Sustainable Technosolutions for Environmental Protection (STEP) Pvt. Ltd.

GREEN TECHNOLOGIES AND SERVICES

STEP specialises and works in following areas of green technologies:

- ✓ **COLUMN CHROMATOGRAPHY – for recovery and purification of chemicals**
- ✓ **SUSTAINABILITY AND PROCESS INTENSIFICATION- converting batch reactions to continuous**
- ✓ **DOWNFLOW GAS CONTRACTOR (DGC)- for Effluent Treatment, Biogas Upgradation & Chemical Reactions**

COLUMN CHROMATOGRAPHY

Industrial effluents may contain difficult to degrade chemicals e.g. nitrogen containing chemicals viz. aniline, Di Methyl Formamide (DMF); and aromatic chemicals like Methylene Di Chloride (MDC), Ethylene Di Chloride (EDC). Such chemicals are difficult to treat biologically and require pre-treatment/ anoxic treatment/ external bio-cultures etc. Uncontrolled entry of such chemicals into biological reactor can destroy biological sludge.

Effluent streams generated in manufacturing process may contain raw materials/ solvents/ by-products/ main product. We identify such streams, and explore the possibility of separating & recovering the chemical with column chromatography using adsorption-separation technology. We develop the process using commercially available adsorbents.

This approach not only helps in recovery/ reuse of the chemical but also reduces the cost of effluent treatment. These adsorbents can be a better alternative to activated carbon, which is commonly used in chemical industry, since the adsorbent can be regenerated & reused over several cycles, while activated carbon is generally for single use.

We have developed processes for colour removal of chemical streams using adsorbents; whereby activated carbon used can be replaced.

STEP conducts proof of concept studies and optimizes the process using column chromatography. We provide report with techno-economic feasibility data; and also provide support in scale-up of the process to pilot/ commercial plants.

SUSTAINABILITY AND PROCESS INTENSIFICATION

Process Intensification (PI) is an engineering development that leads to a substantially smaller, cleaner, safer and more energy efficient technology. PI helps to improve productivity and reduce waste generated in chemical operations. We assist our clients in this area through initiatives listed below:

- ✓ **Convert batch reaction into continuous mode with appropriate reactor design**
- ✓ **Use newer technologies like cavitation (for crystallization & milling) & chromatographic separation (for purification or colour removal) for downstream processing**
- ✓ **Explore new route of synthesis or use novel catalyst for shorter batch time/ higher yield.**

PI approach can reduce resources consumed & waste generated, thereby leading to sustainability approach & lower cost of production.

STEP has demonstrated PI through following projects, which have been established in lab trials and some of them are being scaled up to pilot level with objective of commercializing them.

- ✓ **Chemical Reaction** Batch process to continuous using fixed bed reactor with higher productivity & yield, lower time and improved product quality.
- ✓ **Milling** of specialty chemicals to produce desired range of fine particle size distribution
- ✓ **Colour removal** from crude stream to produce improved quality product; eliminating use of activated carbon
- ✓ **DGC reactor** for an oxidation reaction to produce aldehyde with high conversion & selectivity (~95+%) in a short time vs. conventional process.

