CFD Investigation of Cross Bubbly Flow through a Column with Rectangular Geometry

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Introduction:

Bubbly column reactors are multiphase reactors in which disperse phase (gas) is distributed into continuous phase by means of bubble diffuser (sparger). Co-current and counter-current flow bubble columns are widely applied in industry. A cross-flow is the more complicated case and has significant practical interest but less developed. Figure 1 and 2 presents advantages and challenges of using bubble column reactors.

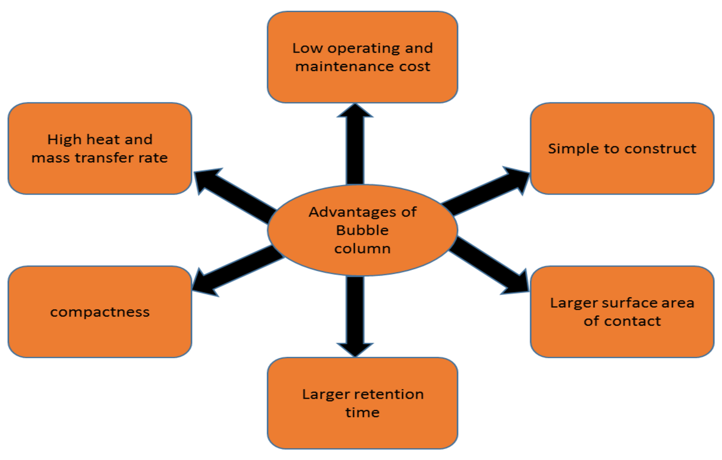

Figure 1. advantages from bubble column

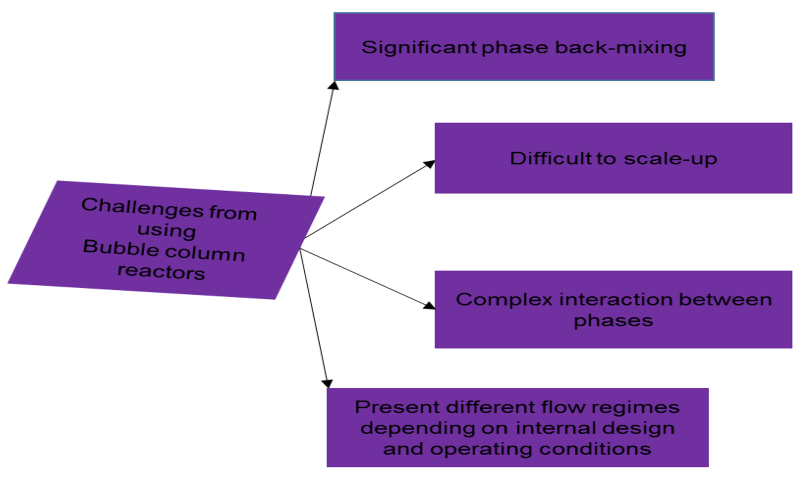

Figure 2. challenges from bubble column

Computational Methods:

The model described laminar cross bubbly flow in column with rectangular geometry. The laminar bubbly flow interface was used to simulate hydrodynamics parameters such as volume fraction of gas, gas and liquid velocity magnitude, flow regimes and liquid holdup in column.

Laminar bubbly flow continuity equation

$$\frac{\partial}{\partial x}(\rho_l\phi_l + \rho_g\phi_g) + \nabla.(\rho_l\phi_l u_l + \rho_g\phi_g u_g) = 0 \qquad (3.2)$$

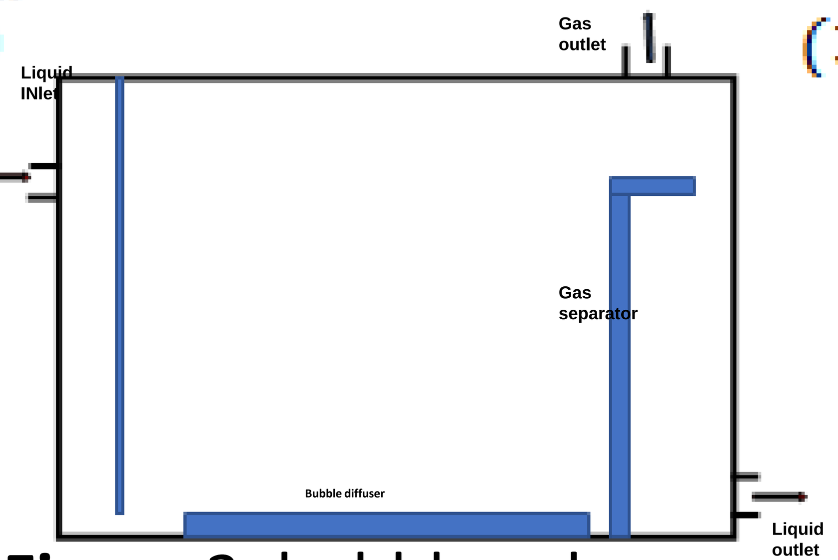

Figure 3. bubble column Geometry

Boundary	Materials	Type	Value
Liquid inlet	30 wt % MEA	Volumetric flow rate	0.1-0.2 L/min
Gas inlet	Flue Gas	Volumetric flow rate	1-20 L/min
Liquid outlet	Rich-MEA	0 Pa	
Gas outlet	Treated Gas	0 Pa	

