AERATION & AGITATION

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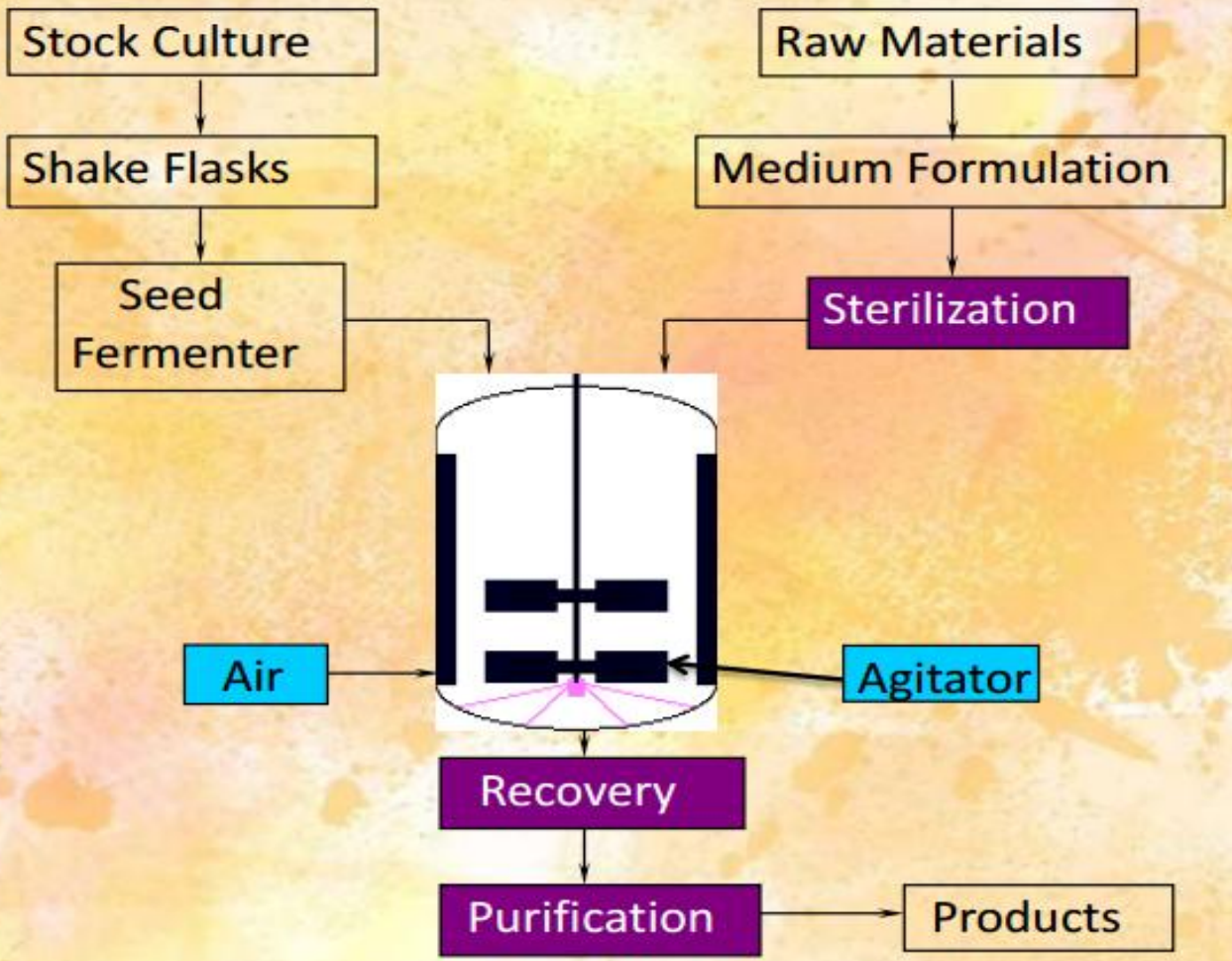
INTRODUCTION

