Bioreactors

BOT A_SEM-V (DSE A)

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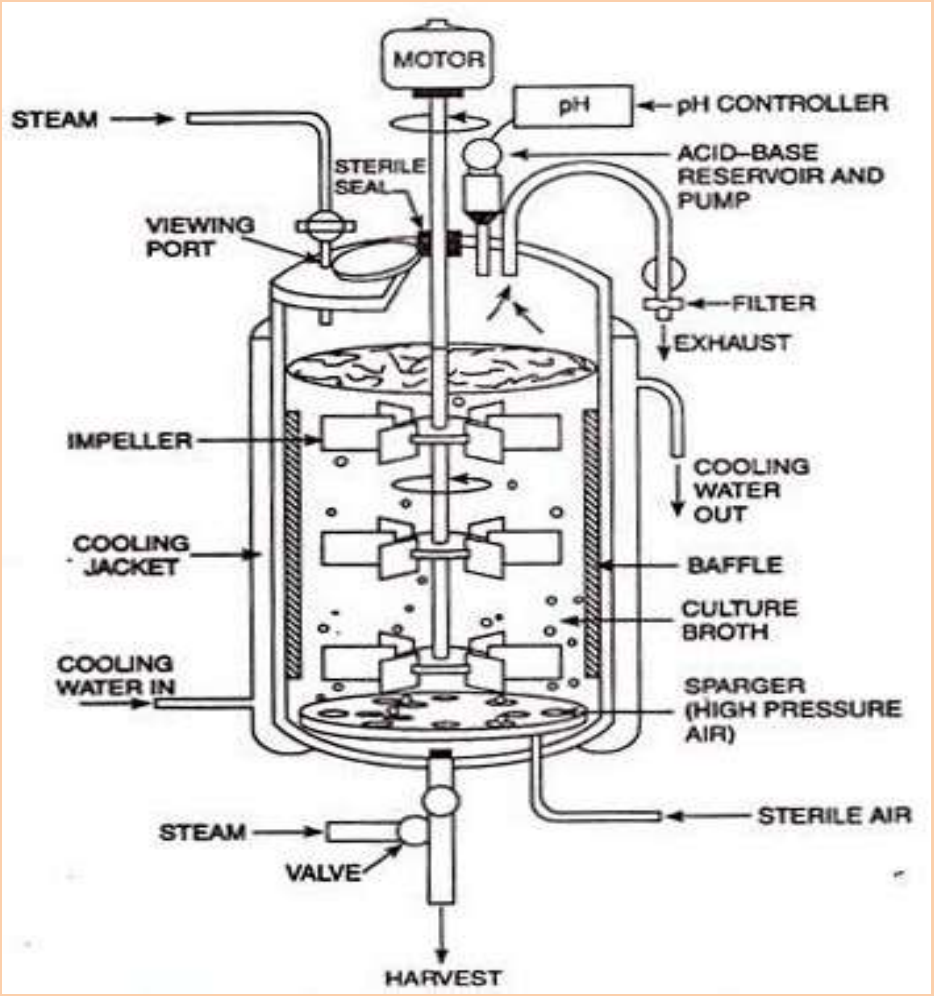
- A bioreactor (fermenter) is a large cylinder closed container designed to provide an optimum environment in which microorganism or enzymes can interact with a substrate and form the desired product.

- Bioreactors are the vessels/containers which provide biological, biochemical, and biomechanical requirements for the optimal growth of the fermenting microorganisms and/or biochemical reactions on the industrial scale for the synthesis of desired products.



