

Heat transfer in bioreactors

Instrumentation through innovation

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SPECIAL POINTS OF INTEREST:

Mechanism of heat transfer

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A bio-technology news letter

Maintaining a fluid at a constant temperature under dynamic conditions as in a bioreactors is a complex phenomenon. The followings points are to be considered to understand the magnitude of the problem. To workout the input parameters all the material characteristics are to be known.

- The temperature difference between the hot and cold bodies.
- The geometry of the system.
- The surface area of the system concerned.
- The fluid flow conditions
- The inputs, such as air/ gases and ingredients
- Heat to be dissipated due to the processes

Equipment for heat transfer:

The exchange of heat in case of bioprocess is always between fluids that should not mix with each other.

So the fluids are Kept separated using a large surface area highly conducting metal medium. Such systems are generally called as heat exchanger. Various designs of heat exchangers are used. Most efficient are being the tube and shell type. Depending of the rate of heat transfer required the systems are designed.

Bio - Reactors:

In case of bioreactors two differing applications of heat transfer are common. The first is the insitu batch sterilization of the liquid medium. In this method the reactor

vessel containing the medium etc is heated using steam and is held at the required temperature for pre-determined time. Cooling water is applied to bring back the system to normal temperature. The processing times are dependent of the reactor size and medium quantity etc.

The second application of heat transfer is for temperature control of the system while the process is on. In this case the process heat evolved is to be removed so that the reaction is allowed to proceed with utmost efficiency at the set temperature. In order to maintain the temperature within $\pm 1^{\circ}$ cooling water is employed. The rate of flow and the temperature of the cold water source is manipulated using sophisticated electronic control incase of enzyme reactions the system are to be heated to maintain the temperature.

Mechanisms of heat transfer

1. Conduction.

The conduction occurs because of transfer of vibration energy between molecules or free electronics. This is possible where the packing density of the matter (i.e.) inter atomic distances. The process is predominant in metals and to some extent in liquids. The specific heat of the materials also play an important role. Aluminum and copper, silver and gold are good conductors in metals. Such materials are employed in designing the heat exchangers and heater as well as cooling coils.

2. Convection:

convection required movement in macro scale. Say boiling of water. As the few layers of the liquid close to the container wall take in the heat and as a result of change in density becomes lighter and moves to top. This way a convection current sets in. Heavier fluids move down close to the heat source. The thermal balance will result only when the total liquid attain the set temperature.

Radiative Heating:

Energy is radiated by Matter in the form of electromagnetic waves. When radiation is absorbed by matter, it appears as heat which in turn makes the fundamental particles of the matter absorb the energy and goes to a higher state of energy. The absorbed energy can raise the P E and K E of the particles. The increase in KE results in the heating of the medium. The increase in PE results in the emission of radiation at a different wavelength. It can be atomic, fluorescence or phosphorescence.

The resulting heat content of the medium is only of our concern for the present and quantification and control is of prime importance in this chapter. In most of the heat transfer equipment, the transfer of heat takes place across a solid metal wall that separates the hot and cold fluids.

The rate of heat conduction is given by ...

$$\phi = -K A \frac{dT}{dY}$$

Where 'φ' is the rate of heat transfer K is the thermal conductivity of the wall and A is the surface area perpendicular to the direction heat, T is the temperature and Y is the distance measured normal to A. dT/dy is the temperature gradient. The design is to indicate that the heat is always transferred from hot to cold.

$$G = -K \frac{dT}{dY}$$

Where 'Q' is the heat flux. By knowing the specific proportions if materials and required end parameters are can calculate the required heat transfer characteristics for the process and reactor design. In the last news letter the measurement and control of temperature is explained in detail. Proper heat transfer can only be achieved by having good temperature regulation and total power source control.

Our systems include a four stage control wherein, the source power i.e. either heater or compressor is controlled. Apart from this, the independent hot water or cold water circulation pumps are also controlled. Altering the circulation media dwell time increases the efficiency of the circulation system.

In our next issue:
Solid state bioreactors

We also offer projects for biotechnology students in reactor design, process control, fermentation, DSP,



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