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# EXPERIMENTAL INVESTIGATION OF MICROEMULSION IN A SPLIT CYLINDER SPARGED REACTOR

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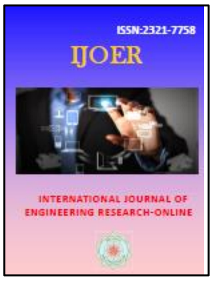

## ABSTRACT

Many industries such as oil refineries, metal, cosmetics, food industries, petrochemical and petroleum production usually produce a wastewater containing emulsions of oil in water. Because of toxic nature, important effects and different kinds of oily wastewater on the surrounding environment soil, water, and necessary to treat the wastewaters before sent to the environment. Methods to treat the waste water such as adsorption, hydro cyclones, sedimentation, biological treatment and dissolved air flotation. Treatments of oily waste water are not suitable for Conventional treatment methods. This can overcome by Split cylinder sparged reactor. Split cylinder sparged reactor is a modified type of bubble column in which the internal structure is divided into two separate sections by a baffle split which is the riser and down comer. An extensive literature survey has been the carrier at to study the split cylinder sparged reactor. Conventional multiphase reactors like bubble column, jet-loop reactors, gas lift reactors are not suited for treatment of oily based effluent. Any improvement made in the conventional multiphase reactor may be employed to treat the oily based effluent. The objective of the present work is to perform to treat the oily based effluent by novel split cylinder sparged reactor. For this purpose experiments will be carrier at in 0.15m diameter, if the height of column 0.61m, the height of the baffle 0.51. In our study, volumetric flow rate varies (0-1200lph) the calculate the hydrodynamic parameters such as Gas holdup, Pressure drop, Reynolds number, Friction factor, and Power were determined.

*Keywords:* Split cylinder sparged reactor, gas holdup, pressure drop, microemulsion.

## I. INTRODUCTION

Split cylinder sparged reactor is a modified type of bubble column in which the structure is divided into two separate sections by split the baffle inside the column, which is riser (upward) and (downward) downcomer. The conventional treatment methods are not suitable to treat oily waste water. This can overcome by Split cylinder sparged reactor. The gas hold-up (ε) difference between the initial height of stagnant liquid to dispersion height of liquid of an airlift reactor creates a density difference as a driving force for circulation of microemulsion liquid. Since the upper limit of permissible oil in the effluent is steadily reduced by governing bodies, industries have to improve the treatment plants to meet the new limits. The oil-in-water emulsion is a colloidal dispersion of oil droplets in an aqueous medium. These droplets have a tendency to coalescence and separate from the aqueous phase. One of the useful equipment that can treat wastewaters is the split cylinder sparged reactor. Most of the published works on airlift bioreactors have been on air-water based systems with properties different from the real conditions of the aerobic bio desulfurization (BDS) processes. S.B.Sawant et al. (1979) [15] Gas hold-up in the packed bubble column, investigates the effect of velocity and height of dispersion column. B.G.Kelkar et al (1983) [14] Five aliphatic alcohols were investigated with concentration varying from 0.5 weight percentage to 2.4 weight percentage. For dilute aqueous solutions of aliphatic alcohols, observe the length chain of alcohol increase in the gas holdup. This was found for the batch as well as continuous bubble columns. E.Molina et al (1999) [13] A linearly increased by homogeneous bubbly flow, where the gas holdup and velocity. F.P.Shariati et al (2006) [11] amount of surfactant on the hydrodynamics and mass transfer inside a draft tube air lift reactor was studied in order to correlated that can be used for design of DTAB employed in diesel biodesulfurization processes. M.Asgharpour et al (2010) [10] dynamic method was measured using a volumetric mass transfer coefficients of oxygen between air and water for various gas aqueous organic systems. M.K.Moraveji et al (2011) [09] Alcohols addition minimize bubble size, to change gas holdup, mass transfer interfacial area, mass transfer coefficient higher. M.Y.Chistit et al (1987) [08] Gas-liquid or gas-slurry reactors are used in aerobic fermentations. Increased power inputs lead to smaller bubbles, however, coalescence also became important at higher bubble densities and tended to break up the offset bubbles resulting from the force due to dynamic pressure increases. Khare.A.S.et al. (2006) [07] it has been observed that the addition of fine particles increases the fractional gas hold-up, It also increases with an increase in the non-coalescing behavior of the liquid phase. Jha.A, Raj Mohan.B et al. (2008) [29] the rate of increase of gas holdup for a fixed concentration of the solution is independent of the level of water in the column and dependent upon a type of sparger. A.A.Al Shamrani et al (2002) [01] dissolved air floatation in a separation of oil droplet from a synthetic wastewater to enhance the efficiency, opitimized and to improve the understanding of separation mechanism in terms of zeta potential measurements. A.K.Hashmi et al (2004) [02] that can be used for the treatment of wastewater. A slop oil stage 2 hydro cyclone system was set up, hot water was added in-line and an in-line static mixer was installed to ensure mixing of slop oil and water. Bench-scale test results indicated that the slop oil contained 20% or more oil (by volume) and must be diluted to maintain 15–20% oil in order to effective separation achieved the hydro cyclone. M.J.Ayotamuno et al (2004) [03] Adsorption isotherms were derived from the two forms of activated carbon used, namely granular activated-carbon (GAC) and powdered activated-carbon (PAC). It reveals that the powdered form of activated carbon is more effective than the granular form. A.Cambiella et al (2006) [04] Oil-in-water (O/W) emulsions have industrial applications in the metalworking industry in operations such as forming, rolling, machining and alkaline degreasing. A wide variety of additives: emulsifiers, corrosion inhibitors, extreme pressure agents, biocides, antifoam compounds. Efficient method as secondary treatment, compared to gravity settling treatment of waste emulsified oils by centrifugation {attractive method}. X.Zhao et al(2006)[05] As an alternative to the conventional activated sludge (CAS) process, this paper investigates the use of microorganisms immobilized on carriers in a pair of Biological Aerated Filter (BAF) reactor to pre-treat oil field wastewater before desalination.

