

Supplementary Information

Table 1: Experimental details and results from liquid residence time distribution results

Sr No	Flow rate (mL/min)	ω (Hz)	x_0 (mm)	Re_o	2 Vessel				4 Vessel			
					τ (min)	$\bar{\tau}$ (min)	t_m	σ^2	τ (min)	$\bar{\tau}$ (min)	t_m	σ^2
1	5	2	10	1567.65	48.0	49.84	1.038	0.213	96.0	94.98	0.989	0.120
2	25	2	10	1567.65	9.6	9.16	0.954	0.204	19.2	20.41	1.063	0.163
3	5	3	10	2351.48	48.0	49.89	1.039	0.212	96.0	84.5	0.880	0.095
4	25	3	10	2351.48	9.6	10.41	1.084	0.220	19.2	20.89	1.088	0.111
5	5	2	20	3135.31	48.0	51.4	1.071	0.252	96.0	96.22	1.002	0.120
6	25	2	20	3135	9.6	8.85	0.922	0.198	19.2	17.87	0.931	0.109
7	5	3	20	4702.96	48.0	49.8	1.039	0.203	96.0	92.17	0.960	0.119
8	25	3	20	4702.96	9.6	9.104	0.948	0.215	19.2	19.22	1.001	0.096
9	1	2.5	15	2939.35	240.0	128	0.533	0.262	480.0	423	0.881	0.086
10	29	2.5	15	2939.35	8.3	8.6	1.039	0.210	16.6	16.64	1.005	0.148
11	15	1.8	15	2116.33	16.0	16.37	1.023	0.226	32.0	26.29	0.822	0.052
12	15	3.2	15	3762.37	16.0	16.98	1.061	0.238	32.0	29.3	0.916	0.123
13	15	2.5	8	1567.65	16.0	16.274	1.017	0.209	32.0	31.88	0.996	0.133
14	15	2.5	22	4311.05	16.0	18.01	1.126	0.139	32.0	34.75	1.086	0.145
15	15	2.5	15	2939.35	16.0	16.921	1.058	0.212	32.0	30.78	0.962	0.011
16	15	2.5	15	2939.35	16.0	18.2	1.058	0.212	32.0	33.79	1.056	0.120
17	15	2.5	15	2939.35	16.0	13.6	0.850	0.208	32.0	32.42	1.013	0.123

Table 2: Experimental details and results from solid residence time distribution results

Sr No	flow rate (mL/min)	ω (Hz)	x_0 (mm)	Re_o	1 Vessel				4 Vessel			
					τ (min)	$\bar{\tau}$ (min)	t_m	σ^2	τ (min)	$\bar{\tau}$ (min)	t_m	σ^2
1	5	2	20	3135.31	24	31.20	1.30	0.55	96	53.46	0.56	0.23
2	25	2	20	3135.31	4.8	10.80	2.25	0.47	19.2	19.56	1.02	0.22
3	5	2.5	10	1959.57	24	14.63	0.61	0.76	96	48.8	0.51	0.20
4	25	2.5	10	1959.57	4.8	6.00	1.25	0.37	19.2	18.16	0.95	0.19
5	5	3	10	2351.48	24	13.75	0.57	0.32	96	49.83	0.52	0.20
6	25	3	10	2351.48	4.8	5.14	1.07	0.45	19.2	17.32	0.90	0.25
7	5	2	10	1567.65	24	11.61	0.48	0.37	96	40.75	0.42	0.30
8	25	2	10	1567.65	4.8	4.17	0.87	0.43	19.2	17.98	0.94	0.43
9	5	2.5	20	3919.14	24	8.13	0.34	0.97	96	31.01	0.32	0.24
10	25	2.5	20	3919.14	4.8	3.02	0.63	0.52	19.2	20.299	1.06	0.45
11	5	3	20	4702.96	24	6.56	0.27	0.42	96	23.75	0.25	0.18
12	25	3	20	4702.96	4.8	3.26	0.68	0.50	19.2	13.1	0.68	0.47
13	15	2.5	10	1959.57	8	7.33	0.92	0.38	32	21.63	0.68	0.20
14	15	2.5	10	1959.57	8	7.10	0.89	0.44	32	21.99	0.69	0.18
15	15	2.5	10	1959.57	8	7.44	0.93	0.41	32	23.32	0.73	0.16
16	12	3	20	4702.96	10	3.90	0.39	0.59	40	13.45	0.34	0.41

