to show the unit operations, flow direction, conditions etc of the process.
- Why process flow sheet is important?
 - For the process to be easily monitor, understand, explain, troubleshoot and optimize



Discussion 3 min

	Feed- preparation	Reaction	Recovery
Definition			
Challenges			



Upstream and down stream in bioprocess engineering

- Upstream: Generally refers to the reaction part.
- include the process setup and plant setup
- From the feed tanks to bioreactors (fermenter, reactor vessels).
- Include all the unit operations that supports the bioreactors such as pump, compressor, heat exchanger, etc.
- In summary:
 - Upstream= feed preparation + reaction portion

Upstream and down stream in bioprocess engineering

- Down stream: product recovery (refinery) and purification
- Include the separation of solid and liquid
- Include the separation of cells from culture broth
- Include the breaking of cells to harvest intracellular products
- Include the separation of soluble products in the crude solution
- Include the finishing steps for purification such as crystallization and drying.
- Include product formulation and packing

Use of symbols in process flow sheet

- There may be hundreds of “operation units” in a complete flow sheet.
 - It will be difficult and impossible to squeeze all words and picture of machines into a piece of paper.
 - Instead, symbols are frequently used in actual engineer-drawn flow sheet.
-

1. Vessel

Vessel= a container that hold something, e.g
liquid



Usage of a vessel

In industry, vessel can be use for:

Application	Examples
Storage	
Transport	
Reaction	

Not all vessels are the same, so are you!

Materials for bioprocess vessel

- Vessels can be made from plastic, glass, etc.
- In bioprocess/pharmaceutical industries, vessels are usually made of **stainless steel**
- Stainless steel = chromium + iron.
- The chromium reacts with ambient oxygen and forms a passive layer of chromium oxide (Cr_2O_3) on the surface that protects the steel from corrosion.

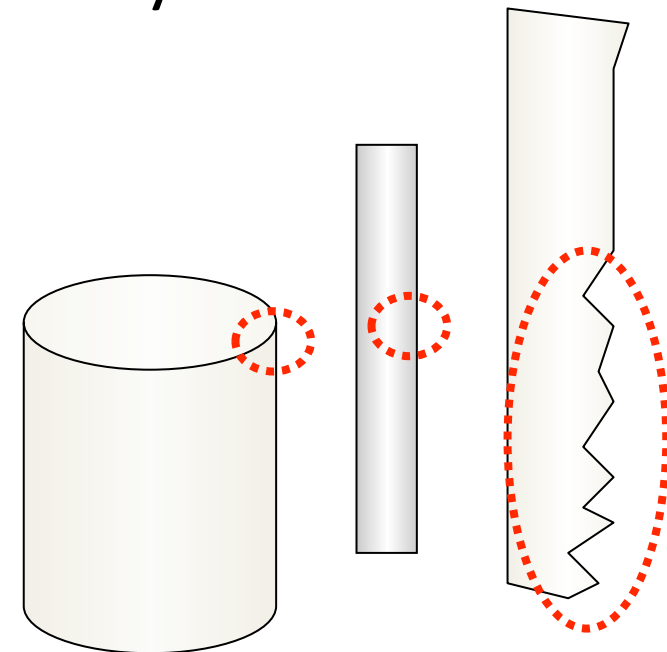
Materials for bioprocess vessel

- In bioprocess, the most welcome stainless steel are:
 - 304/304L
 - 316/316L (*Most watches are made of stainless steel Type 316L*)
- 304/304L stainless steel is cheaper and mostly used in food technology.
- “L” designation refers to a low carbon steel..

Polished surface (2 min discussion)

- The surface of a stainless steel is not smooth and may consist rust.
- The surface need to be polished. Why?

- _____
- _____

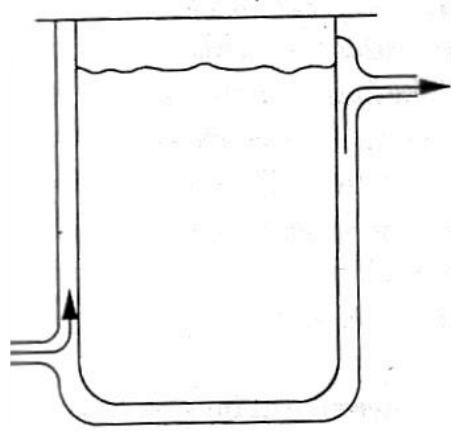


Heating and cooling in plant

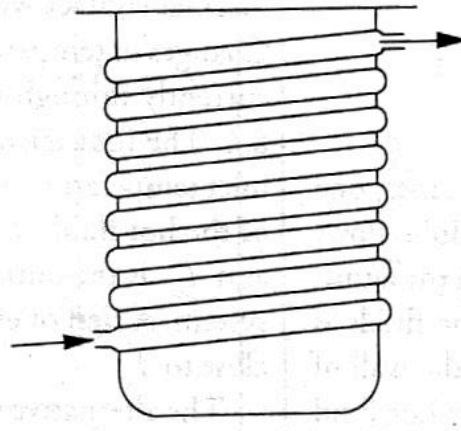
- Almost all the unit operation in the flow sheet are operating at different temperature.
- Can you suggest why different temperatures are applied?
- Can you transform your idea into a flow sheet?