## II. EXPERIMENTAL DETAILS

In this experimental investigation of a split cylinder sparged reactor assemblies were fabricated using transparent acrylic materials {sheets/cylinders}. First one was a cylindrical column insert the baffle inside the reactor column having specifications as mentioned in Table 1.

**Table 1 Specifications of columns**

| Columns and Notations | Parts | Specifications, cm | | | | C/S Area,$cm^2$ |
|---|---|---|---|---|---|---|
| | | ID | OD | H | T | |
| A Split Cylinder Sparged Reactor (SCSR) | Column | 14 | 15 | 61 | 0.5 | 154 |
| | Baffle | 14 | - | 51 | 0.5 | |

ID-Inside Diameter, OD-Outside Diameter, Height, T-Thickness

### A. A Split Cylinder Sparged Reactor (SCSR)

The experimental setup of a split cylinder sparged reactor is shown in Figure.2.1, it consists of a transparent cylindrical column and one baffle having specifications as given in Table 1. The baffle used in this investigation was placed a center of the column and held using an insert tightly chloroform paste mechanism. The gap between the baffle and the column was uniform on two sides throughout the length of the baffle. Small thin square acrylic pieces to be heated, bend the pieces were also pasted at end of baffle. The ceramic pall ring packing material was mounted left side of riser section. The top and bottom of the baffle clearance 0.5m of reactor column.

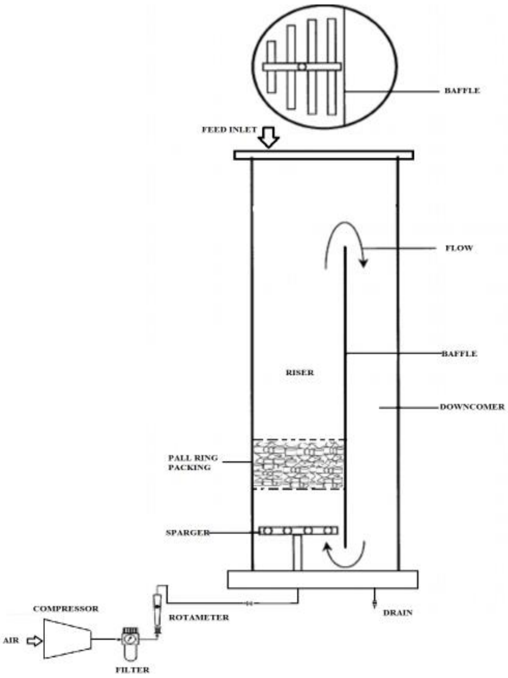

**Figure. 2.1 Schematic of experimental setup of an SCSR**

The air was sparged into the column through gas sparger that was fixed at the base of the column using thread and bolted assembly. Holes were fitted on the all side tighten the assembly so as to prevent gas and liquid leakage during experiments. This arrangement also helped vertical mounting of the column on the main stand as shown in Figure.2.2 (g). A gas chamber beneath the sparger ensured the uniform distribution of air through sparger as shown in Figure.2.2 (c). A hole was also drilled in the bottom of this round plastic sparger for the entry of air from the compressor into the column.