- The majority of fermentation processes are aerobic and therefore require the provision of oxygen.
- The oxidation of glucose may be represented as;
  $C_6H_{12}O_6 + 6O_2 = 6H_2O + 6CO_2$
- It is not possible to provide a microbial culture with all the oxygen it will need for the complete oxidation of glucose in one addition.
- Therefore, a microbial culture must be supplied with oxygen during growth at a rate sufficient to satisfy the organisms demand.
- The oxygen demand of an industrial fermentation process is normally satisfied by aerating and agitating the fermentation broth.
- However, the productivity of many fermentations is limited by oxygen availability and therefore, it is important to consider the factors which affect the fermenter's efficiency in supplying microbial cells with oxygen.

TYPICAL BIOPROCESSING



AERATION AND AGITATION

- Important factor in a fermenters .
- Provision for adequate mixing of its contents
  Mixing in fermentation
- to disperse the air bubbles
- to suspend the cells
- to enhance heat and mass transfer in the medium
  All relate to Gas-liquid mass transfer

AERATION AND AGITATION

- Aeration refers to the process of introducing air to increase oxygen concentration in liquids .
- Removes unwanted volatile products of metabolism .
- Aeration may be performed by bubbling air through the liquid, spraying the liquid into the air or agitation of the liquid to increase surface absorption .
- Agitation – uniform suspension of microbial cells in homogeneous nutrient medium .

AERATION AND AGITATION

- **Agitation** – uniform suspension of **microbial cells** in homogeneous nutrient medium
- Importance of agitation
- 1. To increase the rate of oxygen transfer from the air bubble to the liquid medium.
- 2. To increase the rate of oxygen and nutrients transfer from the medium to cells.
- 3. To prevent formation of clumps of cells, aggregates of mycelium.
- 4. To increase the rate of transfer of product of metabolism from cell to medium.
- 5. To increase the rate or efficiency of heat transfer between the medium and the cooling surfaces of the fermenters.

