SPECTROCHEM INSTRUMENTS PVT. LTD.

Fluid flow & mixing

Instrumentation through innovation

VOLUME:002

01/2004

SPECIAL POINTS OF INTEREST:

- **Impeller types**

INSIDE THIS ISSUE:

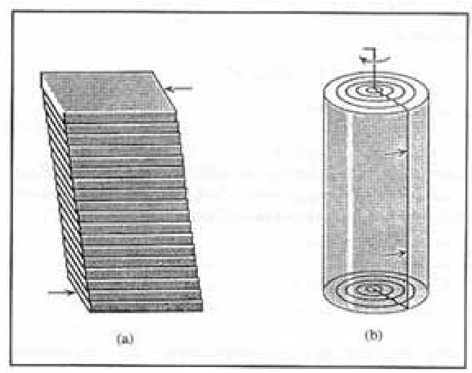
- Viscosity of fluids
- Reynold's number

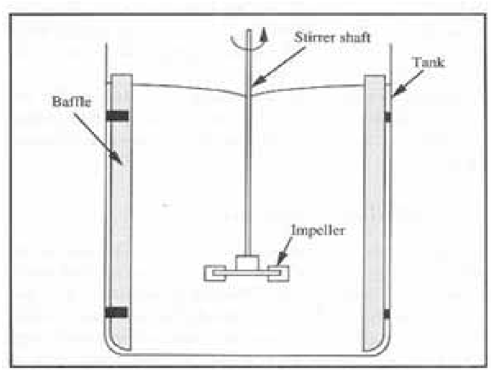
A bio-technology news letter

The properties of fluids affect process energy requirement and mixing. Incase of bioreactors and fermentor analysis of the processes is more complicated since the fluids have large amounts of suspended solids and heterogeneous. Also they affect the mass and heat transfer as well as mixing. All these phenomena often affect the cell growth since mixing controls the availability and proximity of food and other vital needs.

One can classify fluids as compressible and incompressible. Generally gases are compressible fluids and liquids are considered to be incompressible. Fluids are also classified as Newtonian or Non-Newtonian. Most slurries, suspensions and dispersions are non-Newtonian, similar to homogeneous solutions of long chain polymers and other large molecules. Since most of the fermentation processes consume/contain starches extra cellular polysaccharide and culture broths containing cell suspensions, they are non-Newtonian. Fluids are also classified on the basis of viscosity. Viscosity is the property of the fluid responsible for internal friction during flow. All real fluids have finite viscosity and are generally termed as viscous fluids. Viscosity is related to the fluid resistance to flow. So viscosity has a marked effect on pumping, mixing mass transfer heat transfer and aeration in bioprocesses. Also viscosity is an important aspect of rheology, (i.e.) the science of deformation and flow. Laminar deformation due to planar shear and rotational shear can be easily under stood by the following figure.

Slow or steady fluid flow is called streamline or laminar flow. Incase of fast motion the fluid particles frequently cross and re-cross the stream lines and is called Turbulent and is characterized by the formation "eddies". The transition from laminar to Turbulent depends on velocity, viscosity, density and the geometry of the flow conduit. A useful parameter to characterize the fluid flow is the Reynolds number defines as





$$R_e = D\, u\, \rho/\mu$$

Where D is the pipe dia, **u** ave- rage linear velocity, **ρ** is the density and **μ** is the viscosity. Incase of fluid flow in stirred vessels it is defined as

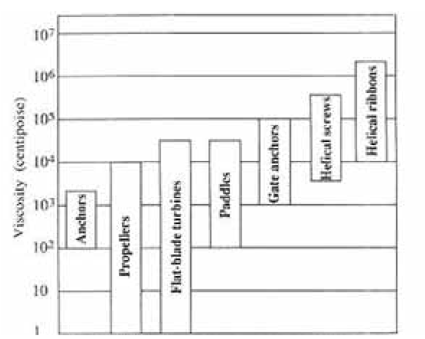
$$R_{ei} = N_i \; D^2_i \quad \rho/\mu$$

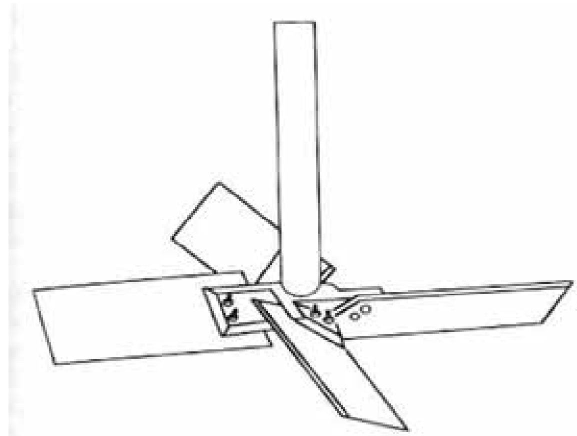
Where R_{ei} is the impeller Reynolds No, Ni is the stirrer speed, $\mathbf{D_i}$ is the impeller diameter, ρ and **µ** are density and viscosity.

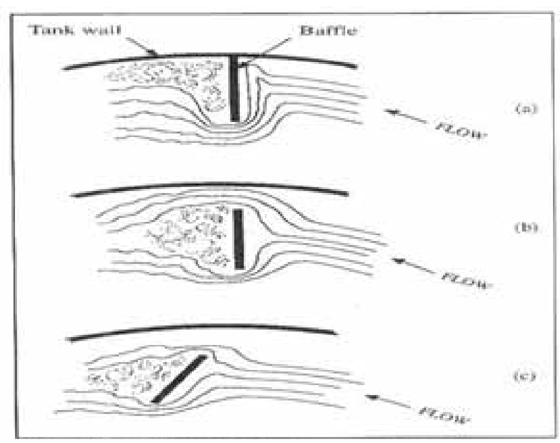
To achieve the required degree of mixing of the fluids and to maintain mass and heat transfer under reasonable control the fermentation or bio-reactor tanks are constantly stirred. Various designs are employed depending on the specific requirements. Basically the tank is a closed cylindrical glass/steel vessel the base of which is rounded at the edges. This way stagnant regions are eliminated. The tanks are fitted with baffles and various types impellers as illustrated in the picture stirred tank reactor.

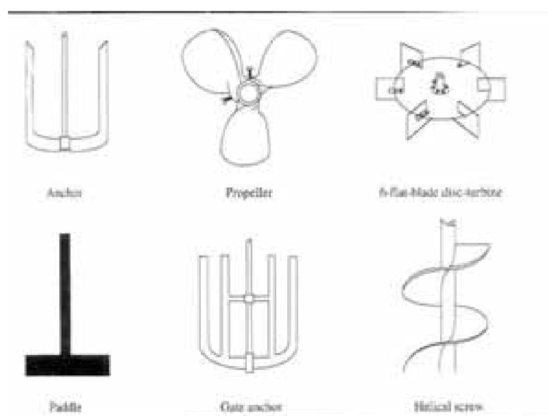
Mixing time is a useful parameter for assessing the mixing efficiency. The mixing time 'tm' is the typical time required to achieve a given degree of homogeneity starting from completely segregated state. Incase of small reactors i.e. less than 1 cubic meter the time is less than 10 sec. And in large vessels i.e. 1 to 100 m^3 it can vary from 30 to 120 seconds.

Also the power required for mixing (i.e.) to drive the motor is dependent on the viscosity, density and the Resistance offered by the fluid to the rotation of the impeller.









In our next issue:
pH and its control

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

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