(a) (b) (c) (d)

**Figure.2.2 (a) Baffle attachment (b) Rotameter (c) Gas Sparger and (d) Acrylic Nipple**

(e) (f) (g)

**Figure.2.2 (e) Sampling valve, (f) Air control valve (g) A SCSR mounted on stand & Manometer**

**Figure. 2.2 Snapshots of a split cylinder sparged reactor and its parts**

The air was supplied by using the single stage, air-cooled compressor. This compressor was equipped with a 45 liters horizontal tank complete with a safety valve, air gauge, and drain valve. The maximum compressor capacity was 10kgf/cm$^2$ and minimum pressure 2kgf/cm$^2$ was to deliver at reactor column. Air flow was regulated at constant pressure, using the pressure regulator and measured using calibrated rotameter working in the range of 0-1200LPH. A Graph sheet was mounted behind the column for measurement of liquid level and also gas holdup the measurement. Microemulsion liquid samples required for various analyses were drawn through a sampling valve located at the bottom of the column. Figure.2.2 (e) shows the valve, fitted into the turnings made in a copper nipple, which was then fixed on the bottom of the column. A Mseal and Teflon tape were used in the acrylic based mounting assembly of a sampling valve to avoid any leakage. Chisti and Moo-Young [12] discussed by (1987) gas spargers exist in the literature. However, for biotechnological applications the perforated plate and to a lesser extent the porous plates are most commonly used. In this work plastic type spargers having a same number of holes, the diameter of holes and pitch were used for a hydrodynamic study of Air-Water system, and Kerosene- Water system in a Split Cylinder Sparged Reactor. The specifications of the plastic type spargers used are given in Table 2. Plastic type sparger is also shown in Figure.2.2(c).

Table 2. Spargers and their specifications for a SCSR

| **Sparger** | **Sparger specifications** | | |
|---|---|---|---|
| | **$N_h$, Number of holes** | **$d_h$, Hole diameter, mm** | **$P_t$, Pitch, mm** |
| Plastic type sparger | 20 | 1 | 20 |

## III. MATERIALS AND METHODS

The gas holdup, pressure drop, Reynolds number, friction factor and power etc. are the important hydrodynamic parameters of a split cylinder sparged reactor which determine the overall performance of a split cylinder sparged reactor. The literature was numerous techniques and protocol to determine and evaluate these parameters. An account on those techniques as well as detailed description is used in the present investigation such as change in volume method for gas holdup measurement, incorporating the requirements of chemicals, instruments and techniques are discussed in the following sections. Again, the methods specific to the applications of a split cylinder sparged reactor for oily based effluent treatment and also wastewater treatment of are described in the respective chapters detailing these applications.

**A. Gas holdup determination**: The gas holdup was determined by measuring the increase in height of the dispersion upon aeration were investigated, the gas hold-up was then calculated from the following equation

$$\varepsilon_g = \frac{H_G - H_L}{H_G}$$

Where,

$H_G$ is the gas-liquid dispersion height,

$H_L$ is the height of gas free liquid and

$\varepsilon_g$ is a gas holdup.

## IV. DISCUSSION OF RESULTS

**Air -Water system.**

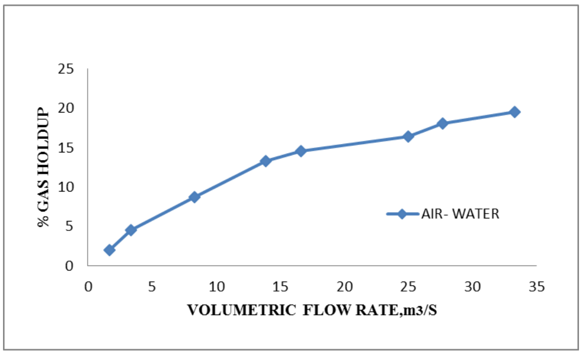

**Figure A1**: Volumetric flow rate versus % Gas holdup.

Bulk volume decreases smaller bubbles were produced in microemulsion compared pure water, gas holdup increases. Characteristics of microemulsion system, increased hindering of coalescence compared to pure water, the higher density of liquid buoyancy forces enhanced to bubble to rise gas holdup decreases, it creates bigger bubbles and increases buoyancy forces, therefore, gas hold up decreases.The flow regimes like homogeneous, heterogeneous and transistion state.