Table 3: Experimental details and results for heat transfer characterisation

ω (Hz)	x_0 (mm)	Re_o	H_{tube} (W/m ² K)	H_{ov} (W/m ² K)	Nu_t (W/m ² K)
2.5	20	3919.1	1099.7	293.3	45.8
0.5	20	783.8	664.8	249.7	27.7
0	0	0.0	464.4	214.9	19.3
3	5	1175.7	952.4	281.7	39.5
1.5	10	1175.7	952.4	281.7	39.7
0.8	20	1254.1	920.0	278.8	38.3

Table 4: ALM PSD size

Sample Name	Dx (10) (μm)	Dx (50) (μm)	Dx (90) (μm)	Span
Seed	12.5	32.3	50.6	1.179
sample1	10.1	48.8	78.6	1.403
sample2	16.8	58.4	98.3	1.397
sample3	15.6	68.1	125	1.565
sample4	19.3	66.5	105	1.296
sample5	21.6	69.9	135	1.623
sample6	20.1	71.5	138	1.654
sample7	21.4	67.6	118	1.431
sample8	19.6	67.5	128	1.608
sample9	29.3	70.3	124	1.348
sample10	21.8	69	110	1.274
Average	19.6	65.9	116	1.46

Table 5: PCM PSD size

sample name	Dx(10) (μm)	Dx(50) (μm)	Dx(90) (μm)	Span
Seed	146	287	494	1.209
RT1	160	362	687	1.456
RT2	170	401	771	1.499
RT3	161	433	882	1.665
RT4	134	398	827	1.741
Average	156.25	398.5	791.75	1.59

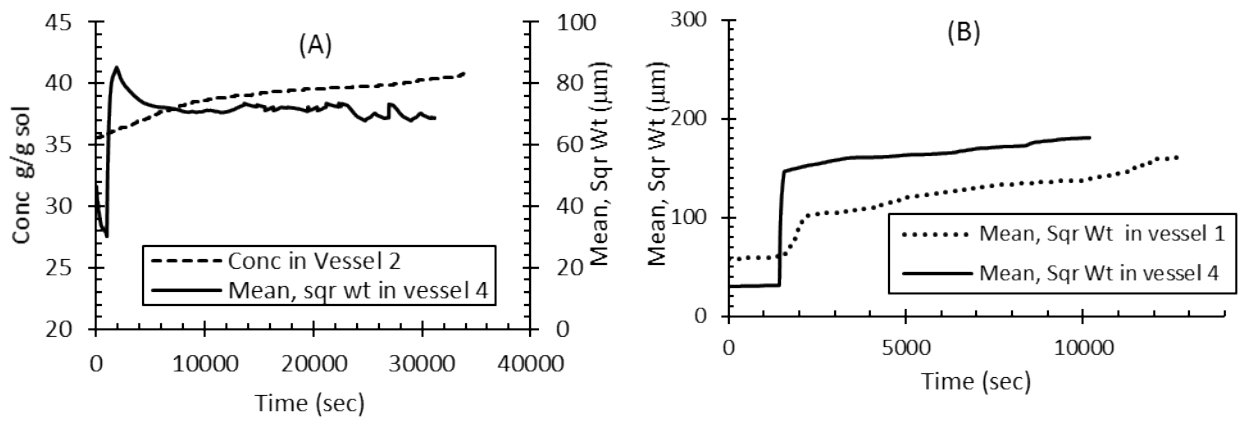


Figure 2 (A) FBRM mean,sqr wt trend in vessel 2 and infrared spectroscopic data in vessel 4 for ALM crystallisation case study (B) FBRM mean,sqr wt trend in vessel 1 and vessel 4 for PCM case study