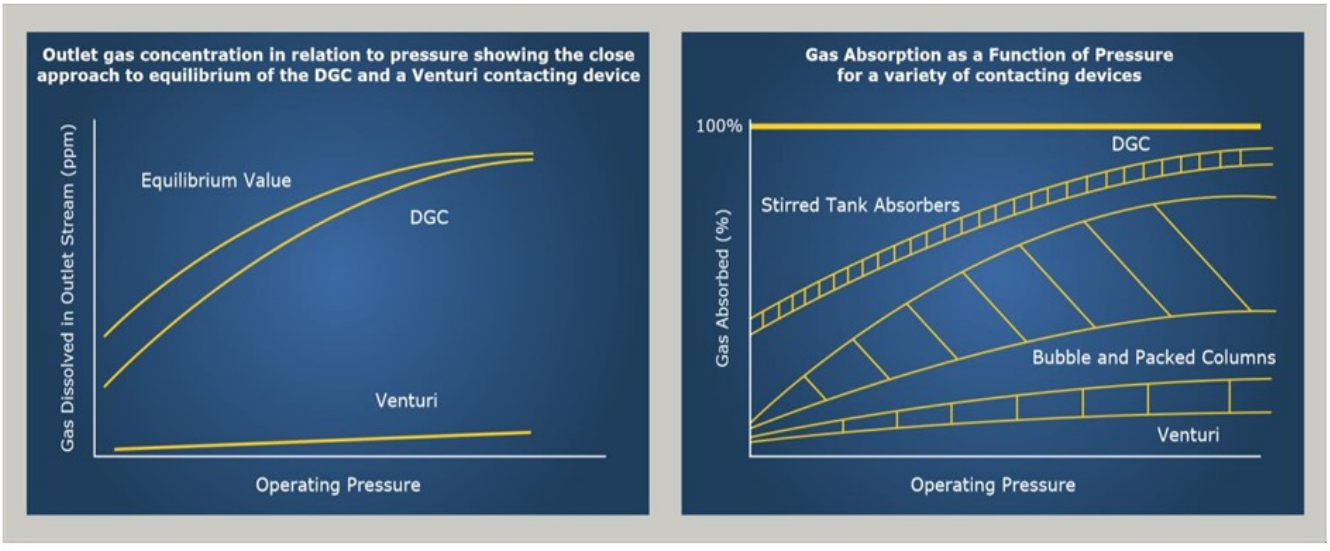
Downflow Gas Contactor (DGC)

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. Liquid and gas are introduced co-currently through a specially designed inlet (SDI) at the top of a fully flooded column. The high velocity liquid passing through the inlet generates intense shear and energy input to the system.

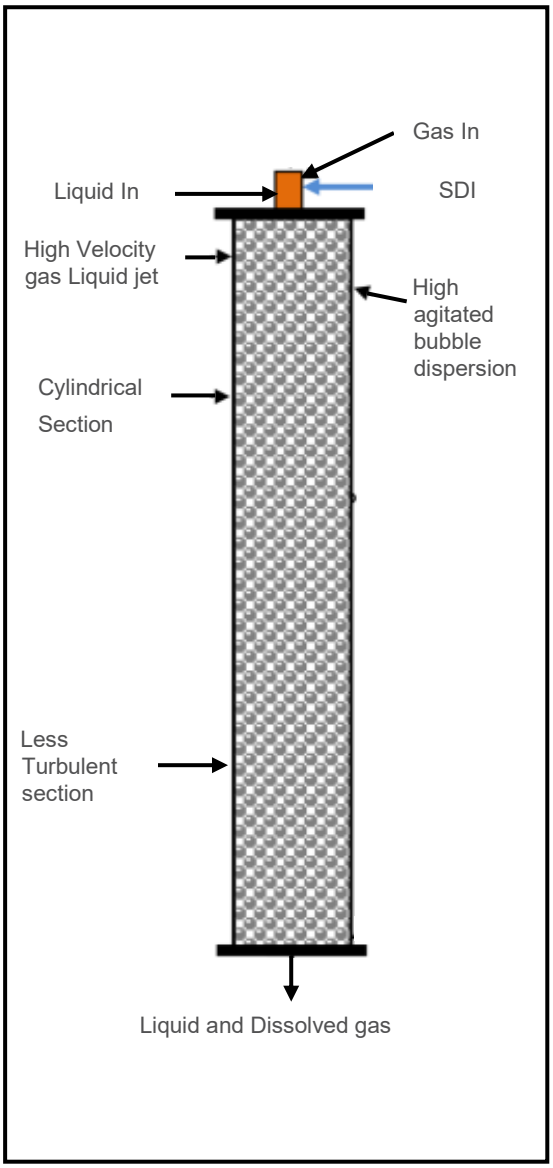
The high degree of intense shear and turbulence caused by the liquid jet, induces intense mixing, good gas-liquid contact, efficient mass transfer as well as constant surface renewal. The gas-liquid bubble dispersion slowly expands downward along the fully flooded column and the level of dispersion (and thereby volume of the gas-liquid dispersion) can be controlled by control of operating conditions (liquid and gas flow rate).