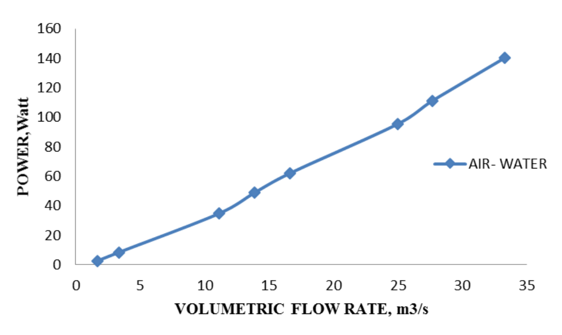

**Figure A2 :** Volumetric Flow Rate versus Power

In split cylinder sparged reactors with stagnant liquid, increased the air flow rate, higher air velocity and power also increased.

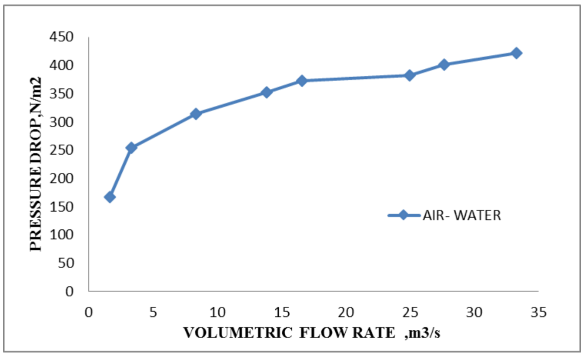

**Figure A3:** Volumetric flow rate versus Pressure drop

To determine the change of pressure drop along the air flow rate of the reactor.

### A. Kerosene –water system

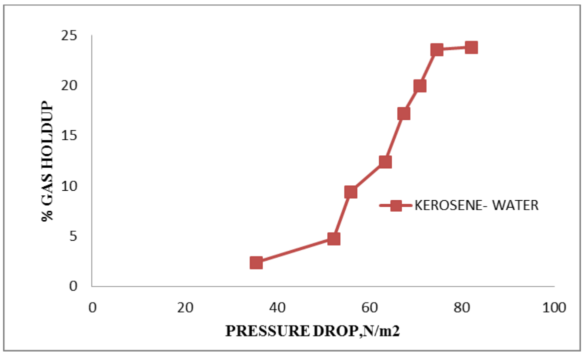

**Figure B1**: Pressure drop versus % Gas holdup.

The gas holdup increases in kerosene-water system, the change in pressure drop. Gas holdup slightly changes compared air-water system and kerosene–water system. Figure B2 shown in the gas holdup increases in the kerosene-water system. Slight variation in the kerosene- water system. The flow rate is directly proportional gas holdup.

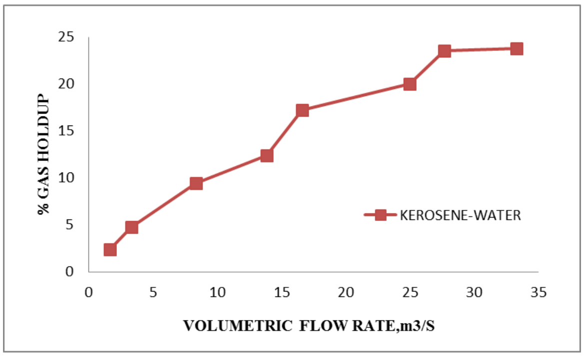

**Figure B2**: Volumetric flow rate versus % Gas holdup.

The gas holdup increases in the kerosene –water system. Slight variation in the kerosene- water system. The flow rate is directly proportional gas holdup.

