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FLUIDIZATION IN TAPERED BEDS

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UNION CARBIDE NUCLEAR COMPANY
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A B S T R A C T

The concept of a tapered fluidized bed is explored briefly. Data are given showing that in bench scale apparatus a tapered bed gives better fluidization with some materials that are difficult to fluidize in a conventional cylindrical bed.

FLUIDIZATION IN TAPERED BEDS

Small scale studies of fluidization processes frequently encounter difficulties which may not be present in studies using larger apparatus. For example, even with a 2-inch diameter bed, which is generally considered to be a minimum size, slugging and channeling often occur with some materials. Also, even if a 2-inch bed gives satisfactory fluidization, it is frequently inconveniently large for laboratory studies. Baffles and stirred beds have previously been used to overcome these difficulties (1).

It was conceived that it might be possible to utilize a tapered bed, small at the bottom, to obtain good fluidization of materials difficult to fluidize, and at the same time perhaps reduce the quantity of material in the bed.

As the literature yielded no information on a tapered fluid bed, one was constructed and a few exploratory runs were made. To have a basis for comparison, the same materials were also fluidized in a cylindrical 2-inch diameter apparatus.

The information presented in this report is not intended to be a complete coverage of the subject. Rather, it describes a few qualitative studies of a preliminary nature, and only sufficient data were taken to show that the concept of a tapered fluidized bed should have advantages for certain systems.

EXPERIMENTAL

Apparatus

Two fluid beds were used in this study. Number 1 was a conventional cylindrical bed and number 2 was the tapered bed. Both beds are shown in figure 1 with pertinent dimensions. The remaining apparatus consisted of rotameters for measuring fluidizing air flow and a sulfuric acid manometer for determining the pressure drop across the bed. No provision was made for collecting the fines that were elutriated from the bed.

Materials

Four materials were used in these studies.

1. Common sand - -20 +40 mesh. Rounded, irregular shaped.
2. Ottawa sand - mixed sizes. Primarily rounded cubes and irregular spheres.

Figure I
FLUID BED REACTORS

1. CYLINDRICAL BED

2. TAPERED BED

N.B. All diameters are inside.

<u>Sieve Analysis</u>	
+ 40	0.4 %
- 40 + 60	25.5 %
- 60 + 80	37.3 %
- 80 +100	17.9 %
-100 +200	17.3 %
-200	1.3 %

3. Ottawa sand - -100 +200 mesh from sample 2.

4. Uranium trioxide. Average Fisher sub-sieve size 8.0μ .

Procedure

All runs with sand were made with 724 g. of material which gave a bed depth of approximately $14\frac{3}{4}$ inches in the tapered bed and $10\frac{1}{2}$ inches in the cylindrical bed. The runs with uranium trioxide were made with 750 g. of material which gave bed heights of $10\frac{3}{8}$ inches and $6\frac{1}{16}$ inches, respectively.

An initial fluidization to homogenize the materials was made prior to the runs. Air at room temperature, ca. 75°F , was used as the fluidizing gas for all runs. Air flow and pressure drop across bed were measured as the air flow was varied from zero up to the maximum.

RESULTS

Results of this study were more in the nature of qualitative observations rather than quantitative data. However, some data were taken and these are shown in figures II through VI.

Several differences were noted in the operation of the two types of beds. As expected, slugging was materially reduced by the tapered bed, especially with the larger particle material. At the other end of particle size range, with very fine uranium trioxide, a significant difference in the shape and position of the fluidization curve was obtained. The shape of the curve obtained in the tapered bed much more closely corresponded to an ideal fluidized system, but the pressure drop observed is three times that of the cylindrical bed.

The results as shown in the figures are largely self-explanatory. In general, where slugging was observed in the cylindrical bed it was eliminated or sharply reduced in the tapered bed.

In all cases with the tapered bed an abnormally high pressure drop was obtained prior to fluidization. This excess pressure was roughly proportional to the particle size of the material being fluidized.

The 40 mesh sand, which is perhaps somewhat coarser than materials normally used for fluidization, was never successfully fluidized in the cylindrical bed (figure II). Slugging started soon after fluidization was achieved and upon a slight increase in air flow, was so bad that the bed was continuously lifted out of the lower section of the reactor into the larger disengaging section. In the tapered bed slugging also occurred, primarily in the bottom of the bed, but the top of the bed was relatively stable and well defined. The tapered bed was a significant improvement.

With both the 200 mesh and the mixed sand (figures III and IV, respectively), fluidization was better and significant differences in behavior were not noticed except for severe slugging in the cylindrical bed with the mixed sand.

One final experiment with sand consisted of equal quantities of 40 mesh and 200 mesh material (figure V). As might be expected from the figure, these results were rather singular. At two different velocities in the tapered bed the two sizes of sand classified so that all the large particles were in the bottom of the bed. At a flow of 3 l/min. fluidization and classification started. Most of the fine sand was blown out of the bottom of the bed which immediately reverted to a packed bed. Upon increasing air flow this process was repeated with the remaining fines being blown out of the bottom of the bed until at an air flow of 23 l/min. the whole bed fluidized and mixed. On decreasing air flow the entire bed remained fluidized and mixed until an air flow of 3 l/min. was reached. This same phenomenon occurred to some extent in the cylindrical bed, but complete classification was never obtained.

The final runs were made with UO_3 powder. As noted above, this material is very fine, the average particle size being 8.0 microns. Figure VI shows a significant difference that was obtained when fluidizing these powders in the two different reactors.

Two possible advantages, better fluidization and the use of smaller quantities of material, were suggested in the introduction. The results obtained support the first hypothesis. Better fluidization is obtained in several instances with a tapered bed. In the latter case, while no data were obtained, it is believed that tapered beds down to 0.5 inch diameter could be operated with better fluidization of either very coarse or very fine solids. Depending on the taper, these would hold smaller quantities of material. Additional work is necessary to define the amount of taper required as it is felt that the 5° taper used here is too great, especially for the coarse material.

The easy classification of powder obtained with the mixture of coarse and fine sand in the tapered bed is a development that might have use in some processes such as one in which particle size changes occur.

The effect of utilizing a tapered bed in industrial size equipment can only be surmised. No reason is known why one would not work to advantage. In fact, beds with a small tapered section have been operated with apparent advantages over similar straight beds.

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REFERENCE

- (1) R. A. Beck. Evaluation of Fluid Catalyst, Development of Laboratory Scale Units. Ind. Eng. Chem., 41, 1242 (1949).

Figure VI
FLUIDIZATION OF UO_3

PRESSURE DROP - INCHES H_2O

FLUIDIZING AIR - L/MIN.