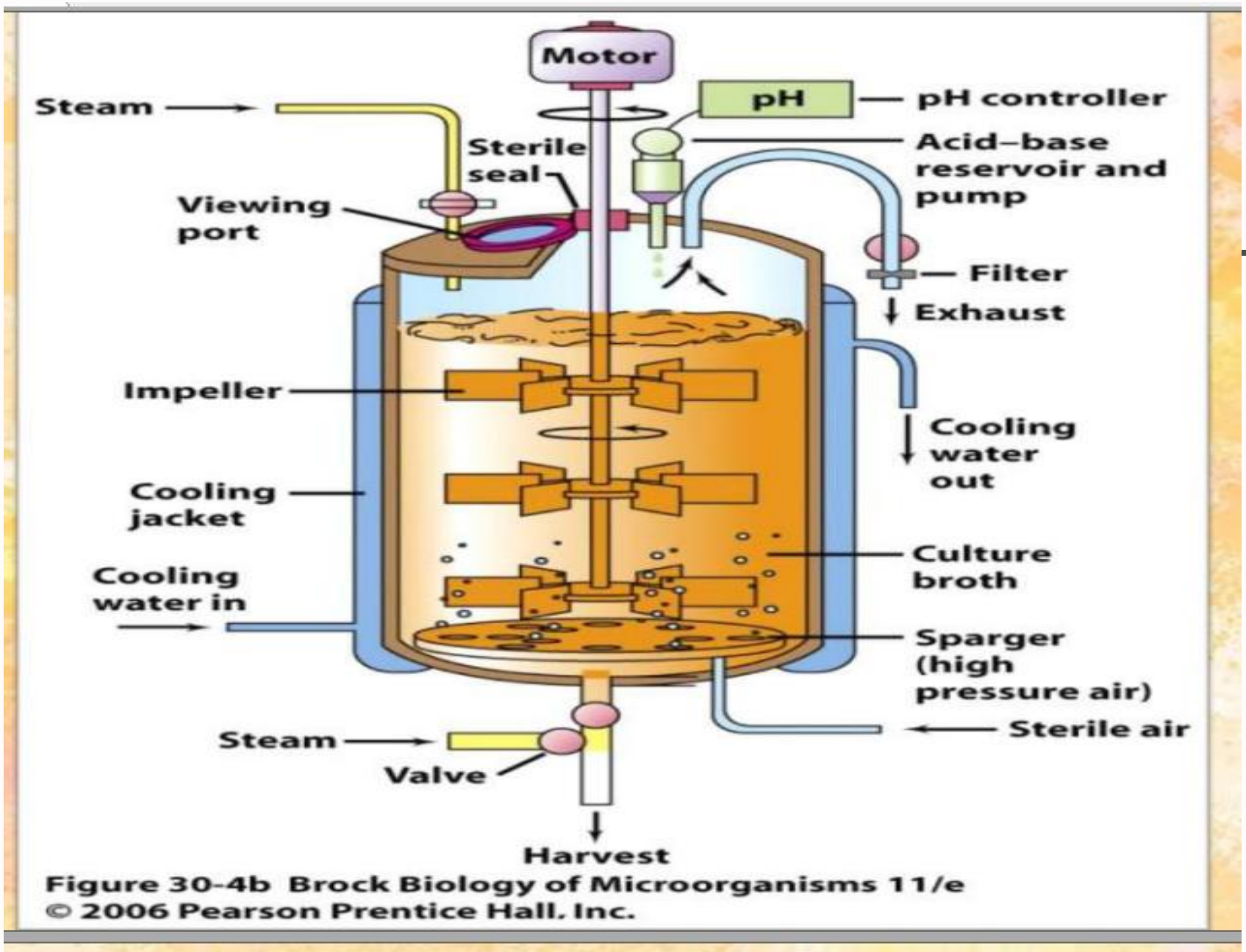


Figure 30-4b Brock Biology of Microorganisms 11/e

EFFECT OF AGITATION UPON AERATION

- 1. by dispersing the air in smaller bubble.
- 2.by causing the bubbles to follow a more tortuous path and delaying their escape from the culture.
- 3. by preventing the coalescence of bubbles.
- 4. by decreasing the rate-limiting thickness of the liquid film at the gas/liquid interface

FACTORS AFFECTING OXYGEN SUPPLY

1. Type of agitation:

The shape, number and arrangement of impellers and baffles.

Either 2 or 3 impellers for large fermenters at suitable level on the stirrer shaft or 3 or 4 baffles on the wall of the vessel.

2. Speed of agitation:

1000 or more for lab. fermenters. But this is not possible for large vessels.

For penicillin fermentation requires 50rpm needs high input of energy and uneconomical.

3. Depth of liquid in the fermenters:

Bubble remain longer in the medium of a tall, deep fermenter. Greater hydrostatic pressure at the sparger improves solution of oxygen.

Height : diameter ratio of 3:1 or 4:1 is common.

FACTORS AFFECTING OXYGEN SUPPLY

4. Type of sparger:

One single opening preferred to produce large bubble.