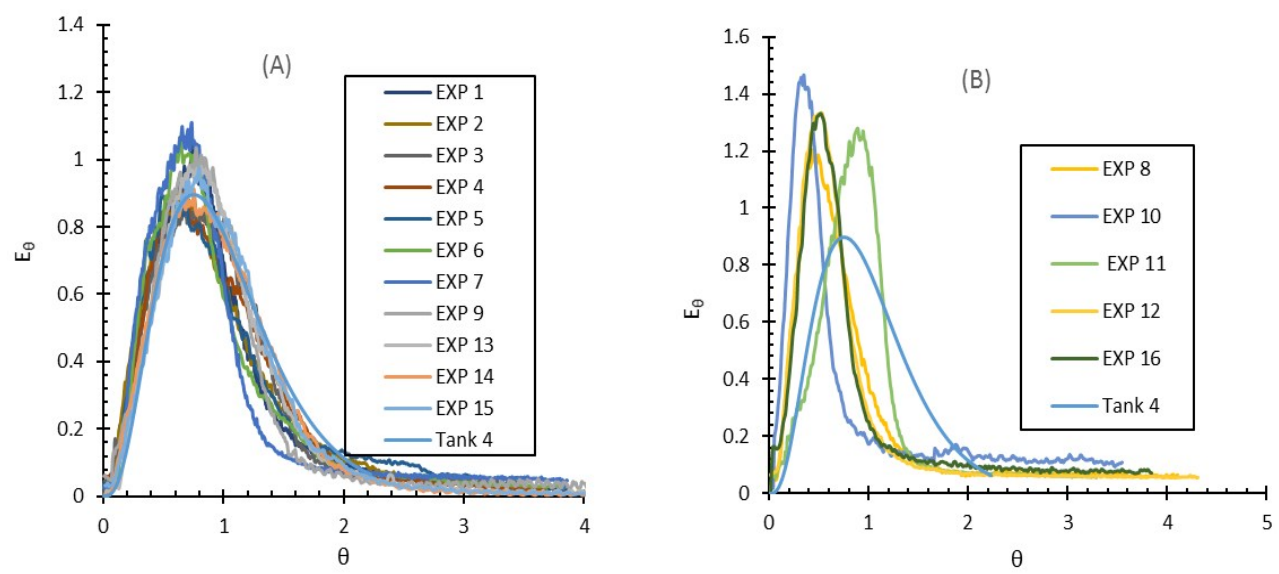


Figure 1 Solid RTD E_{θ} Vs θ (A) experiments condition match with theoretical 4 tank-in-series model (B) experiments condition which does not match with theoretical 4 tank-in-series model

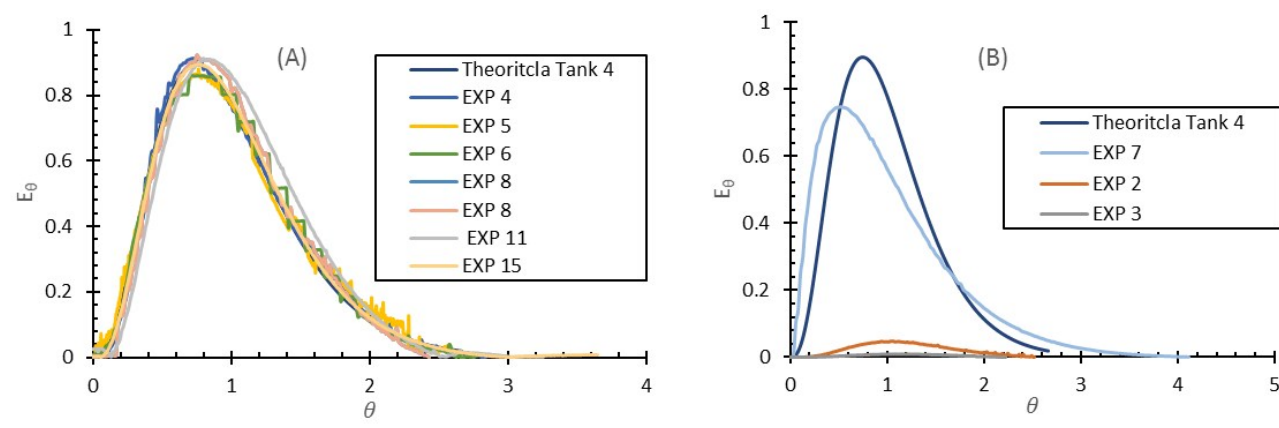


Figure 3 liquid RTD E_{θ} Vs θ (A) experiments condition match with theoretical 4 tank-in-series model (B) experiments condition which does not match with theoretical 4 tank-in-series model

Nomenclature

τ	Theoretical mean residence time
t_m	Dimensionless experimental mean residence time
$\bar{\tau}$	Experimental mean residence time
θ	Dimensionless time based on the mean residence time in all tank
σ^2	Variance or a measure of the spread of the curve
C_i	Concentration of tracer at i time interval
Δt	Difference between each time interval
E_θ	Exit age distribution function
N	Number of tanks
ω	Oscillation frequency
x_0	Oscillation amplitude
D	Diameter of Vessel
μ	Viscosity of Fluid
ρ	Density of fluid
Re_o	Oscillatory Reynolds number
Nu_t	Tube side Nusselt number
H_{tube}	tube side heat transfer coefficient
H_{ov}	overall heat transfer coefficient
CMBOC	Cascade of moving baffle oscillatory crystallisers
MBOC	moving baffle oscillatory crystallisers
MSZW	meta stable zone width