Concept Quiz

True or False?

Fine sand can be poured like a liquid. Therefore, based on the fluid mechanics definition, fine sand is a *fluid.*

What do you think?

(Answer is on the next slide.)

Concept Quiz

True or False?

Fine sand can be poured like a liquid. Therefore, based on the fluid mechanics definition, fine sand is a *fluid.*

False! Sand is **NOT** a fluid.

Why not? A fluid cannot resist shear stress, no matter how small.

Friction between the solid sand particles will resist shear. Sand exhibits *static friction*, thus is not a fluid.

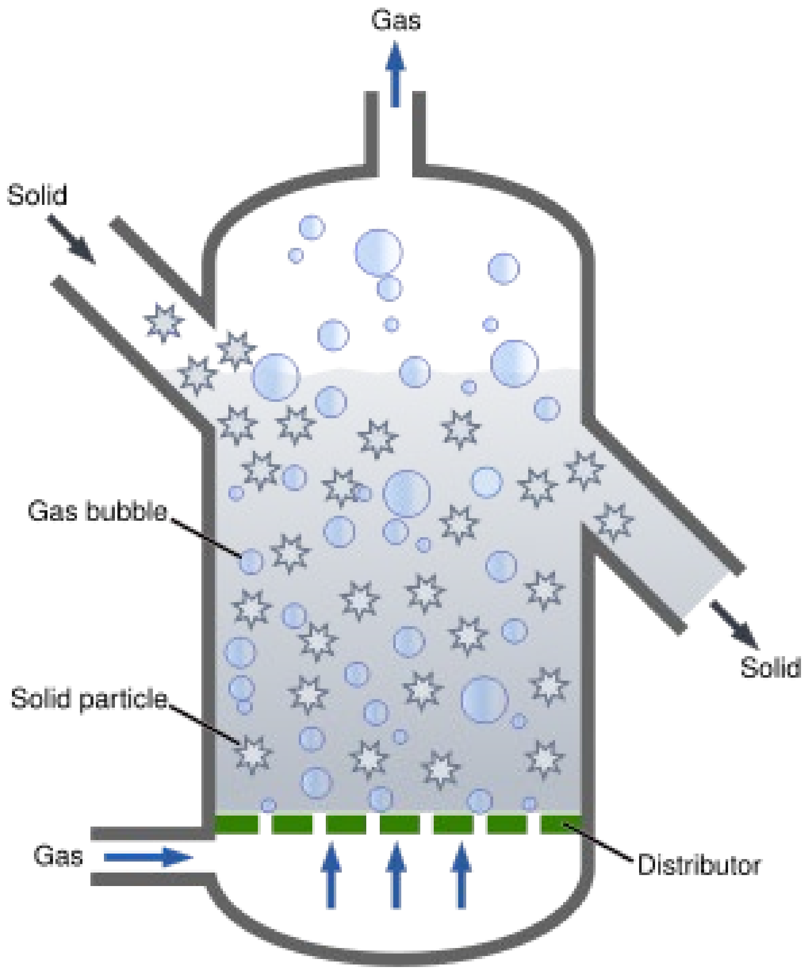
Fluidized Beds

- That said…

- Solid particles can be made to *act* like fluids, i.e. no resistance to shear

- A flow of gas is introduced at the bottom of pile of particles e.g. sand

- Fluidized beds have a wide range of industrial applications



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Heat Transfer to Small Horizontal Cylinders Immersed in a Fluidized Bed

Heat transfer to horizontal cylinders immersed in fluidized beds has been extensively studied, but mainly in the context of heat transfer to boiler tubes in coal-fired beds. As a result, most correlations in the literature have been derived for cylinders of 25–50 mm diameter in vigorously fluidizing beds. In recent years, fluidized bed heat treating furnaces fired by natural gas have become increasingly popular, particularly in the steel wire manufacturing industry. These fluidized beds typically operate at relatively low fluidizing rates ($G/G_{mf}<5$) and with small diameter wires (1–6 mm). Nusselt number correlations developed based on boiler tube studies do not extrapolate down to these small size ranges and low fluidizing rates. In order to obtain reliable Nusselt number data for these size ranges, an experimental investigation has been undertaken using two heat treating fluidized beds; one a pilot-scale industrial unit and the other a lab-scale (300 mm diameter) unit. Heat transfer measurements were obtained using resistively heated cylindrical samples ranging from 1.3 to 9.5 mm in diameter at fluidizing rates ranging from approximately $0.5\times G_{mf}$ (packed bed condition) to over $10\times G_{mf}$ using aluminum oxide sand particles ranging from $d_p=145$–330 μm (50–90 grit). It has been found that for all cylinder sizes tested, the Nusselt number reaches a maximum near $2\times G_{mf}$, then remains relatively steady (±5–10%) to the maximum fluidizing rate tested, typically 8–$12\times G_{mf}$. A correlation for maximum Nusselt number is developed.

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Keywords: fluidized bed, heat transfer, cylinders

YouTube Clip: Physics Girl (2 min)