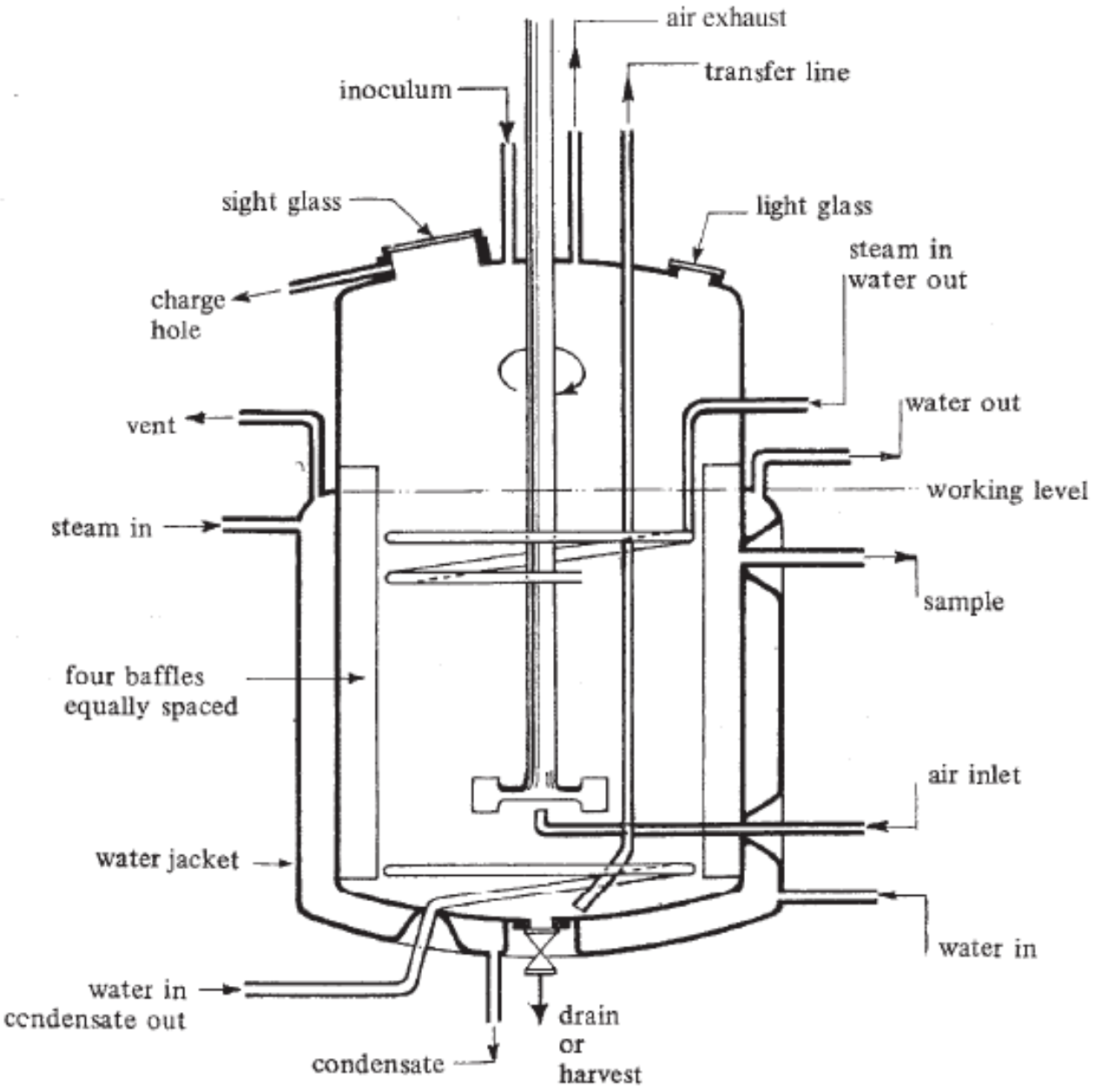
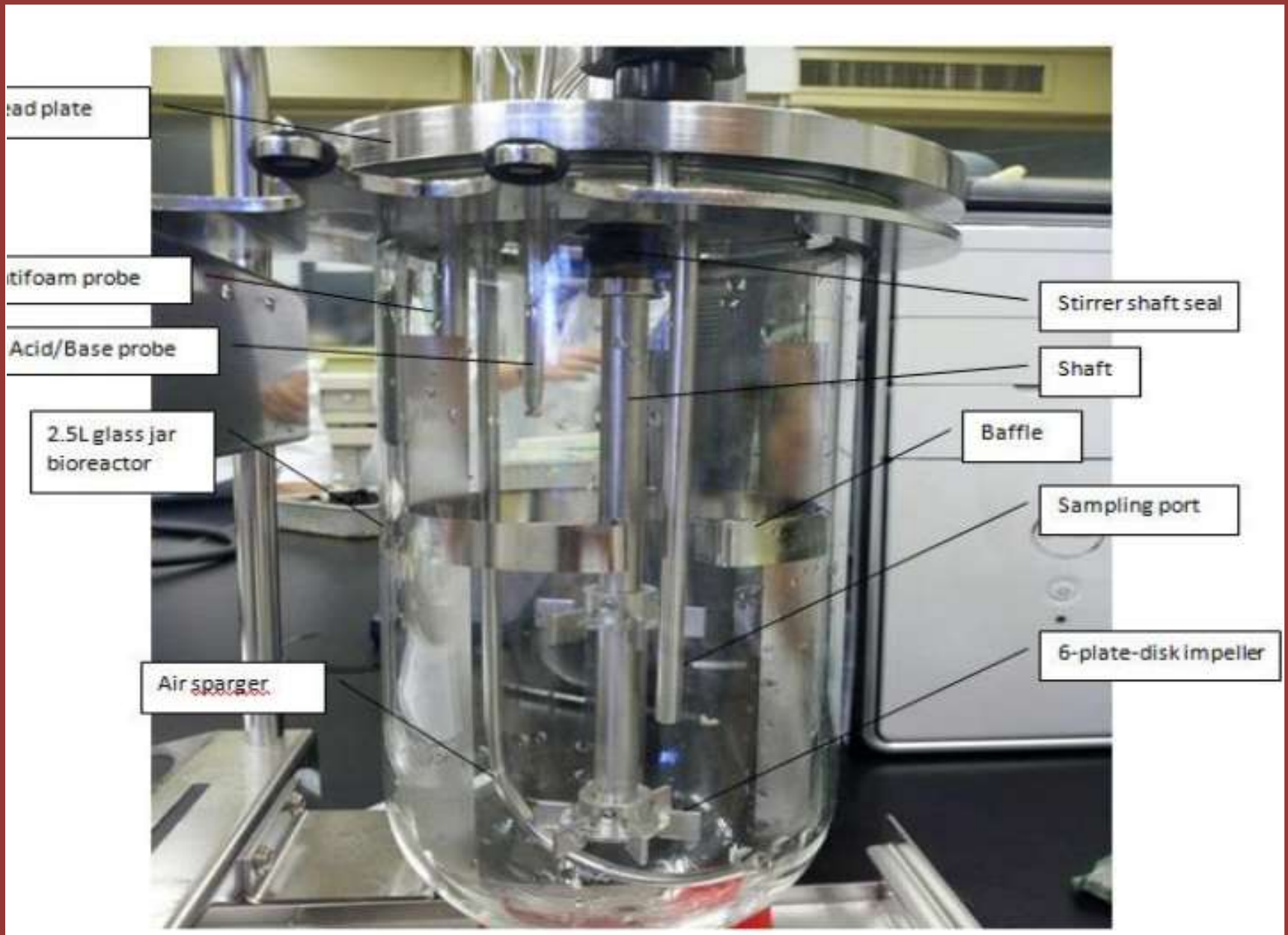


