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RTD studies in Liquid – Solid Tapered Fluidized bed

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ABSTRACT

In this present study, experiments were carried out to find Residence Time Distribution (RTD) in a liquid – solid tapered fluidized bed of 600 mm height with the bottom cross section area of 50x50 mm, tapered angles are 10^0 & 15^0, fluidized particles are Glass beads size range was 0.8 - 1.0 mm and total weight of the bed charged was 1kg at each tapered column, using water as the fluidizing medium. Measured the residence time distribution with increasing height from bottom section to 20 cm height with intervals of 5cm to calculate mean residence time with help of E-Curves.

Key words: Liquid – Solid Fluidization, Tapered bed, Residence time distribution.

1.0 Introduction

Conical fluidized bed is very much useful for the fluidization of wide distribution of particles, since the cross sectional area is enlarged along the bed height from the bottom to the top, therefore the velocity of the fluidizing medium is relatively high at the bottom, ensuring fluidization of the large particles and relatively low at the top, preventing entrainment of the small particles. Since the velocity of fluidizing medium at the bottom is fairly high, this gives rise to low particle concentration, thus resulting in low reaction rate and reduced rate of heat release. Therefore, the generation of high temperature zone near the distributor can be prevented. Due to the existence of a gas velocity gradient along the height of a conical bed, it has some favorable special hydrodynamic characteristics. The conical bed has been widely applied in many industrial processes such as Biological treatment of waste-water, Immobilized biofilm reaction, Incineration of waste-materials, Coating of nuclear fuel particles, Crystallization, roasting of sulfide ores, Coal gasification and liquefaction, Catalytic polymerization.

A Non-catalytic gas-solid reaction continuously operated inside the fluidized bed where the effect of particle residence time distribution on the average conversion rate of particles evaluated and measure the shrinking of reacting solid during conversion [1] most of the cases, mixing process characterized by residence time distribution[2-5]. From the literature, research concerning tapered columns has focused majority on hydrodynamics of gas–solid [6-8] and lesser on liquid–solid systems [9-13]. Modified sedimentation–dispersion model was applied to Tapered slurry bubble column and found the uniform axial solid concentration distribution [14]. A dispersion character explored by means of liquid mixing in a tapered fluidized bed of coal and glass materials with tapering overall angle 1.47^0 [15].

2.0 Experimental Studies

The experimental set up shown in fig.1. Liquid – Solid tapered fluidized bed columns were made up of Perspex sheets to allow visual observation with different tapered angles. A120 stainless wire mesh is placed over the distributer plate for uniform flow of water and also act as support for the bed. The bed of spherical glass beads having density 2600kg/m^3 was fully fluidized and flow rate of water is gradually decreased until the particles became loosely settled to form an initial fixed bed. To perform an experimental run, the flow rate of water through the tapered column was increased incrementally. When the stable state was established after each increment, a liquid tracer (1N NaOH) was injected at the bottom of the riser, clearly 5cm above the distributor and flow rate of water using Rota meter was noted and the samples were collected from four different sections of the bed, such as 5cm, 10cm, 15cm, and 20cm at equal intervals of time. By determining the concentration of the tracer quantity collected was titrated with Oxalic Acid for every collected sample it was possible to obtain the average residence time and the residence time distribution for the different size ranges. Tapered column having series of rubber septum's are at equal distances and these are helpful for taking samples. The experiments are repeated to get results as accurate as possible. Tracer taken fresh samples for every set of experiments. This procedure was repeated for two tapered fluidized beds of different angles. Initial bed heights was 13.9 cm and 13 cm for tapered angle of 10^0 and 15^0 respectively, the bed weight was 1kg in each bed and water as fluidized medium having density 1000 kg/m^3, all these experiments are conducted at room temperature. Fig.1 Shows the Schematic diagram of Liquid – Solid Tapered fluidized beds.