5. Air flow:

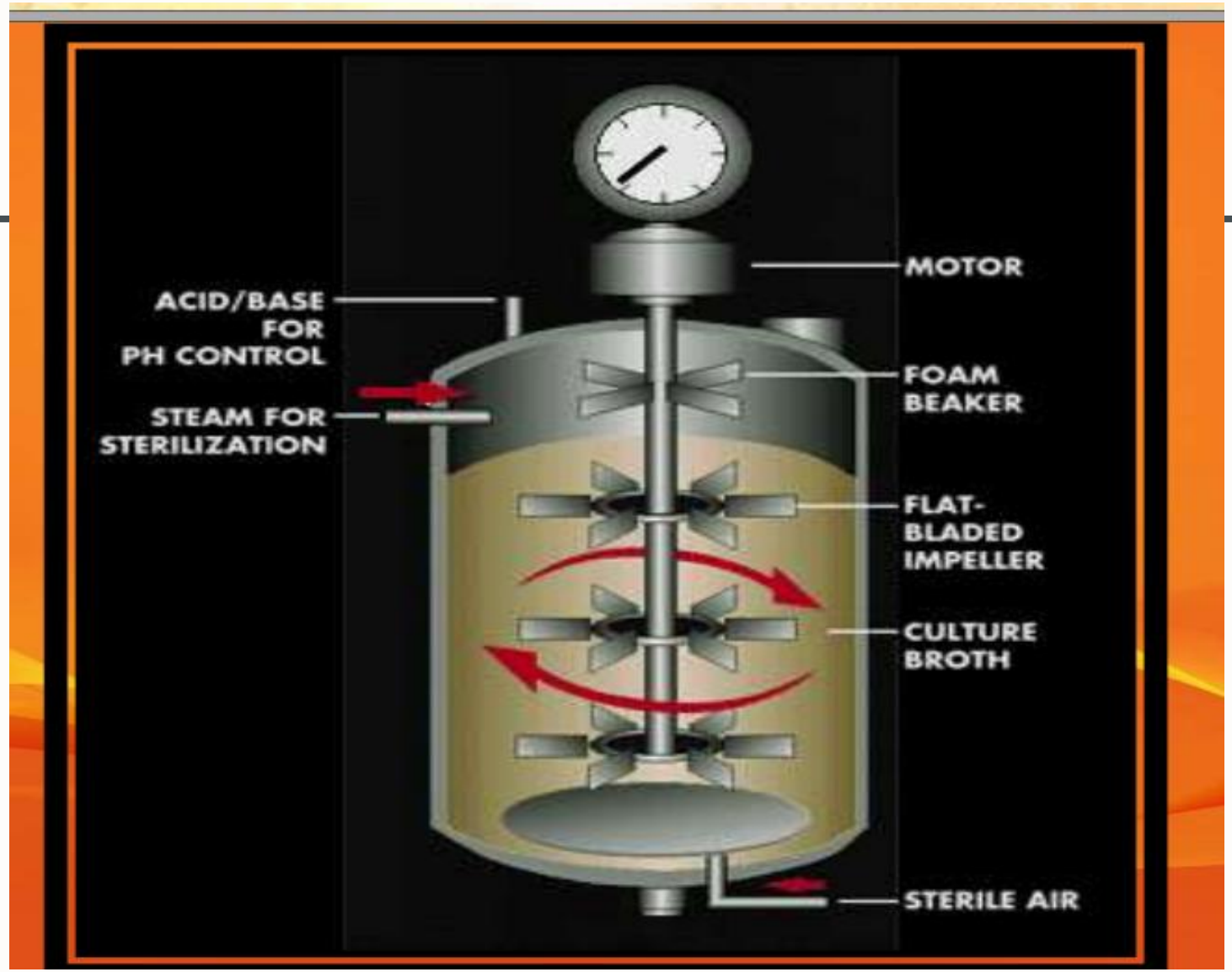
Aeration – increased by air flow rate, expressed in vvm (Vol. of air/vol. of medium/min.). Large fermenters cannot be supplied with air at greater rates than 0.5 to 1.0vvm.

6. Physical properties of the medium:

Temp., viscosity, surface tension and nature of organism , all affects solubility of oxygen directly or by bubble size and turbulence.