Fig. 9.1 Structure of a Typical Fermentor (Stirred Tank Batch Bioreactor)


ead plate
tifoam probe
Acid/Base probe
2.5L glass jar bioreactor
Air sparger
Stirrer shaft seal
Shaft
Baffle
Sampling port
6-plate-disk impeller

- All bioreactors deal with heterogeneous systems having two or more phases, e.g., liquid, gas, solid.

- Therefore, optimal conditions for fermentation necessitate efficient transfer of mass, heat and momentum from one phase to the other.

- Efficient bioreactors are capable of maintaining the desired biological activity by -
  - ✓Controlling the temperature, pH.
  - ✓Fluid velocity, shear stress, mass and heat transfer.
  - ✓O_2, CO_2, and nutrient supply.
  - ✓Reaction rate, and cell growth.

Basic functions of bioreactors

i. Fermenter is to provide a controlled environment for growth of a microorganism, or a defined mixture of microorganism, to obtain a desired product.

ii. The vessel should be capable of being operated aseptically for a number of days and should be reliable for long term operation.

iii. The adequate aeration and agitation should be provided to meet the metabolic requirements of the microbes. However, the mixing should not damage the microorganism.

iv. The power consumption should be low and temperature and pH control system should be provided.

v. The evaporation losses from the fementor should not be excessive.

vi. The vessel should be designed to require the minimal us of labour in operation, harvesting, cleansing and maintenance.