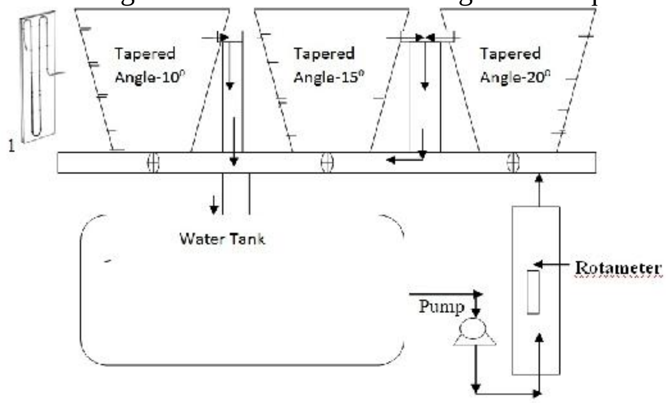

Fig.1.Schematic diagram of the liquid – solid Tapered Fluidized bed

3.0 Results and Discussion

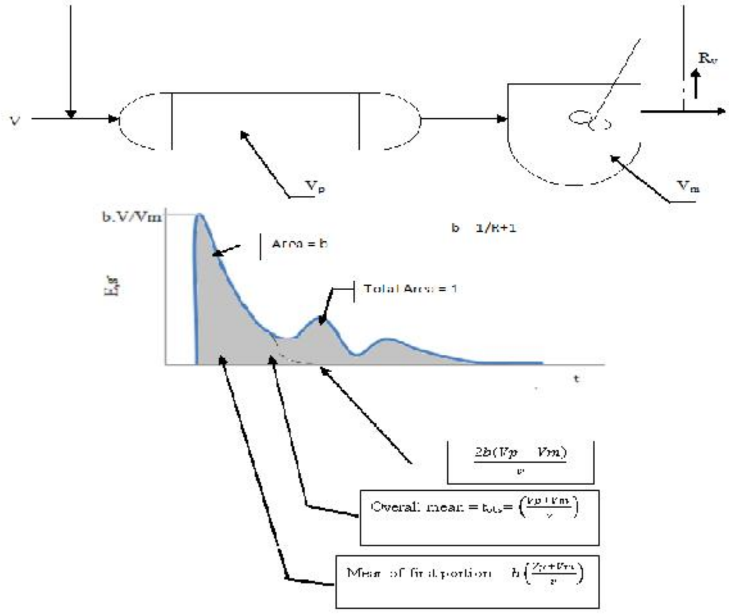

Fig.3: Compartment model for LSTFB

The experimental data obtained and the visual observations made are presented here and then summarized in detail. Several methods have been proposed, in our case, graphical method [16] opted and to evaluate overall mean residence time(ŧ) from curve of E as a function of the time,firstly it was recorded the concentration – time of tracer leaving the column, this is C-curve,from it developed E-curve as a function of time for glass beads at different heights of the bed for two different tapered angles of 10^0 & 15^0 respectively and for different flow rates and fixed solid flow rate. After words overall mean residence time(ŧ) (or) Average residence time can be calculated with help of Praposed compartment model, is was shown in Fig.2. The results from the tracer experiments are in good agreement with the average residence time measurements. E vs. Time curve for tapered angle 10^0 at different heights shown in Figures[3-7]and E vs. Time curve for tapered angle 15^0 at different heights shown in Figures[8-12]

Concluded that the early curve is a sure sign of stagnant back waters and double peaks come from flow in paralal paths, channeling in Fig.3.

