Residence time distribution of large solid particles in fluid suspensions was studied in a continuous tubular (without baffles) aseptic processing system and it was found that particle interactions promoted an increased mean residence time and dispersion, even for low particle concentrations; mixing particles with different characteristics led to a decrease in both the mean and minimum residence time of each type of particle.[55]

3.3.3.3 Gas–Liquid

Investigations of gas–liquid mixing in OBR were for the purpose of evaluating mass transfer performance where liquid is the dominant phase and gas the discrete phase, *e.g.* increase the mass transfer of O_2 or H_2 into liquid as dissolved gases. In OBR, the combination of increased residence time of bubbles, the more uniform bubble size distributions and the smaller bubble sizes together with the increased gas hold up contributed to the enhanced mass transfer rate as well as mass transportation rate in comparison with that from bubble columns and stirred tanks.[56–59] This feature has found applications in hydrogenation,[60,61] oxygenation,[62] hydroformlyation, heterogeneous catalysis,[63] fermentation[64] and so on, where a gas is a reactant. The presence of bubbles and their effect on crystallisation in COBC will be discussed in Section 3.4.

In summary, perfect Gaussian shaped RTDs are obtained when employing the stimulus tracer method; this indicates that the plug flow characteristics have been achieved in COBC. It should be noted that deviations from the Gaussian function occur when either solid or gas is present and appropriate adjustments of oscillation and flow conditions are required in order to maintain the degree of plug flow. In other words, the RTDs of a single phase only service as a guide for cases involving two or more phases.

3.3.4 Moving Fluid *vs.* Moving Baffles

In batch set up, there are two ways of generating oscillation: (a) pulsing fluid at the base or one end of the tube by a piston or bellows arrangement where baffles are stationary, (b) moving a string of baffles at the top by a linear motor, as shown in Figure 3.9. The former is used in all COBCs, and the latter is found in lab OBCs. Eddies are generated similarly in both cases, however, there are some subtle differences:

a) the baffle spacing in the moving baffle set up is usually larger than that in the moving fluid devices for enhanced mixing operation in OBCs;[20]
b) the axial dispersion coefficients in the moving baffle-COBR were 10–17% higher than in the moving fluid COBR due to enhanced shear rate in the former device.[47]