Table 1. Other boundary conditions

		Flue gas		Liquid Solvent	
Flux	L/min	1-20		0.1 – 0.2	
Mass content	%	N_2	87.1	H_2O	70
		CO_2	11.4	MEA	30
		H_2O	1.5	additives	0

Table 2. Liquid and gas media composition

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Results:

Velocity profile is not symmetrical throughout the column and varies in magnitude Fig. 3. The velocity profile indicates that there is an intensive liquid circulation (vortex) developing in the column due to cross-flow.

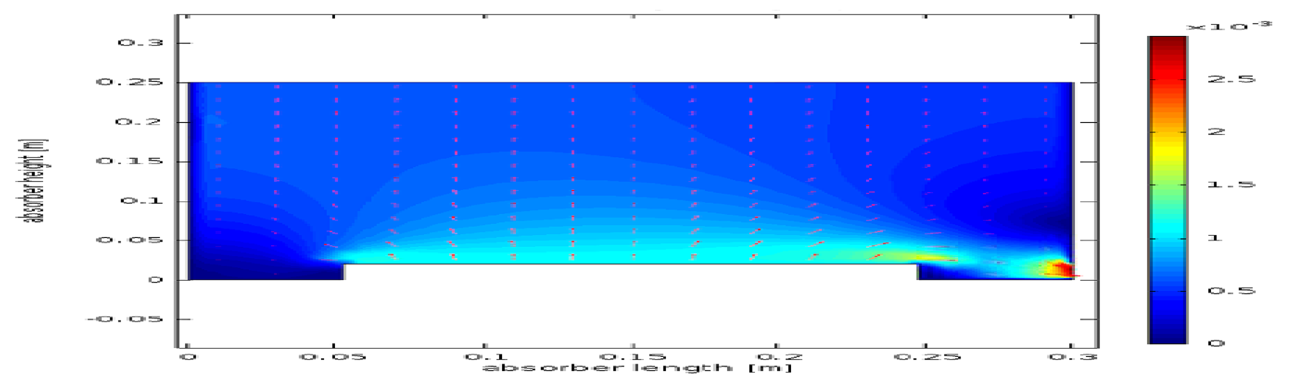
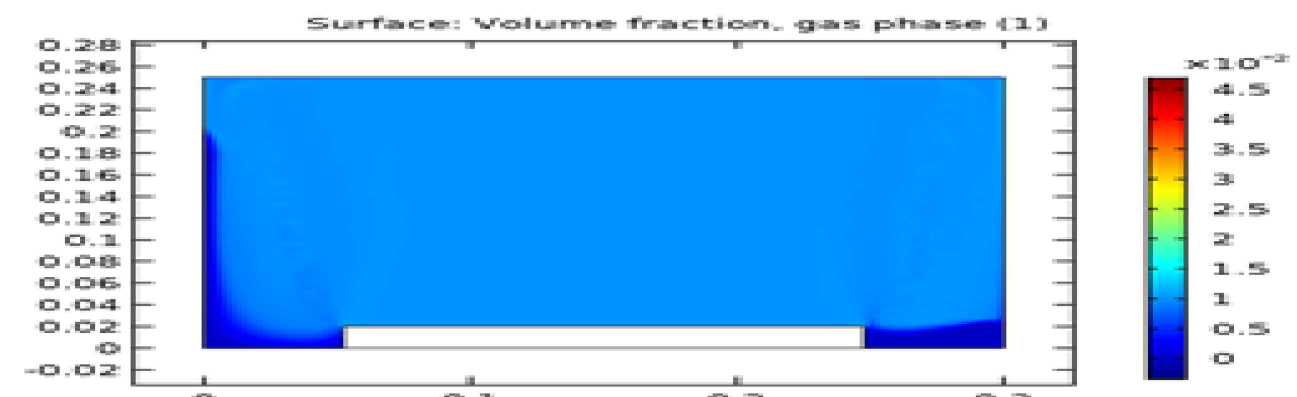