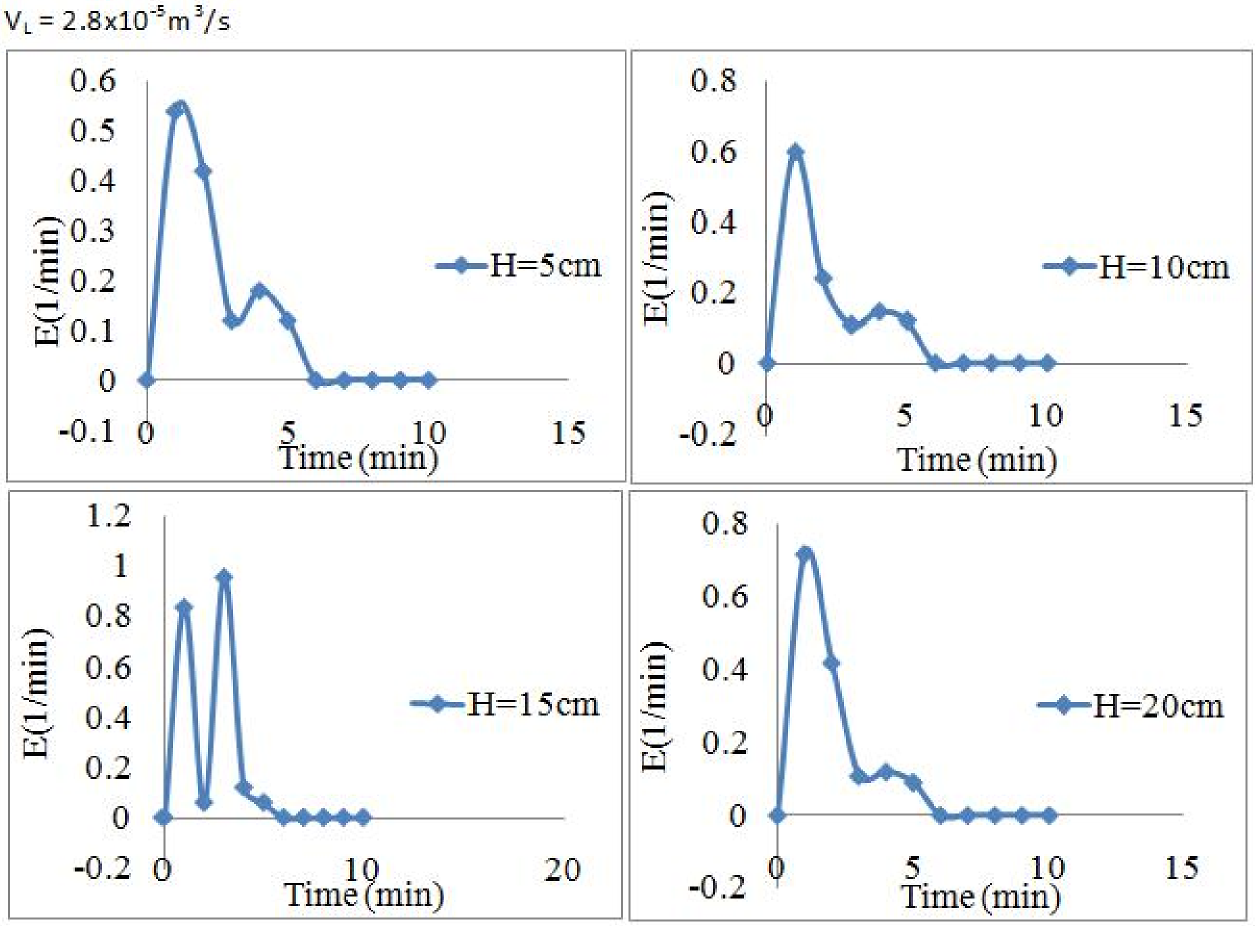

Fig.3: E - Curve as a function of time(min) for Glass beads at $V_L = 2.8x10^{-5}m^3/s$ for tapered angle 10^0