Heat exchanger

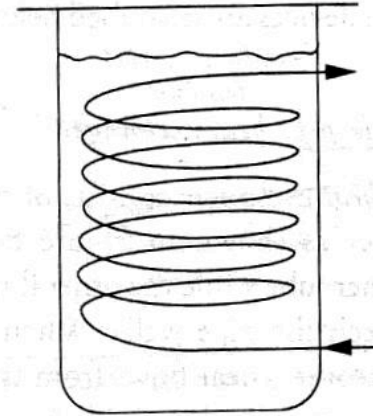
- Each changes of temperature in any part of the flowsheet normally require a heat transfer equipment—either heating up the stream or cooling down the temperature.



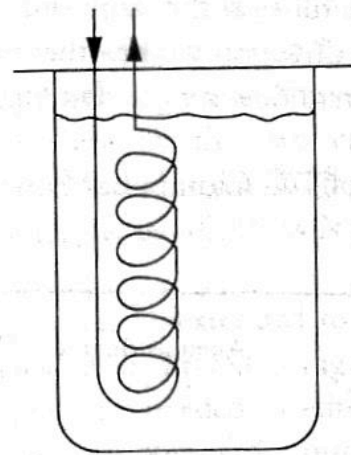
(a)



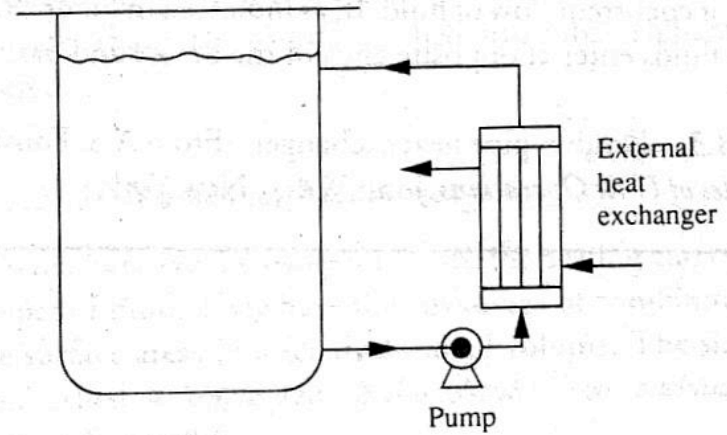
(b)



(c)



(d)



(e)

(f)

(g)



Mixing in bioprocessing

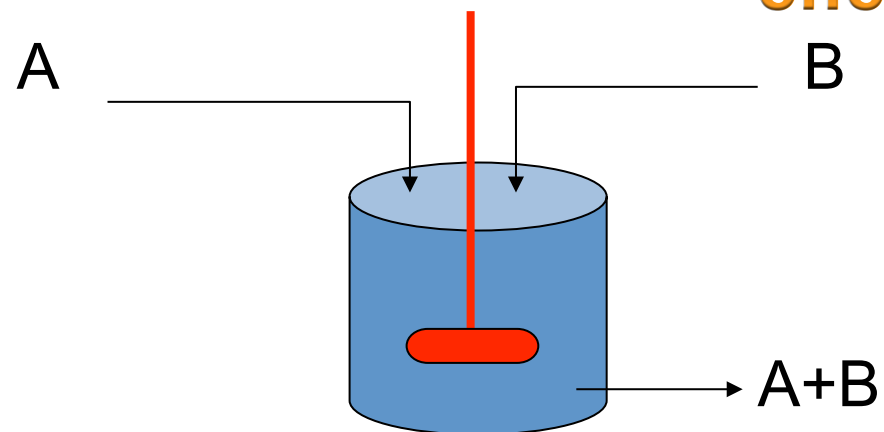
- Consider $A + B + C + D \rightarrow \text{Product}$
- Do you think mixing is important to improve the rxn?
- Do you think there is a different in approach if:
 - All A,B, C,D and product are all liquid?
 - Some of A,B,C, or/and D are solid/slurry?

Common unit operations/components in bioprocess flowsheet-mixer

- A mixer is a device to blend/combine multiple compounds.
- Normally no reaction occur in the mixer.
(Think: if there is a reaction occur during the mixing, what should we call the unit operation as if we cannot named it a mixer?)



Which one is more effective? Cheaper?



Pump

- A pump is a device used to move liquids or slurries.
- A pump moves liquids from higher/lower(?) pressure to higher/lower(?) pressure, and overcomes this difference in pressure by adding energy to the system

Compressor

- A gas pump is generally called a compressor



compressor

- A gas compressor is a mechanical device that increases the pressure of a gas by reducing its volume. Compression of a gas naturally increases its temperature.