❖ A bioreactor should provide for the following:

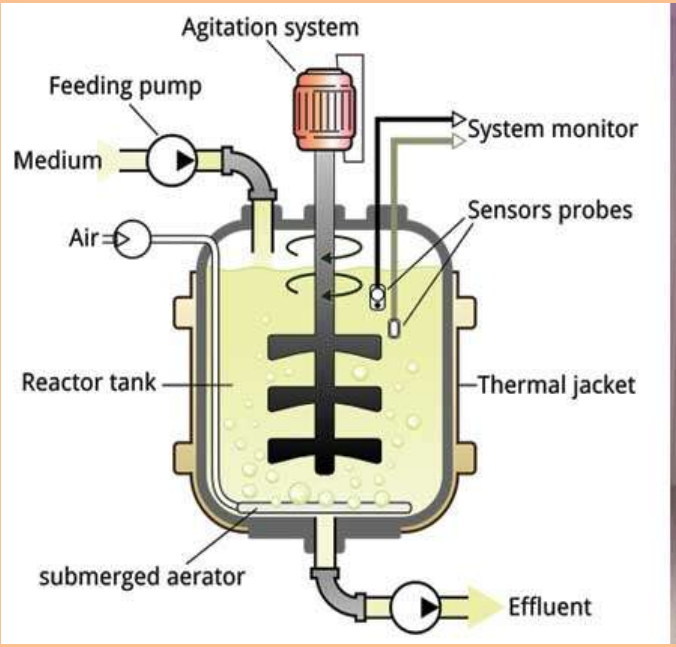
i. agitation (for mixing of cells and medium),
ii. aeration (aerobic fermenters; for O2 supply),
iii. regulation of factors like temperature, pH, pressure, aeration, nutrient feeding, liquid level, etc.,
iv. sterilization and maintenance of sterility,
v. withdrawal of cells/medium (for continuous fermenters).

Parts of bioreactor:

1. Reactor vessel
2. Cooling jacket
3. Agitator
4. Sparger

Aeration System

5. Baffles
6. Sample valve with steam connection
7. Sight glass
8. Connections for acid, alkali, and antifoam agents
9. Motor
10. Harvest nozzle
11. Controlling Devices



Temperature Control

- ✓ Heat is produced by microbial biochemical reactions and secondly mechanical agitation.
- ✓ Temperature control helps to control the temperature at the optimum level by removing or providing heat.
- ✓ Extra heat is provided by hot bath or internal heat coil or heating jacket with a water circulation system or silicon heating jacket.

Cooling jacket:

- ✓ steam (for sterilization) or cooling water (for cooling) is run.
- ✓ sterilization of the nutrient medium and removal of the heat generated are obligatory for successful completion of the fermentation in the fermentor

Agitator (Impeller)

❖ Function

✓ Bulk fluid and gas mixing, air dispersion, heat transfer, oxygen transfer, suspension of solid particles, maintain the uniform environment inside the vessel.

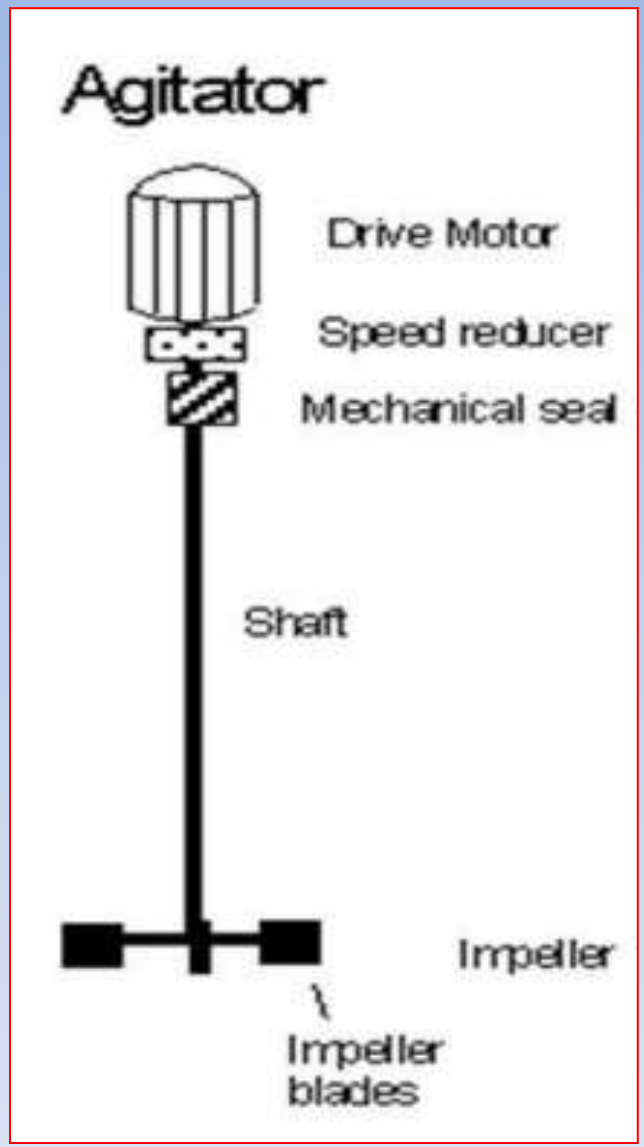
✓ It also involved in breaking the air bubbles produced in a liquid medium.