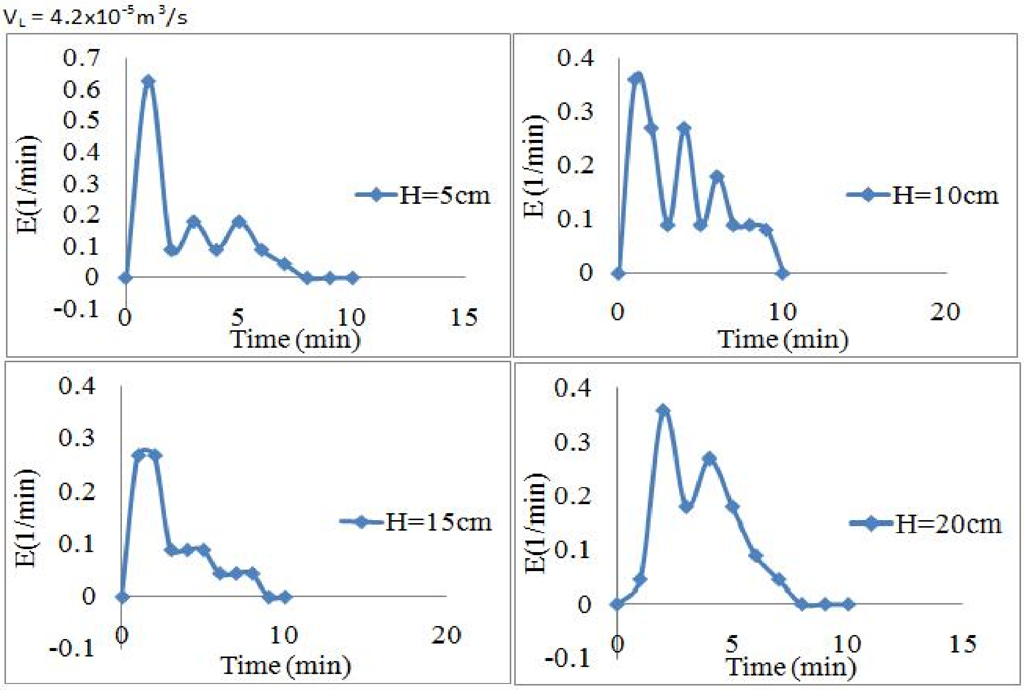

Fig.4: E - Curve as a function of time(min) for Glass beads at $V_L = 4.2x10^{-5}m^3/s$ for tapered angle 10^0

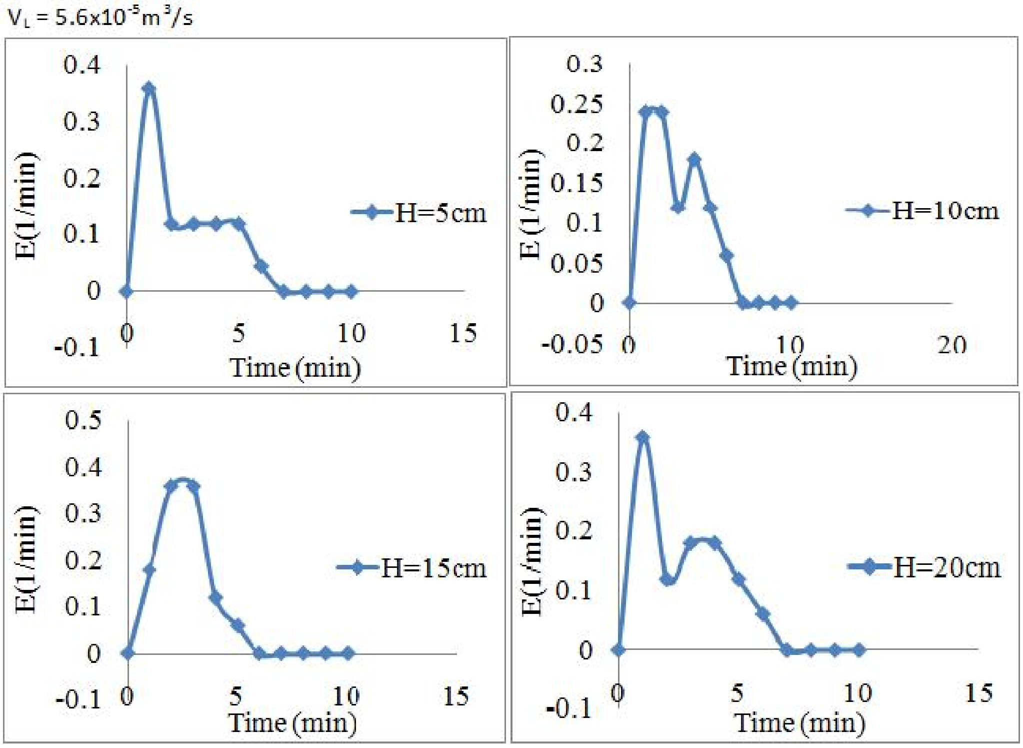

Fig.5: E - Curve as a function of time(min) for Glass beads at $V_L = 5.6x10^{-5}m^3/s$ for tapered angle 10^0

