BATCH CLASSIFICATION OF MIXTURES

PART II: CLASSIFICATION IN A TAPERED COLUMN

By

R. K. SAKSENA and C. R. MITRA*

Harcourt Butler Technological Institute, Kanpur (India)

Received November 14, 1972

LEVEY et al. [2], RIDGWAY and SIM [3], ROWE and SUTHERLAND [4] and SUTHERLAND [5] have used tapered beds for different studies and their work has revealed that the uniformity of fluidization is higher than for a non-tapered bed. No reference on classification in a tapered column is available in the literature. GOPALKRISHNA and RAO [1] have, however, used a streamline baffle in a cylindrical column in their studies on classification and have reported improved segregation.

The objective of the present work has been to study the effect of using a tapered section instead of a cylindrical column on classification of mixtures of solid particles.

Experimental setup

The experimental setup used for conducting studies on classification of coal and calcite in a tapered bed is the same as described in Part I except that a tapered column replaces the cylindrical column. The minimum and maximum diameters are 3.8 cm and 8.4 cm, respectively. The height of the column is 152.2 cm. Holes 1.25 cm in diameter at heights 13.0, 24.5, 36.0 and 47.5 cm are provided to serve as sample ports. The rest of the arrangement is the same as described in Part I for studies on batch classification in a cylindrical column.

Experimental

The known amount of the charge of specific composition with respect to fines component was introduced into the column and the bag filter replaced in position. The air- flow rate was gradually increased and set at the desired rate by manipulating valves. The charge was allowed to fluidize for some time to ensure steady conditions. Samples were collected, subjected to sieve analysis and percentage of fines determined.

* Birla Institute of Technology and Sience, Pilani, India.

Table 1

Experimental data: cylindrical column versus tapered column

Material: Coal Size: $-14+18$ & $-18+22$

Fines in charge %	Air velocity cm/sec	Sampling position	Air velocity at sample port cm/sec	Fines (cylindrical column) %	Fines (tapered column) %
1	2	3	4	5	6
15.0	269.3	47.5	200.0	27.2	18.6
		13.0	261.0	13.4	20.3
22.5	269.3	47.5	200.0	30.0	25.1
		13.0	261.0	28.3	29.6
30.0	269.3	47.5	200.0	33.5	30.0
		13.0	261.0	31.3	32.1
45.0	269.3	47.5	200.0	50.0	43.4
		13.0	261.0	46.2	43.3
60.0	269.3	47.5	200.0	63.1	51.4
		13.0	261.0	53.5	57.4
75.0	269.3	47.5	200.0	68.7	65.8
		13.0	261.0	65.1	68.0
15.0	253.6	47.5	188.5	24.8	20.6
		13.0	245.9	22.1	23.6
22.5	253.6	47.5	188.5	29.9	27.2
		13.0	245.9	30.1	27.8
30.0	253.6	47.5	188.5	30.4	33.6
		13.0	245.9	29.7	36.7
45.0	253.6	47.5	188.5	46.8	46.4
		13.0	245.9	42.5	47.6
60.0	253.6	47.5	188.5	60.4	60.0
		13.0	245.9	53.7	66.3
75.0	253.6	47.5	188.5	69.5	65.0
		13.0	245.9	66.2	68.6
15.0	232.6	36.0	188.0	20.0	22.8
		13.0	225.6	19.0	21.8
22.5	232.6	36.0	188.0	29.2	27.8
		13.0	225.6	34.0	29.3
30.0	232.6	36.0	188.0	30.5	36.8
		13.0	225.6	28.7	33.4
45.0	232.6	36.0	188.5	49.4	50.9
		13.0	225.6	45.5	49.2
60.0	232.6	36.0	188.5	60.7	59.0
		13.0	225.6	58.3	59.6
75.0	232.6	36.0	188.5	72.0	67.9
			225.6	64.8	63.8

Table 1 (cont.)

Material: Coal Size: $-14+18$ & $-22+30$

Fines in charge %	Air velocity cm/sec	Sampling position	Air velocity at sample port cm/sec	Fines (cylindrical column) %	Fines (tapered column) %
1	2	3	4	5	6
15.0	253.6	47.5	188.5	22.6	16.9
		13.0	245.9	20.4	21.0
22.5	253.6	47.5	188.5	43.1	23.0
		13.0	245.9	27.1	25.8
30.0	253.6	47.5	188.5	44.9	32.9
		13.0	245.9	34.4	36.1
45.0	253.6	47.5	188.5	64.4	44.8
		13.0	245.9	44.7	44.0
60.0	253.6	47.5	188.5	73.4	59.8
		13.0	245.9	59.4	69.0
75.0	253.6	47.5	188.5	79.7	72.0
		13.0	245.9	73.5	75.2
15.0	232.6	36.0	188.0	25.3	17.6
		13.0	225.6	22.1	15.4
22.5	232.6	36.0	188.0	40.6	25.7
		13.0	225.6	34.7	33.1
30.0	232.6	36.0	188.0	44.9	35.2
		13.0	225.6	41.9	31.6
45.0	232.6	36.0	188.0	60.1	47.3
		13.0	225.6	57.0	43.8
60.0	232.6	36.0	188.0	77.9	61.5
		13.0	225.6	62.8	62.4
75.0	232.6	36.0	188.5	84.9	73.4
		13.0	225.6	76.4	73.4

The feed mixture was subjected to sieve analysis before and after classification; the attrition during classification was found to be insignificant.