❖ Types of agitators used in industrial-scale bioreactors

➢ ***Disc Turbine*:** It consists of a disc with a series of rectangular vanes connected in a vertical plane around the disc.

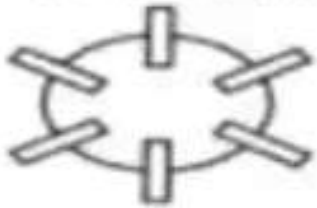
➢ ***Vaned disc*:** In this case, the rectangular vanes are attached vertically to the underside of a disc.

➢ ***Variable Pitch open turbine*:** This type of agitator lacks disc and the vanes are directly connected to a center shaft.



SIDE VIEW

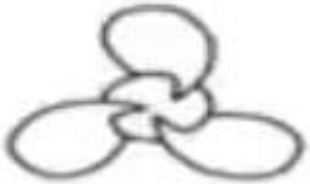
TOP VIEW



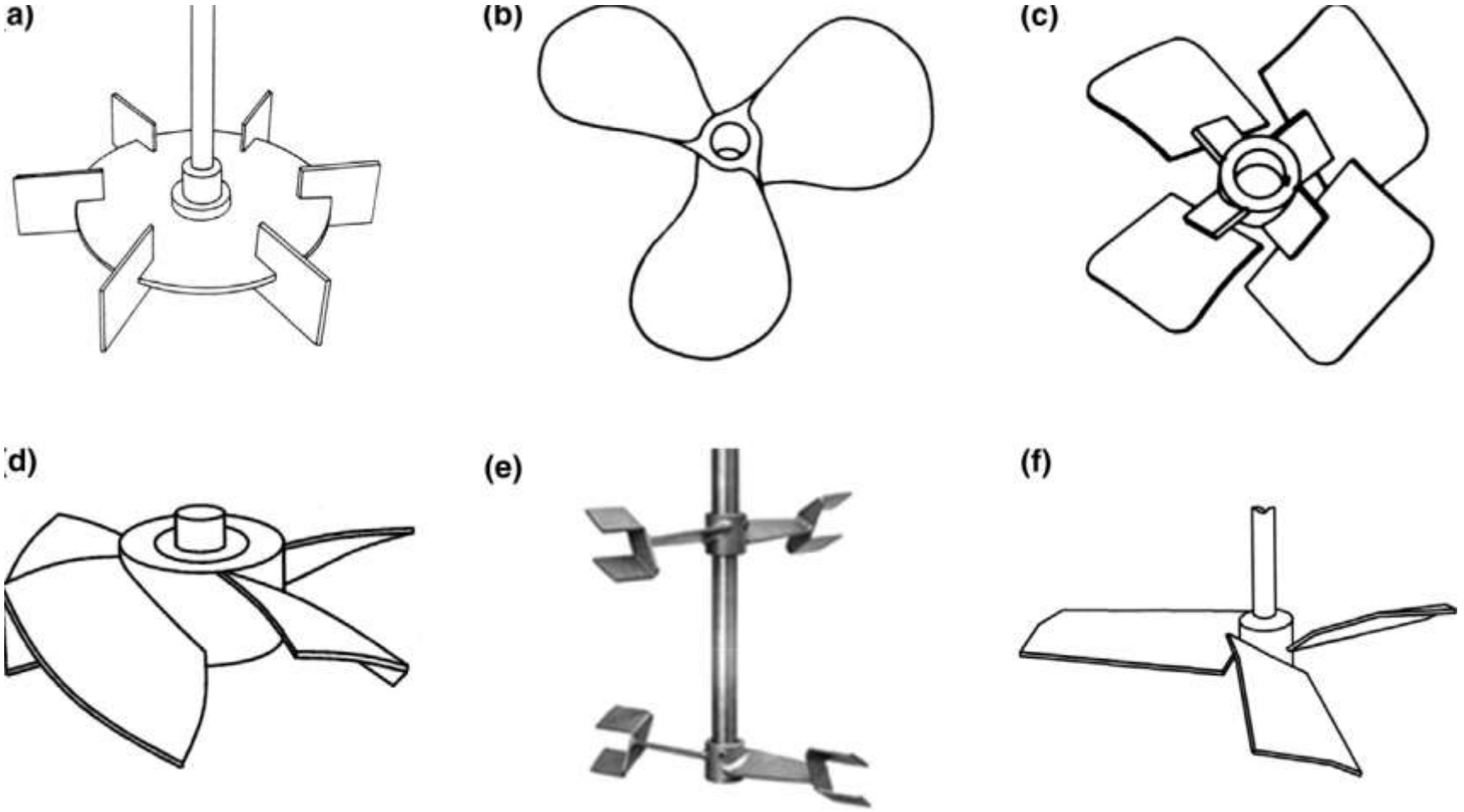
A. DISC TURBINE

B. VANED DISC TURBINE

C. VARIABLE PITCH OPEN TURBINE



D. MARINE PROPELLER



Impellers for stirred-tank fermenters. (a) Rushton disc turbine (radial flow). (b) Marine propeller (axial flow). (c) Lightning hydrofoil (axial flow). (d) Prochem hydrofoil (axial flow). (e) Ekato intermig (axial flow). (f) Chemineer hydrofoil (axial flow).