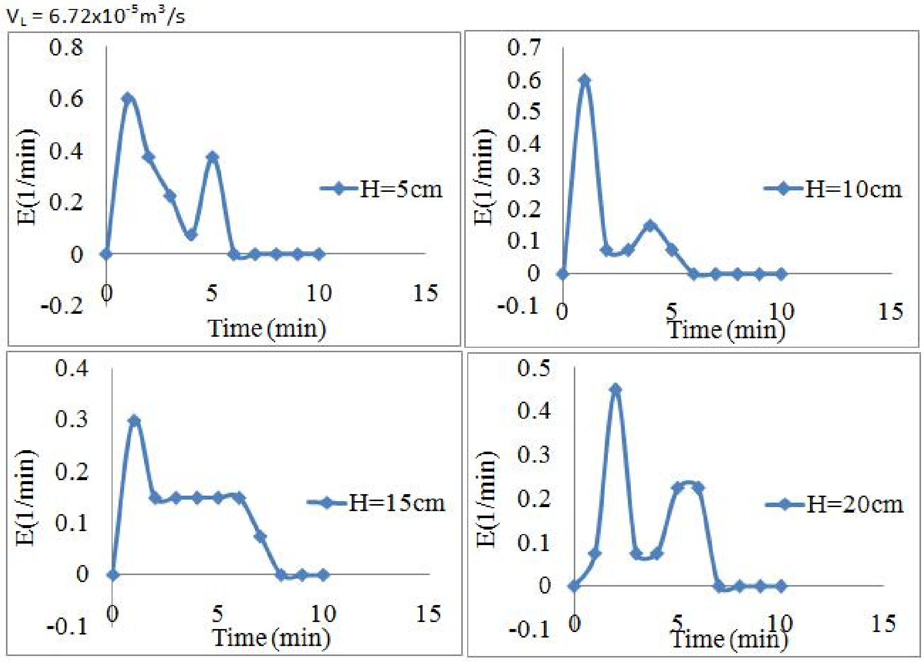

Fig.6: E - Curve as a function of time(min) for Glass beads at $V_L = 6.72x10^{-5}m^3/s$ for tapered angle 10^0

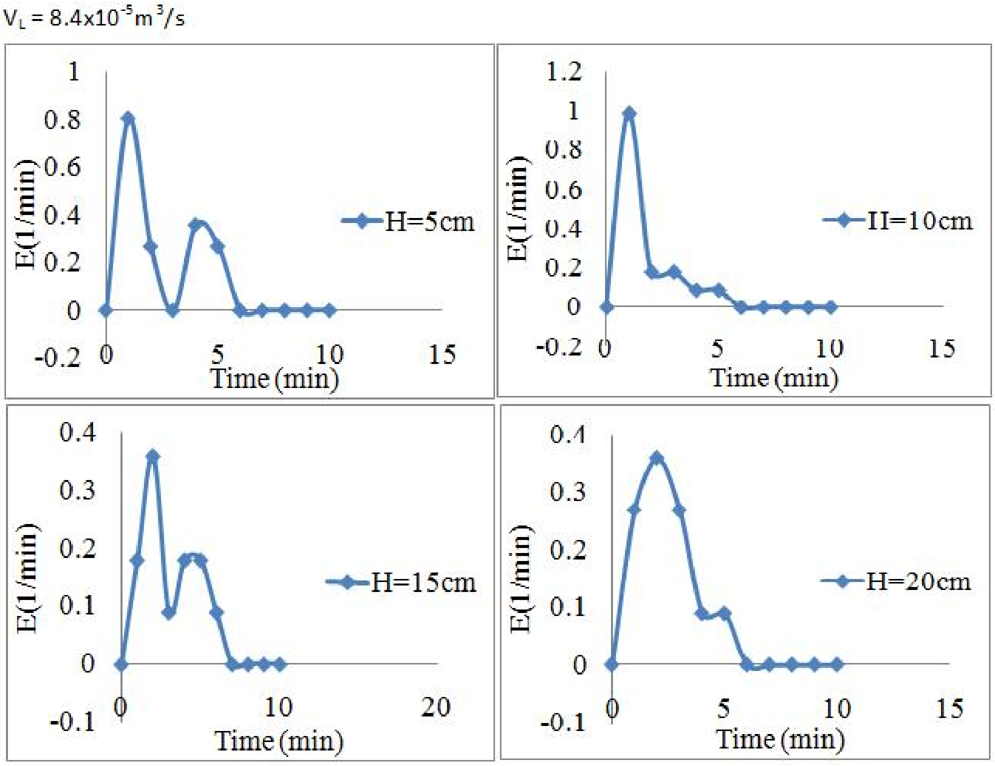

Fig.7: E - Curve as a function of time(min) for Glass beads at $V_L = 8.4x10^{-5}m^3/s$ for tapered angle 10^0

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The spread in residence time increases significantly with increasing liquid velocity with higher liquid velocities the system becomes better mixed with a shorter average solids residence time.

