# STUDIES ON THE RESIDENCE TIME DISTRIBUTION OF SOLIDS IN A SWIRLING FLUIDIZED BED

by

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# ABSTRACT

The Multi-Parameter Two-Layer (MPTL) mathematical model was developed in this work specifically to model the Residence Time Distribution (RTD) of particles in a continuous system of swirling fluidized bed reactor. The model consists of two parallel layers. The top layer is a stirred tanks-in-series model and represents the conventional fluidized bed. Meanwhile, the bottom layer obeys the general recycle model and represents the swirling motion at the bottom layer of the bed. The Laplace transformation and convolution integral techniques are used to derive explicit expressions for the RTD functions of the stirred tanks-in-series model and general recycle model. The proposed model has six independent parameters - recycle fraction ($P$), recycle layer flow rate fraction ($w$), recycle layer volume fraction ($y_r$), number of tanks in the main flow line of the recycle layer ($n_1$), number of tanks in the recycle line ($n_2$) and number of tanks in the top layer ($n_p$). The RTD experiments were conducted at different particle sizes and bed weights. The bed material used in the experimental work is spherical plastic beads with a diameter $d_p = 2.99mm$ and $d_p = 3.85mm$. During hydrodynamics study, it is found that bed pressure drop $\Delta P_b$ increases with air velocity and bed weight. Besides, the smaller bed particle gives a higher pressure drop for a given bed. The effects of parameters on the RTD function $E(\theta)$ are studied and the model is shown to be highly versatile and capable of representing widely different mixing conditions depending on the system variables. By best-fitting of the model response to the experimental data, the model parameters can be evaluated. The experimental result of solid RTD shows that the bed performance varies from one-layer to two-layer bed as the bed weight increased. One-layer bed can be modeled by having number of stirred tanks $n_2 = 4$. $P$, $w$ and $y_r$ ranging from 0.8 to 0.83, 0.9 to 1.0 and 0.75 to 1.0 respectively. For two-layer bed, it is found that the combination of $n_1 = n_2 = n_p = 5$ can fit all the runs. The value

of the model parameters $P$, $w$ and $y_r$ ranging from 0.5 to 0.83, 0.2 to 1.0 and 0.52 to 1.0 respectively.