Structural components involved in aeration and agitation

- Agitator (impeller)
- Stirrer glands and bearings
- Baffles
- Aeration system (sparger)


MOTOR
ACID/BASE FOR PH CONTROL
FOAM BEAKER
STEAM FOR STERILIZATION
FLAT-BLADED IMPELLER
CULTURE BROTH
STERILE AIR

AGITATOR (IMPELLER)

- Achieve **mixing objectives** – bulk fluid and gas-phase mixing, air dispersion, oxygen transfer, heat transfer, suspension of solid particles and maintaining uniform environment throughout vessel contents.
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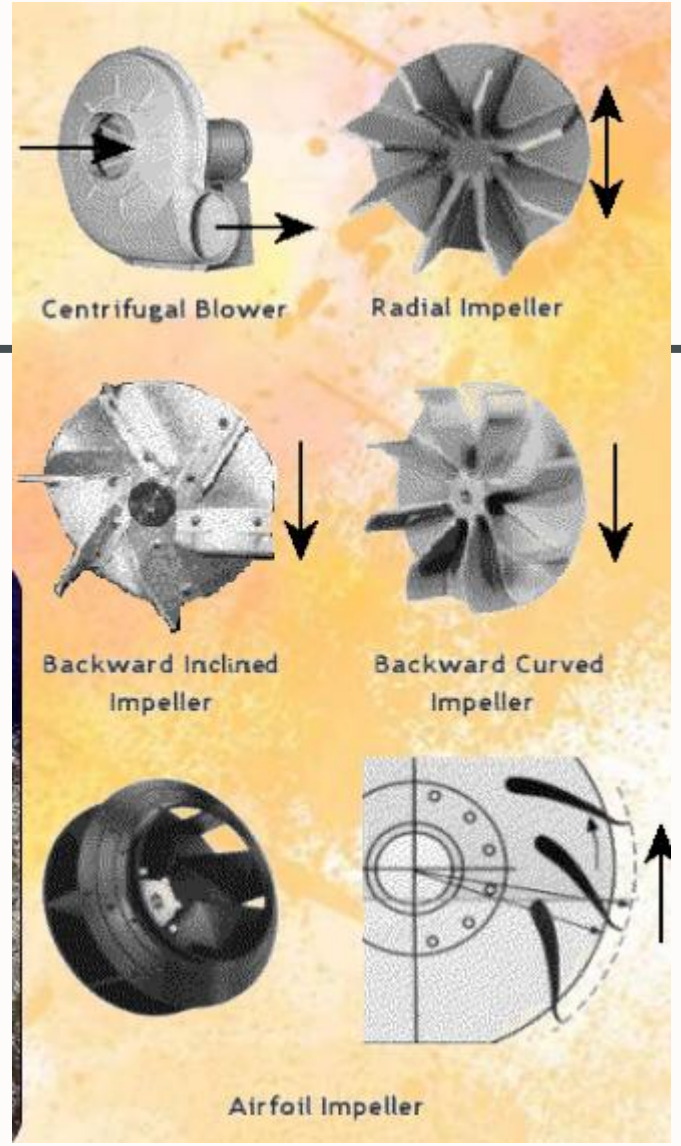


TYPES OF AGITATORS

- Types: Disc turbines, vaned dics , open turbines of variable pitch and propellers.

  Disc turbine:

  • It is with a series of rectangular vanes set in a vertical plane around the circumference .

  • Vane disc:

- It is a series of rectangular vanes attached vertically to the underside.
- Air from the sparger hits the underside of the disc and is displaced towards the vanes where the air bubbles are broken into smaller bubbles.

Application	Typical examples
Maintain Media Homogeneous	Milk storage tanks, cream tanks, mixed product tanks, UHT product storage tanks, etc.
Mixing and Solutions (dissolve)	Fluid and fluid mixing, i.e. drinking yoghurt and fruit mix tanks, flavoured milk mix tanks, syrup mix tanks, etc.
Solid Dispersion	Powder protein + oil mix tanks, micro salt + milk product mix tanks, etc.
Suspension	Fluids with particles, i.e. juice tanks, crystallising tanks etc.
Heat transmission	Circulation of media in tanks with dimple jacket (cooling or heating)
Dairy Fermentation (break coagula + mixing)	Yoghurt tanks, cheese culture tanks, crème fraîche, etc.