Bubble coalescence occurs as the dispersion proceeds downwards, with the formation of larger bubbles, which rise up to the top the column and are again broken up into smaller bubbles by the shear of the high velocity inlet liquid jet.



DGC Features

- Single stage system, compact and flexible design
- Easy to retrofit or can be used as stand-alone system. Easy to scale up
- Small operating volume & small footprint
- No internal moving parts or baffles
- Flexibility of operation – Can be operated at high pressure/ temperature
- Inherently safe
- Batch or continuous mode operation
- Close to 100% Gas utilisation, higher gas hold-up (40-50%)
- Greater than 95% approach to equilibrium in very short contact time
- High and accurate control of interfacial area (1000–6000 m^2/m^3)
- No free gas-liquid interface - No foaming
- Tolerance to particulates



STEP has set up DGC pilot unit in association with Snowtech Equipment Pvt. Ltd., Navi Mumbai This set-up has been successfully used for studies on treatment of industrial effluents with air or combination of air-H_2O_2-UV.

STEP has set up a pilot plant in association with **United Envirotech Pvt. Ltd., Pune** for biogas upgradation (CO_2 & H_2S removal). This is based on WRK's patented technology using a proprietary water-based solvent-ABSOLV, which can be regenerated and reused. This application is being scaled-up and commercialized.

Advantages of DGC over Competing Technologies		
Biogas upgradation- CO_2 Capture	Effluent Treatment	Chemical Reaction
• **Environmental friendly water-based solvent**- ABSOLV used. • **Single solvent** - ABSOLV can capture both CO_2 & H_2S from biogas in single stage. It can be regenerated & reused. • **Compact size** – Plant footprint will be smaller compared to conventional process plant. • Process is operated at atmospheric temperature & pressure. If required, it can be operated at higher pressure for better efficiency. • Captured CO_2 can be recovered and bottled into cylinders or utilized for chemical reactions. • **High efficiency & performance**- 99% CO_2 can be removed and biogas obtained will have 99+% methane	• **Versatility** – Can treat wide range of effluent stream, and land-filled leachates using air, H_2O_2 & UV combination. This includes recalcitrant/ difficult to degrade chemicals. • **Unique characteristic** – COD/ BOD can be reduced even in presence of high TDS (>100000 ppm) • **Shorter treatment time-** Time required to reduce COD to specific level can be significantly lower than biological treatment. • **Smaller footprint-** Due to compact size; it is useful for small scale units, which have space constraint • **Lower operating cost-** As air is sucked in from atmosphere, compressor is not required. Operating cost is mainly for pump + UV and H_2O_2, if used.	• **Faster reaction**- Mass transfer rate is higher due to fine gas bubbles & higher gas dispersion. • **Lower raw materials usage**- Amount of catalyst, solvent and raw materials used in a process can be reduced. • **Lower waste**- Conversion and selectivity to main product can significantly improve, thereby reducing by-product/ waste produced. • **Continuous process**- Reaction can be carried out in continuous mode, thereby improving the productivity and reducing utilities used. • **Lower operating cost**- Due to higher productivity, shorter reaction time, smaller size and high selectivity to product; the operation cost will be lower.

DGC Industrial Applications

- **GAS-LIQUID AND LIQUID-LIQUID REACTIONS-** DGC can be used for range of gas-liquid reactions viz. Hydrogenation, Oxidation, Carbonylation, Ammonolysis, Ethoxylation, Chlorination etc. as well as liquid-liquid reactions viz. biodiesel production
- **BIOGAS UPGRADATION**- For capture & removal of CO_2 & H_2S, to produce high quality biomethane
- **GAS ABSORPTION**- Carbon-dioxide capture from flue gas/ petrochemical stream, Ammonia recovery from gaseous/ waste streams.
- **EFFLUENT TREATMENT** - COD/ BOD reduction, Wet- air oxidation, Land-filled leachates.

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