Stirrer glands and bearings

It is used to maintain aseptic conditions inside the vessel.

Stirrer shafts play an important role to seal the openings of a bioreactor. As a result, it restricts the entry of air from outside.

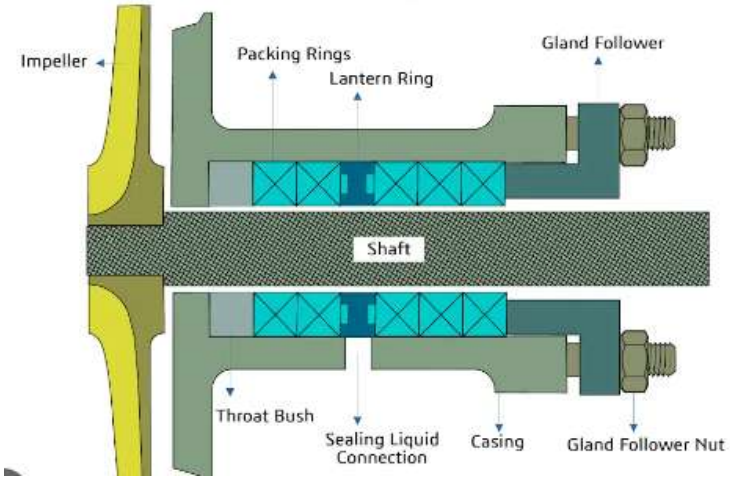
There are several types of seals used for this purpose, which are following:

The Stuffing Box: The shaft is sealed by several layers of packing rings of asbestos or cotton yarn which is pressed against the shaft by gland follower.

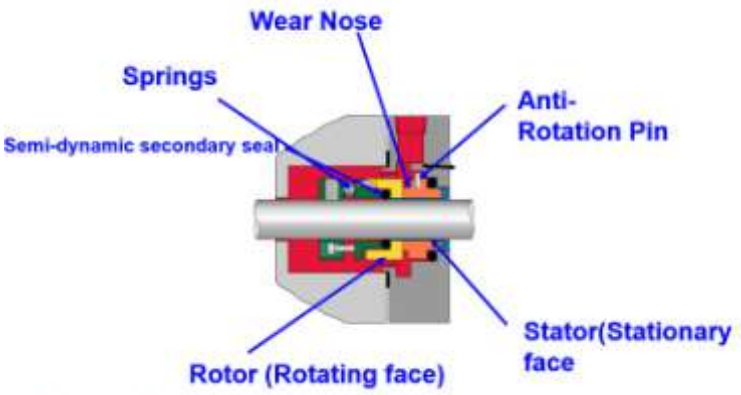
The Mechanical Seal: The seal is divided into two parts which are pressed together by springs, first is the stationary bearing housing and second rotates on the shaft.