Most of of the cases multiple decaying peaks at regular intervals indicating string internal recirculation. With increasing liquid velocity the residence time decreases. Clearly residence time dependent on the liquid velocity, it caused by decreasing the hold-up in the column, the solid particles are more able to swirl and mix through the column; this causes a larger spread in residence time.

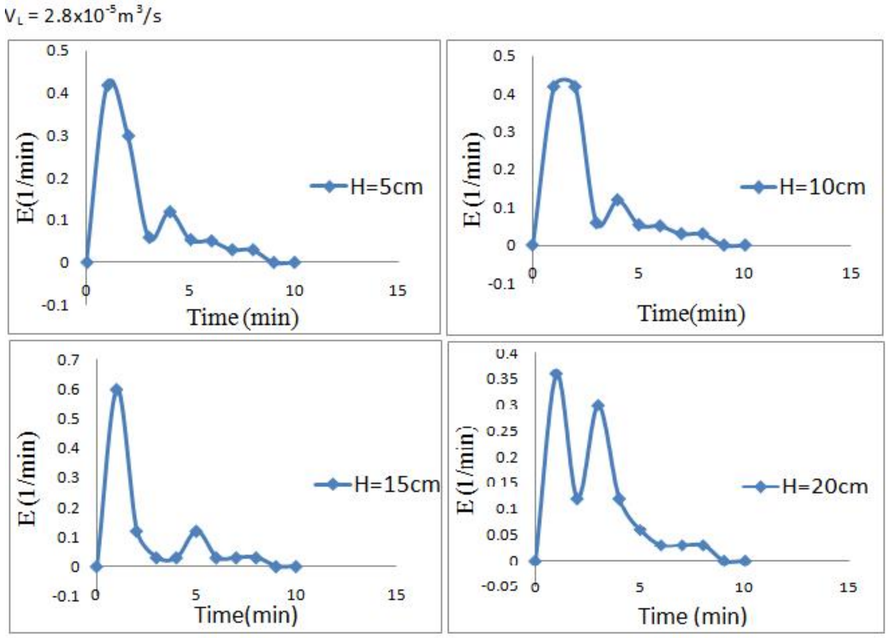

Fig.8: E - Curve as a function of time(min) for Glass beads at $V_L = 2.8x10^{-5}m^3/s$ for tapered angle 15^0

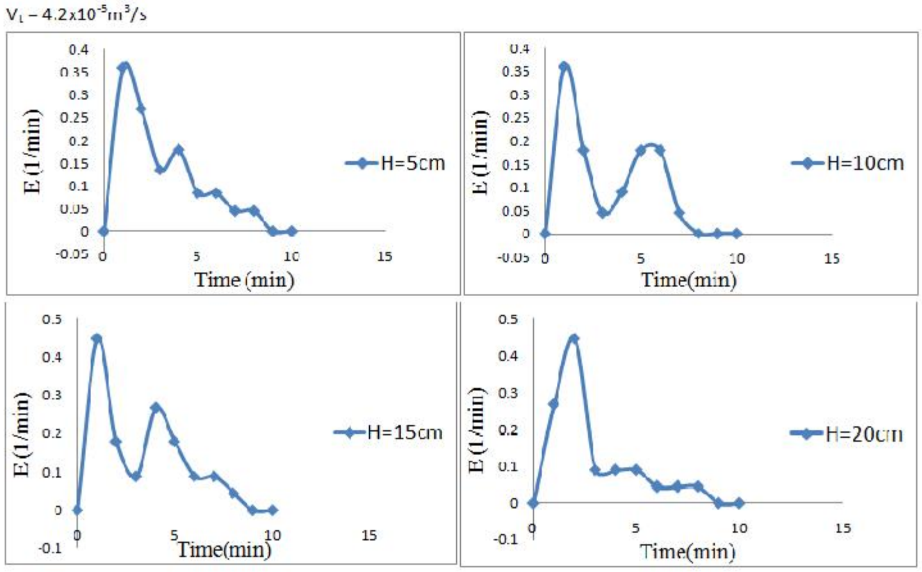

Fig.9: E - Curve as a function of time(min) for Glass beads at $V_L = 4.2x10^{-5}m^3/s$ for tapered angle 15^0