STIRRER GLANDS AND BEARINGS

- Sealing of stirrer shaft – difficult problem in the construction of fermentation equipment .
  - Entry of stirrer shaft – top, side or bottom
  - Basic type of seal assembly:
  - 1. the stuffing box (packed gland seal)
  - 2. the simple bush seal
  - 3. the mechanical seal
  - 4. the magnetic drive.

BAFFLES

- Four baffles incorporated into agitated vessels of all sizes to prevent vortex and to improve aeration efficiency .
- Metal strips roughly one tenth of vessel diameter and attached radially to the wall .
- Minimizes microbial growth on baffles and fermenter walls.
- Increased agitation with wider baffles; drop in agitation with narrower baffles.

AERATION SYSTEM (SPARGER)

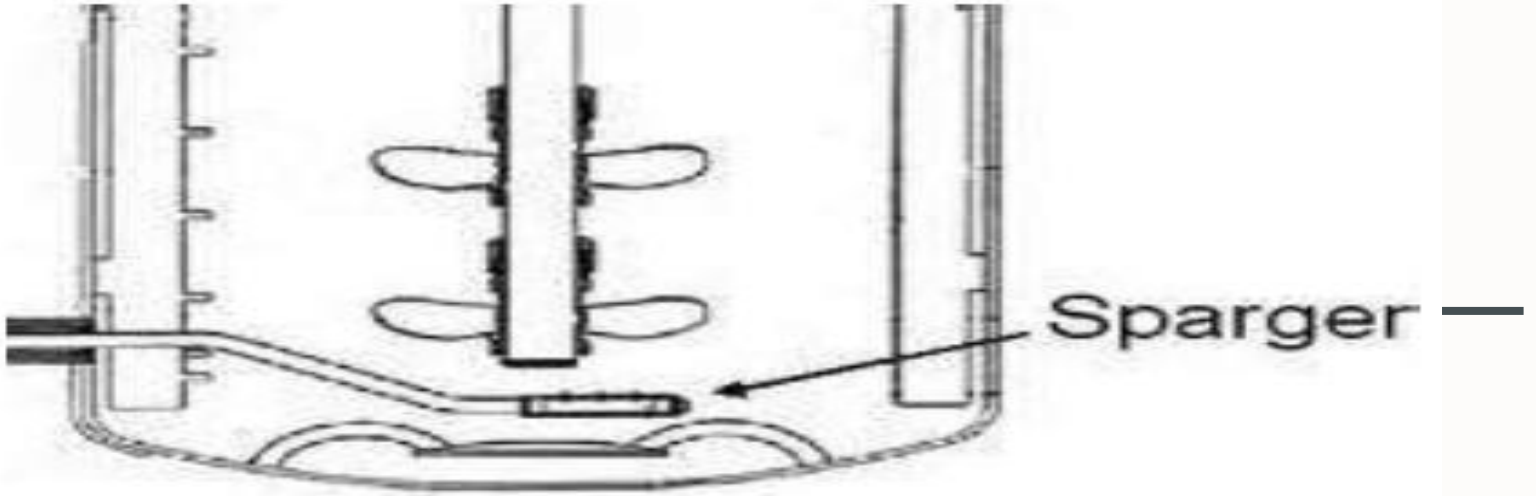
- Introduces air into liquid of fermenter
  Three basic types – porous sparger
  1. Orifice sparger – a perforated pipe
  2. Nozzle sparger – an open or partially closed pipe
  3. Combined sparger-agitator

POROUS SPARGER AND ORIFICE SPARGER

- Made of Sintered glass, ceramics or metal.
• The bubble size produced from spargers is always 10 to 100 times
larger than the pore size of the aerator block.
• Orifice sparger:
• In small stirred fermenters the perforated pipes were arranged
below the impeller in the form of crosses or rings.
• Orifice spargers without agitation -used in yeast manufacturing, effluent treatment and in SCP production.

Nozzle sparger

- It’s a single open or partially closed pipe, provides stream of air bubbles.
  • The single nozzle sparger causes a lower pressure loss than any other sparger and normally does not get blocked.


Sparger