Magnetic Drives: It is made up of two magnets one is driving (outside of the head plate) and one driven (placed one end of the impeller shaft). This type of seals helps to counter the problem originated by the impeller shaft which is going through the top or bottom of the fermenter plate.

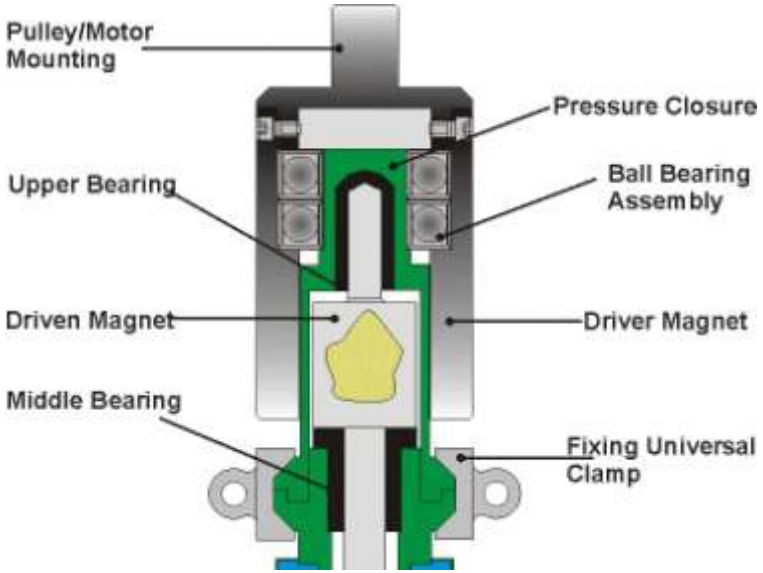
Stuffing Box



Mechanical Seal



Magnetic Drives



Baffles

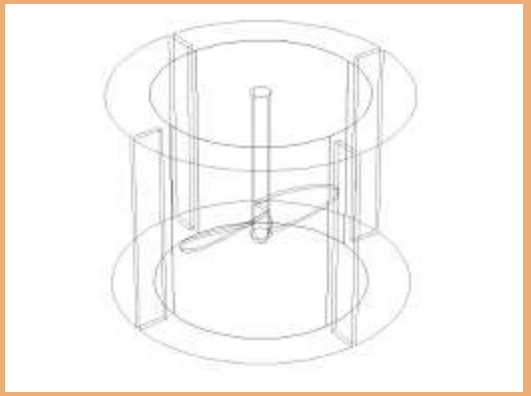
- It is made up of metal strips roughly one-tenth of the vessel diameter and attached to the wall.

- A gap is made between baffles and the vessel wall to facilitates scouring action around the baffles and minimizes microbial growth on the baffles and the fermenter wall.

✓ Baffles are used to increase the mixing efficiency inside the bioreactor

✓ prevent a vortex and improve aeration efficiency.

✓ Baffles are often attached to cooling coils to increase the cooling capacity of the fermenter.



Sparger:

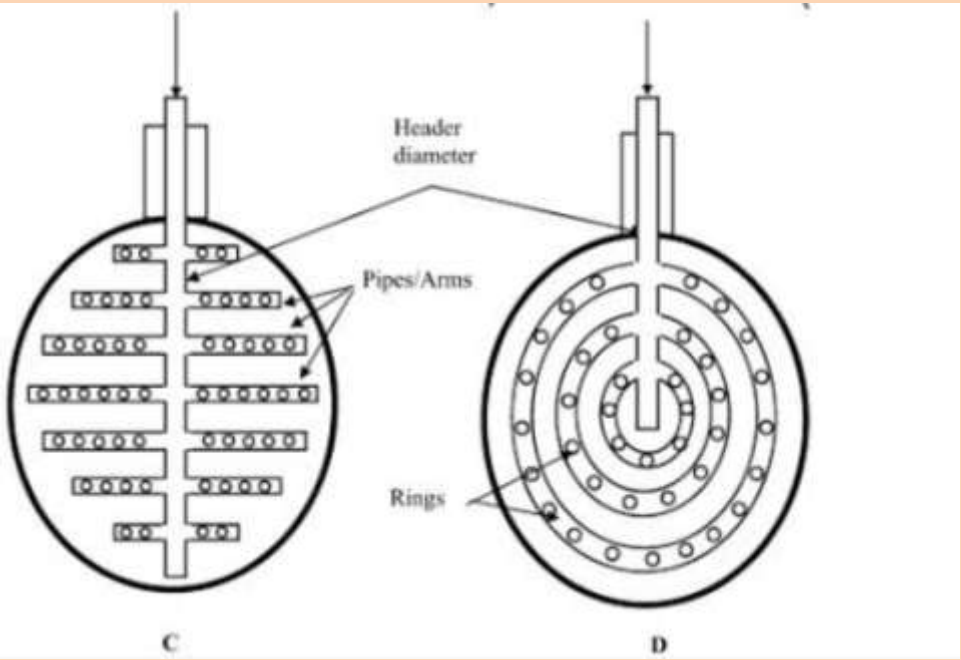
A sparger is a device that introduces air into the liquid medium in a fermenter. There are three main types of sparger used in industrial-scale bioreactors such as

