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The Downflow Gas Contactor Reactor

A Brief Introduction

The DGC reactor is one of the most efficient mass transfer devices for contacting liquids and gases. It has evolved from a novel concept of contacting a liquid continuum and a dispersed phase. An intense shearing of the dispersed phase is induced with a minimum expenditure of energy over that required for motive power. Where the dispersed phase is a gas or another liquid, an enormous interfacial area is generated in a small containment volume.

The interface is subjected to rapid surface renewal through repeated rupture and coalescence, resulting in intense mixing and highly efficient mass transfer. High interfacial areas are produced by exploiting a controlled hydrodynamic flow regime and do not require mechanical aids such as stirrers or baffles. In the case of the DGC, not only has the performance been improved but operational and capital costs have also been substantially reduced.

Many industries require gas/liquid contacting in a wide range of processes and some typical examples where the DGC can be beneficial, are:

Gas Absorption, Stripping, Flotation, Ozone Treatment, Micro-bubble Generation, Oxidation, Catalytic Oxidation, Hydrogenation, Heterogeneous Reactions, Effluent Treatment, Carbonation, Fermentation, Oxygenation, Mineral Separation etc.

The Concept

The DGC consists of a column, the dimensions and configuration of which depend on the application and operating conditions. The novel feature of the design is the downward co-current flow of the dispersed and continuous phases through a specially designed entry zone at the top of the column. As the continuous phase expands into the column, part of the kinetic energy imparted to the fluid on its passage through the entry section is used in the formation of interfacial area. The intense turbulence and shear at the interface results in efficient gas-liquid mixing and allows mass transfer operations to approach equilibrium in very short contact times.

A Brief Description

The DGC is a downflow co-current device and consists of a cylindrical upper section with an inverted conical lower section with a specially designed entry section (at the top), allowing both liquid and gas inputs into the reactor. Liquid enters the top of the column in the form of one or more high velocity liquid streams. Gas may be introduced into the system at any point in the column although the usual method is to feed the gas into the incoming liquid stream immediately prior to the column inlet through the entry section concurrently. The high velocity liquid passing through the entry section generates intense shear and energy.

The specific shape, dimensions and configuration of the DGC reactor depend on the application and operating conditions required. A model DGC could be designed and operated to take into account all variations of operating conditions and applications. The DGC Reactor system also includes a pump and receiver connected together with necessary piping. Suitable control systems (for heating, cooling, dispersion level, pressure, liquid flowrate control etc.) are included as required.

Mode of Operation of the DGC

The DGC reactor is a mass transfer efficient gas-liquid contacting device, where the gas and liquid stream are introduced co-currently through an entry zone at the top of a fully flooded column.

The high velocity liquid jet inlet stream, generating intense shear and energy, produces a vigorously agitated gas-liquid dispersion in the upper section of the column.

This shear causes the break-up of any gas pocket at the inlet and allows the formation at the top of the column, of a vigorously agitated gas-liquid dispersion with an enormously high interfacial area in a small operating volume. It also prevents the formation of a permanent gas space at the top of the column thus maintaining a fully flooded situation.

The high degree of intense shear and turbulence caused by the incoming liquid jet, induces intense mixing and efficient mass transfer as well as constant surface renewal. The downflow liquid velocity in the column is maintained at a value below the rise velocity of the gas bubbles so that there is no tendency for the bubbles to be carried downwards. Hence, there is no net movement of the gas phase whilst the liquid phase flows downwards through the inter-bubble spaces.

The gas-liquid bubble dispersion slowly expands (Figure 1) down the fully flooded column and the level of dispersion, and thereby volume of the gas-liquid dispersion, can be controlled by control of the operating conditions (liquid and gas flow rates).

In the lower section of the column as the dispersion proceeds downwards, there is a degree of bubble coalescence since it is no longer within the region of direct inlet steam impingement. This coalescence produces larger bubbles, which rise up the column where they are broken up by the shear of the high velocity inlet liquid jet.

Figure 1 - Bubble Dispersion in the DGC

Typical bubble dispersion achieved in the DGC is shown in Figure 2. The picture shows the stable bubble matrix formed, which contains nearly uniformed sized bubbles and results in a distinct gas-liquid interface.

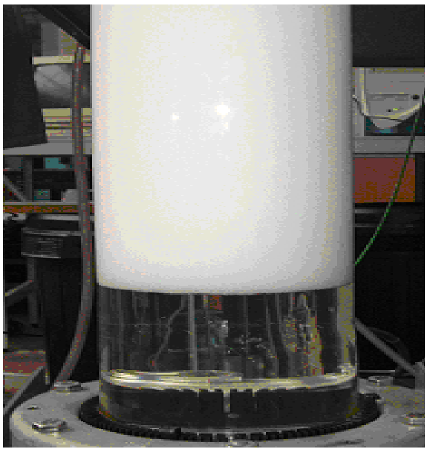

Figure 2 - The Gas/Liquid Interface

The gas/liquid mixture is maintained at a desired level within the Reactor therefore preventing the entrainment of gas bubbles through the outlet of the reactor and ensuring complete gas utilisation.

The inverted conical lower section (Figure 3) is to protect bubbles from leaving the DGC as an added insurance for 100% gas utilisation.

The intense turbulence, good mixing and high gas hold-up within the bubble dispersion, accounts for the efficient mass transfer performance of the DGC.

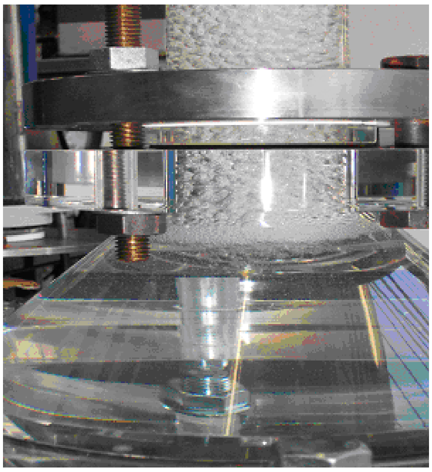

Figure 3: The Cone Section Outlet

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