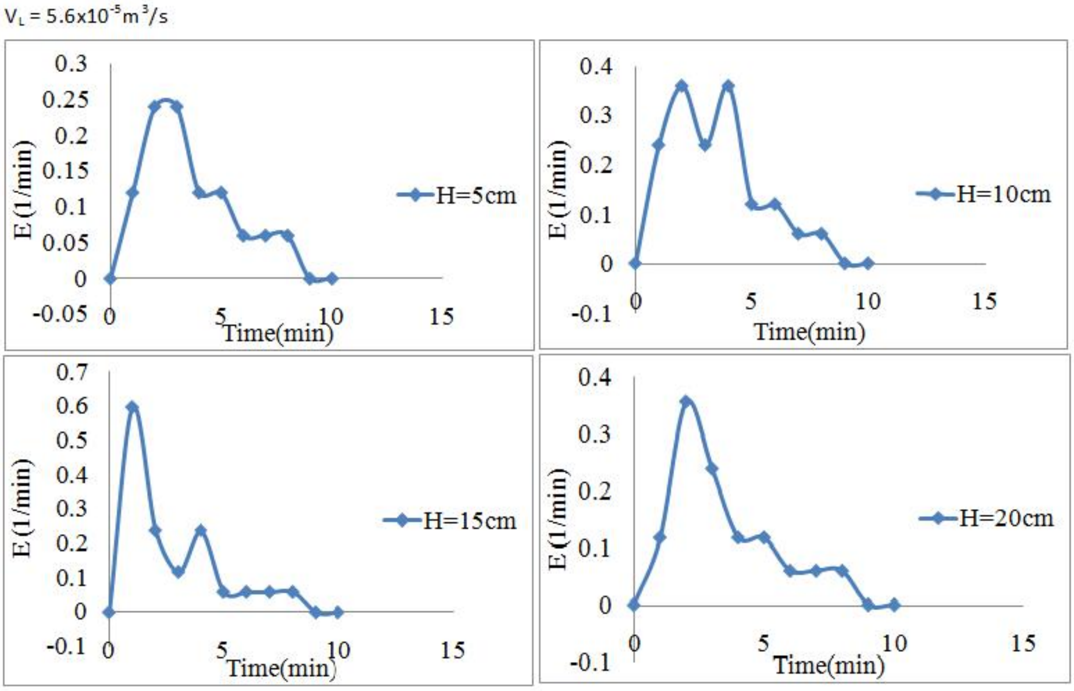

Fig.10: E - Curve as a function of time(min) for Glass beads at V_L = 5.6x10^{-5}m^3/s for tapered angle 15^0