Figure 3. gas and liquid velocity magnitude



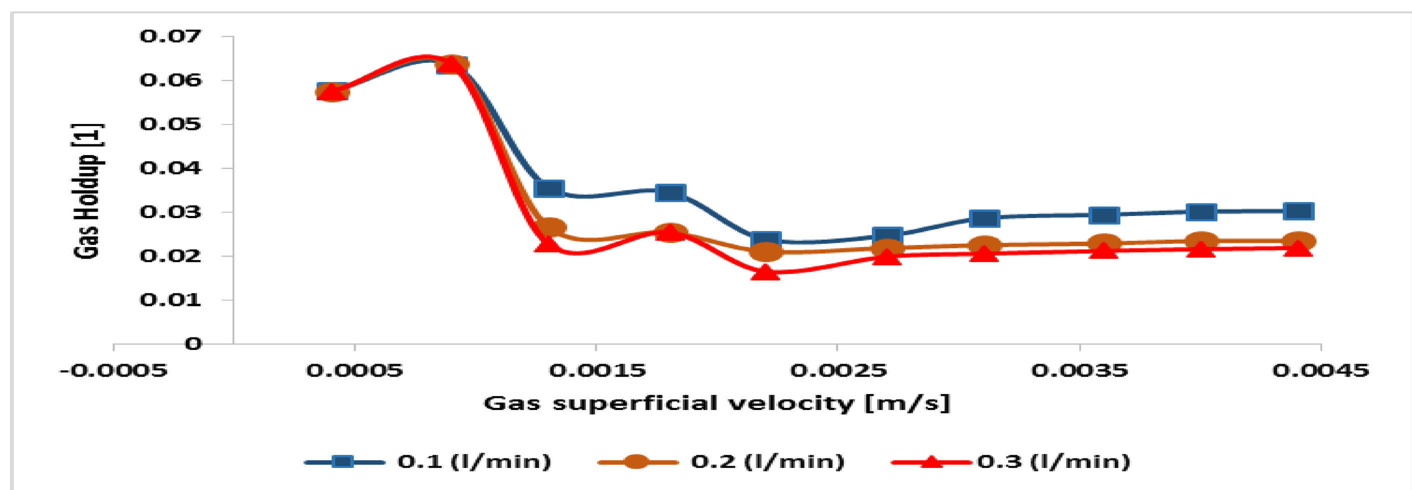


Figure 5. Gas holdup vs superficial vel. For column without internal design

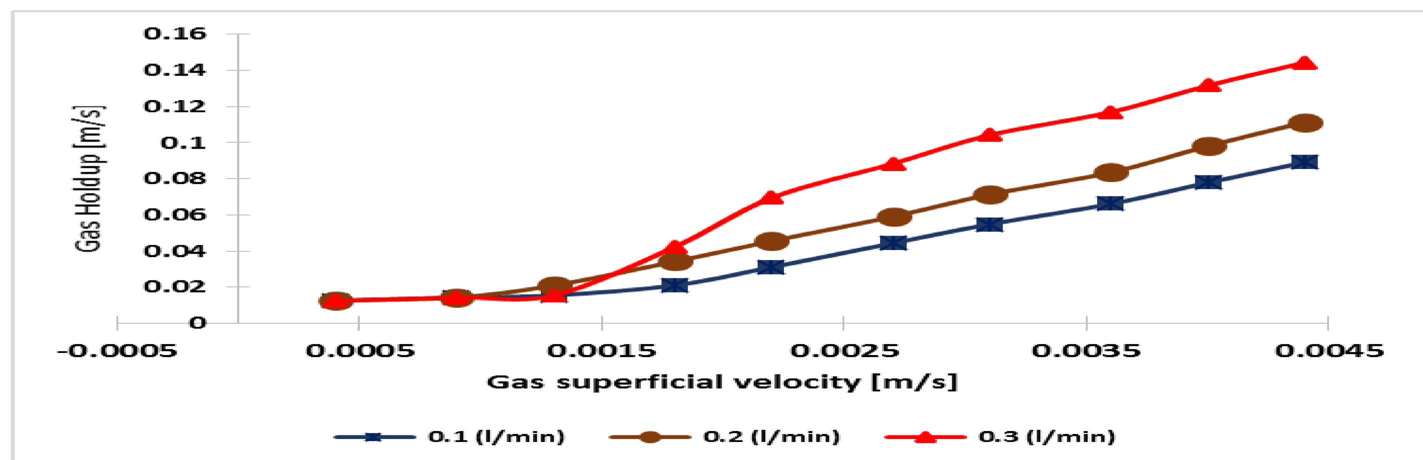


Figure 6. Gas holdup vs superficial velocity For column with internal design

Conclusions:

Hydrodynamics in bubble column varies significantly with change in internal design and configuration. Gas holdup depends on gas and liquid superficial velocity depending on internal design as presented on Fig. 5 & 6.

References

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