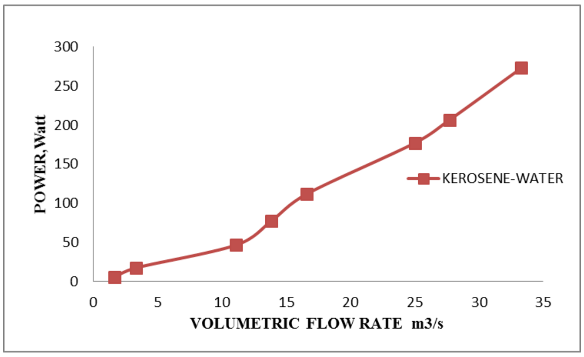

**Figure B3:** Volumetric Flow Rate versus Power

### B. Comparision of Air and Kerosene-water system.

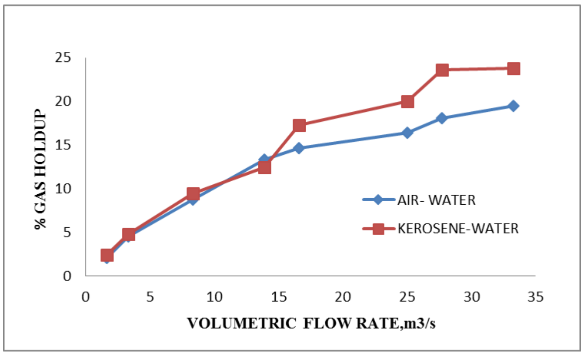

**Figure C1**: Volumetric flow rate versus % Gas holdup.

Volume decrease bubbles were produced smaller in microemulsion compared pure water, gas holdup increases in kerosene-water system. Characteristics of micro emulsion system, increased hindering of coalescence, it creates bigger bubbles and increases buoyancy forces, therefore, gas hold up decreases in air water system.

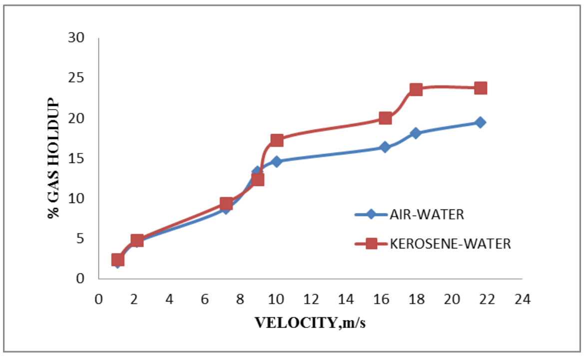

**Figure C2:** Velocity versus % Gas holdup

The gas hold up increased in the air -water system with increasing air velocity. In this project the bulk volume decreases in microemulsion creates smaller bubbles to form high air velocity and increase the gas holdup. The air flow rate increased in following gas hold up, the arrangement is followed

Water<kerosene

The higher density the gas holdup decreases. The lower density the gas holdup increases.

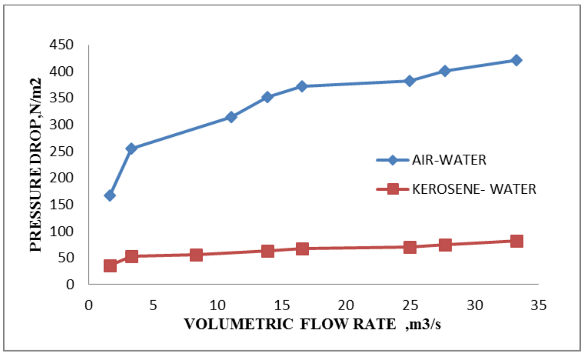

**Figure C3:** Volumetric Flow Rate versus Pressure drop

Hence the friction factor *f* also changes depending on Reynolds number, pressure drop which may or may not change significantly as flow rate changes. The general rule of thumb pressure drop changes as a function of the square of flow rate, kerosene density is lesser than water.

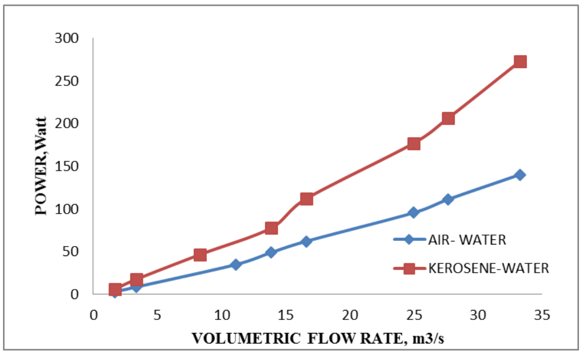

**Figure C4:** Volumetric Flow Rate versus Power

## V. CONCLUSIONS

The hydrodynamic parameters such as Gas holdup, Pressure drop, Friction factor and Power were calculated. It was also observed that the volume capacity will be more for larger diameter reactor column 150mm is preferred. If the length of the column is large, a handled large amount of oily effluent. Increasing the air flow rate increases the gas hold up based on density difference of the micro emulsion fluids like kerosene, diesel. Conventional multiphase reactors like bubble column are not suited for treatment of oily based effluent. Any improvement made in the conventional multiphase reactor may be employed to treat the oily based effluent. In the present work to treat the oily based effluent by novel spilt cylinder Sparged reactor. A hydrodynamic characteristic of the reactor was studied for different geometrical, dynamic, fluid properties and for different operating variables. These optimized results will be helpful for industries recovery of oil and water, petroleum refinery and food industries.

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