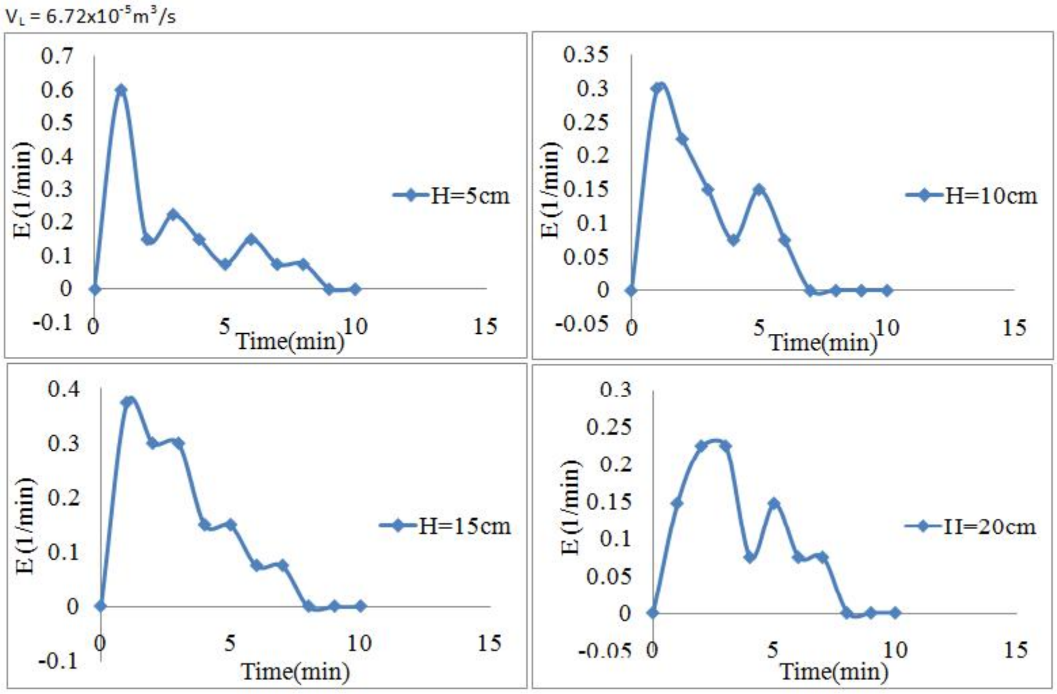

Fig.11: E - Curve as a function of time(min) for Glass beads at V_L = 6.72x10^{-5}m^3/s for tapered angle 15^0

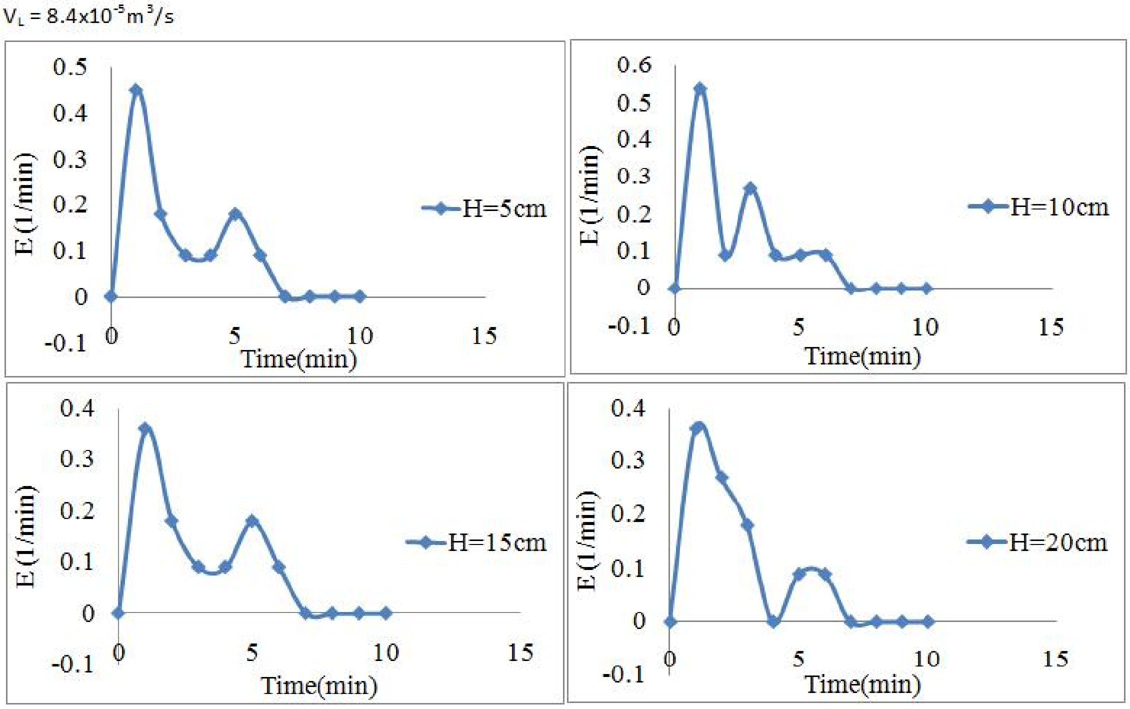

Fig.12: E **-** Curve as a function of time(min) for Glass beads at $V_L = 8.4x10^{-5}m^3/s$ for tapered angle 15^0

Conclusions

Residence time distribution experiments were conducted in tapered fluidized beds with apex angle 10^0 and 15^0. The solids flux is kept constant and the liquid velocity is varied, it has a large influence on the residence time as well as the spread in residence time.

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