Valve

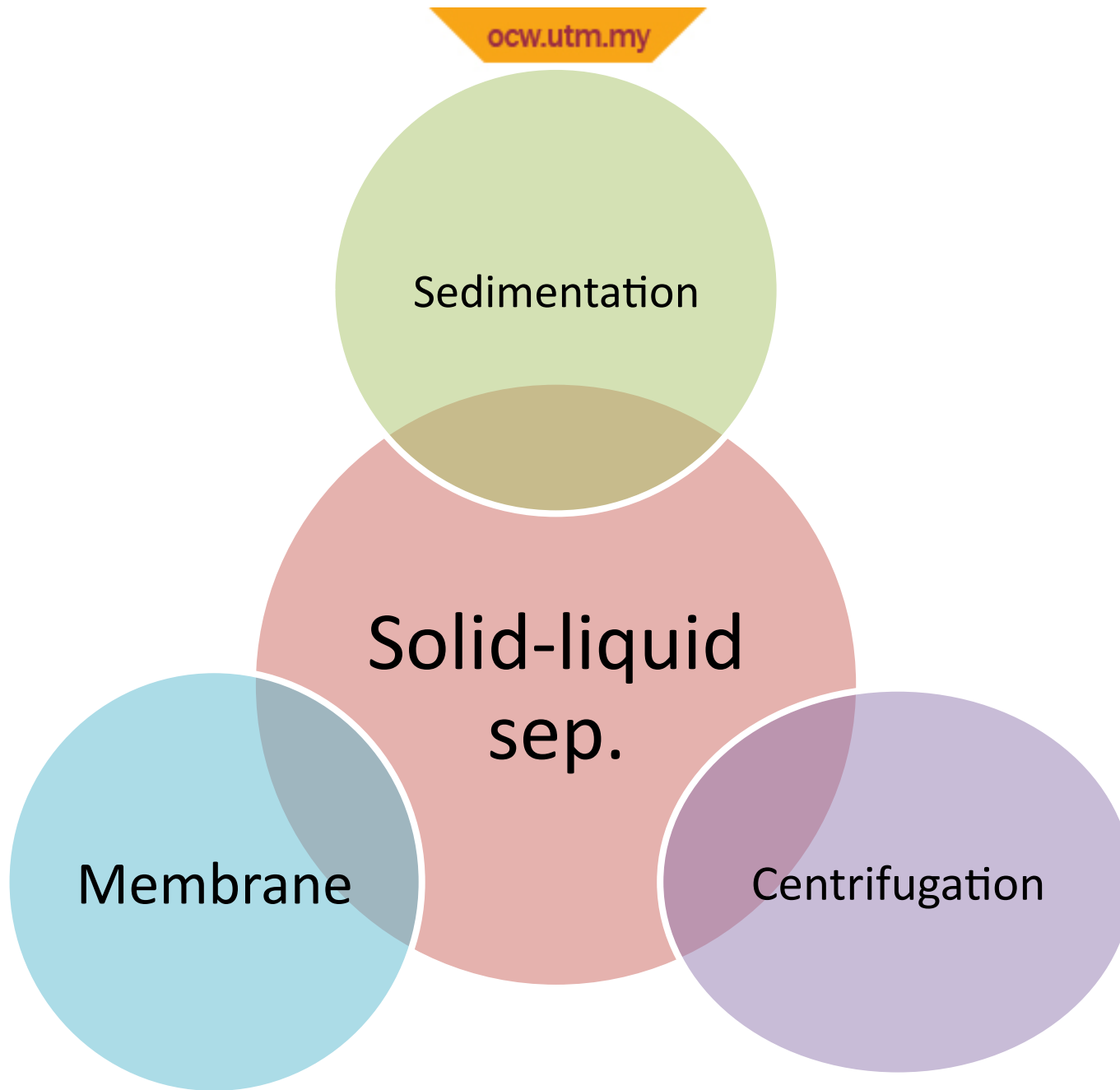
- What can a “pili air” do?
 - ___ and ___
 - ___ n ___ the speed of the flow

Test yourself ! (5 min)

- Please draw a simple flowsheet based on the description below:
 - Use a pump to feed medium into a stirred jacketed reactor,
 - Use a pump to withdraw sample from the reactor.
 - The sample will be transferred into a vessel.
 - Dilute the sample with water.
 - Use a pump to transfer the diluted sample to a cooled vessel.
 - After cooling, samples will be bottled, use a valve to control the flow.

Solid and liquid separation

- Solid–liquid separation refers to:
 - Removing solid from a mixture (to get liquid)
 - Or
 - Removing liquid from a mixture (to get solid)
- Example:
 - Collect supernatant for extra cellular enzyme



Sedimentation by settling tanks

- Settling tanks are used for separating solids and/or oil from another liquid
- Settling system design is controlled by four important elements:
 - 1)
 - 2)
 - 3)
 - 4)

Compare

	Sedimentation	Centrifugation	Membrane
Driving force	Gravity	Centrifugal force	?
Use of energy	lower		
Cost	lower		
Efficiency	lowest		
Advantages			