The materials used were coal and calcite. The mixture consisted of $-14+18$ & $-18+22$ and $-14+18$ & $-22+30$ B.S.S. fractions. The percentage of fines varied from 15 to 75%. The air-flow rate at the base of the column was kept the same as in the case of a cylindrical column.

Experimental data obtained with cylindrical and tapered columns are given in Tables 1 and 2.

Table 2

Experimental data: cylindrical column versus tapered column

Material: Calcite Size: $-14+18$ & $-18+22$

Fines in charge %	Air velocity cm/sec	Sampling position	Air velocity at sample port cm/sec	Fines (cylindrical column) %	Fines (tapered column) %
1	2	3	4	5	6
15.0	269.3	24.5	235.0	19.7	18.9
		13.0	261.0	19.5	24.1
22.5	269.3	24.5	235.0	23.1	24.8
		13.0	261.0	23.7	29.5
30.0	269.3	24.5	235.0	29.7	34.5
		13.0	261.0	35.5	37.5
45.0	269.3	24.5	235.0	44.4	49.1
		13.0	261.0	47.9	52.5
60.0	269.3	24.5	235.0	55.1	59.8
		13.0	261.0	57.6	57.7
75.0	269.3	24.5	235.0	74.1	73.3
		13.0	261.0	78.7	71.4
15.0	253.6	24.5	221.2	17.1	19.9
		13.0	245.9	21.2	21.6
22.5	253.6	24.5	221.2	21.7	28.1
		13.0	245.9	23.0	26.7
30.0	253.6	24.5	221.2	29.9	33.2
		13.0	245.9	31.4	35.7
45.0	253.6	24.5	221.2	36.1	49.8
		13.0	245.9	43.6	52.2
60.0	253.6	24.5	221.2	53.0	59.3
		13.0	245.9	57.1	60.2
75.0	253.6	24.5	221.2	68.7	74.8
		13.0	245.9	62.0	71.0

Material: Calcite Size: $-14+18$ & $-22+30$

15.0	269.3	24.5	235.0	20.1	22.5
		13.0	261.0	22.3	24.3
22.5	269.3	24.5	235.0	32.9	30.7
		13.0	261.0	35.8	33.2
30.0	269.3	24.5	235.0	39.8	39.8
		13.0	261.0	38.4	41.2
45.0	269.3	24.5	235.0	53.0	52.6
		13.0	261.0	60.8	55.6
60.0	269.3	24.5	235.0	69.0	66.5
		13.0	261.0	73.5	70.5

Table 2 (cont.)

Fines in charge %	Air velocity cm/sec	Sampling position	Air velocity at sample port cm/sec	Fines (cylindrical column) %	Fines (tapered column) %
1	2	3	4	5	6
75.0	269.3	24.5	235.0	78.0	79.1
		13.0	261.0	80.6	78.3
15.0	253.6	24.5	221.2	21.6	20.5
		13.0	245.9	21.8	21.4
22.5	253.6	24.5	221.2	29.3	29.8
		13.0	245.9	36.8	28.8
30.0	253.6	24.5	221.2	36.5	39.2
		13.0	245.9	41.4	37.7
45.0	253.6	24.5	221.2	55.8	52.4
		13.0	245.9	61.4	54.1
60.0	253.6	24.5	221.2	67.6	65.1
		13.0	245.9	73.0	66.8
75.0	253.6	24.5	221.2	73.4	74.5
		13.0	245.9	83.6	78.6

Conclusions

The data indicate that in the case of calcite, percentage of fines is higher at the top in some mixtures, while in the case of coal, it decreases in all mixtures. As a result of the present studies on tapered column, it is concluded that this could be used advantageously for materials with higher densities. A properly designed taper should set up a vertical velocity gradient to enhance separation and to minimize slug formation in systems fluidizing heavier materials. A more systematic investigation to study the effect of top- to- bottom- diameter ratio and the angle of taper in relation to the ratio of minimum fluidization velocities of coarse to fine components in the mixture and rheological properties of the mixture seem to be necessary for establishing design criteria for enhanced classification.

Summary

In part I, classification in a cylindrical column has been studied and a design relationship proposed. In the present work, data on separation of fines in a tapered column having the same base diameter as that of the cylindrical column with a top- to- bottom- diameter ratio of 2.2 and the same taper height as that of the cylindrical column are presented. Effect on the separation of varying ratios of fines to coarse size and of varying percentages of fines in the mixture is studied. The data obtained are compared with those obtained with a cylindrical column.

References

1. Gopalkrishna, N.—Rao, M. N.: Ind. Chem. Engr., Vol. V, 3, T45—58 (1963)
2. Levey, R. P.—de la Garza, A.—Jacobs, S. C.—Heidt, H. M.—Trent, P. E.: Chem. Eng. Progr., **43**, 3, 56 (1960)
3. Ridgway, K.—Sim, H. K.: Chem. Pr. Eng., **47**, 6, 281—6 (1966)
4. Rowe, P. N.—Sutherland, K. S.: Trans. Inst. Chem. Eng., **42**, 55 (1964)
5. Sutherland, K. S.: Trans. Inst. Chem. Eng., **39**, 188 (1961)

R. K. Saksena, Harcourt Butler Technological Institute, Kanpur, India
C. R. Mitra, Birla Institute of Technology and Science, Pilani, India