Porous Sparger:

- ✓ It is made up of sintered glass, ceramics or metals' and are mostly used in laboratory-scale bioreactors (non-agitated vessels).
- ✓ It introduces air inside a liquid medium, bubbles are formed.
- ✓ bubbles are10 to 100 times larger than the pore size of the aerator
- ✓ Disadvantage of this sparger is that the fine holes becoming blocked by the growth of the microbial culture

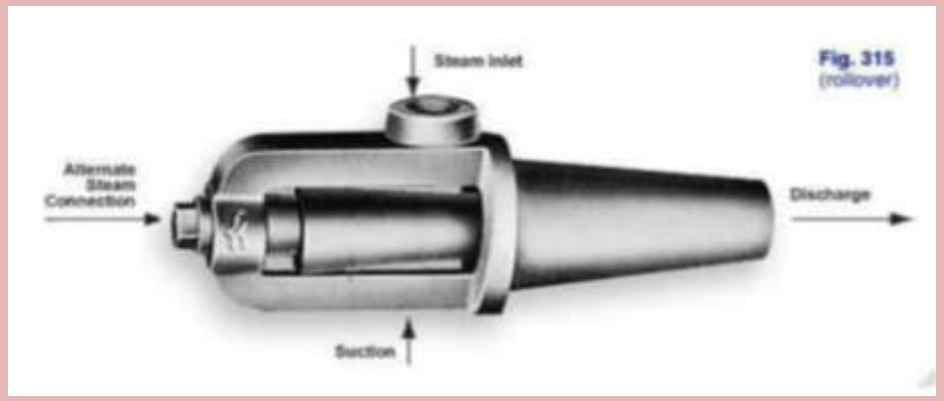
Orifice Sparger:

- ✓ It is used in small stirred fermenters.
- ✓ The perforated pipes are used and attached below the impeller in the form of a ring or crosses.
- ✓ The air holes are mostly drilled under the surface of the tubes.



Nozzle Sparger:

- ✓ It is used in industrial-scale fermenters.
- ✓ Single open or partially closed pipe as an air outlet to provide the stream of air bubbles.
- ✓ The pipe needs to be positioned below the impeller which helps to overcome troubles related to sparger blockage



Sr.	Parts of fermenter	Function
1	Impellor (agitator)	To stir the media continuously and hence prevent cells from settling down. and distribute oxygen throughout the medium
2	Sparger (Aerator)	Introduce sterile oxygen to the media in case of aerobic fermentation process
3	Baffles (vortex breaker)	Disrupt vortex and provide better mixing
4	Inlet Air filter	Filter air before it enter the fermenter
5	Exhaust Air filter	Trap and prevent contaminants from escaping
6	Rotameter	Measure flow rate of Air or liquid
7	Pressure gauge	Measure pressure inside the fermenter
8	Temperature probe	Measure and monitor change in temperature of the medium during the process
9	Cooling Jacket	To maintain the temperature of the medium throughout the process
10	pH probe	Measure and monitor pH of the medium
11	Dissolve Oxygen Probe	Measure dissolve oxygen in the fermenter
12	Level probe	Measure the level of medium
13	Foam probe	Detect the presence of the foam
14	Acid	Maintain the required pH of the medium by neutralizing the basic environment
15	Base	Maintain the required pH of the medium by neutralizing the acidic environment
16	Antifoam	Breakdown and prevent foams
17	Sampling pint	To obtain samples during the process
18	Valves	Regulation and control the flow liquids and gases
19	Control panel	Monitor over all parameters