Classifying Sand Particles by Size

By David Gardellin, President, Onyx Valve Co

Suppose you had a teaspoon full of sand and had to seperte it into two smaller piles based on particle size. Given a magnifier and tweezers I suppose it could be done, but it sounds slow and tedius. Now suppose you had to perform the same seperation for tons of sand.

That's the technical problem confronting the sand mining industry.

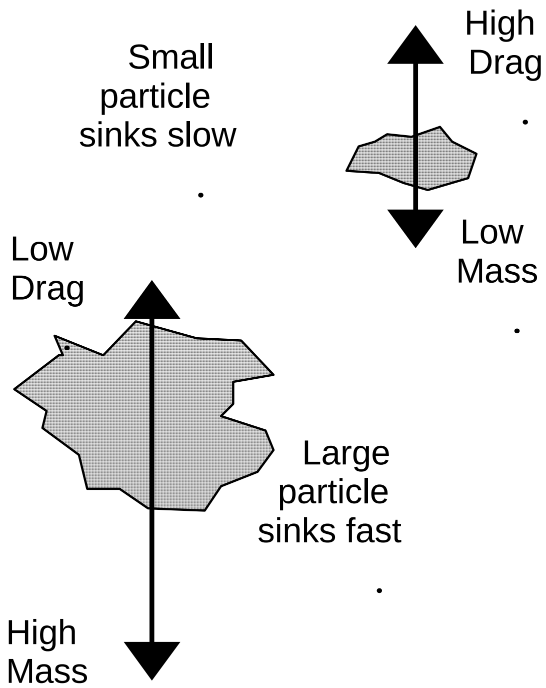
The South Jersy and Eastern Pennsylvania area have been an industrial center for iron casting, glass manufacture, and cement and mortar production since colonial times. All three industries use sand as a raw material or processing medium, but each requires sand particles of different sizes.

The Millville area in South Jersey has an abundance of high quality sand deposites to supply these industries, and they have evolved an ingenious solution to solve the sizing problem.

The physical principle used to classify sand particles takes advantage of differences in relative mass and surface area and their effect on viscous drag.

Large particles are relatively heavy with low surface area, so there is less drag on these particles as they fall through a viscous medium. Large particles fall quickly through water.

Small particles have less mass but relatively more surface area. This increases viscous drag so they fall slowly through water.



The Classifier is a steel box with a slowly rising collumn of water.

Clear water is pumped through a perforated pipe array in the middle of the unit. This clear water volume is slightly greater than the raw pulp volume, so there is an upward flow of water in the upper chamber of the seperator. This creates the teeter zone, where particles are roughly in equilibrium between the force of gravity pulling them down and fluid drag forces pulling them up.

There is a critical threshold in the teeter zone. If any random particle is larger than the 'cut size', gravity predominates, and it falls. For any particle is smaller than the 'cut size', fluid drag forces predominate, and the particle is carried up towards the over flow.

Raw mineral slurry is continuously introduced to the upper unit through the feedwells and is expanded into a teetered state by the rising water current.

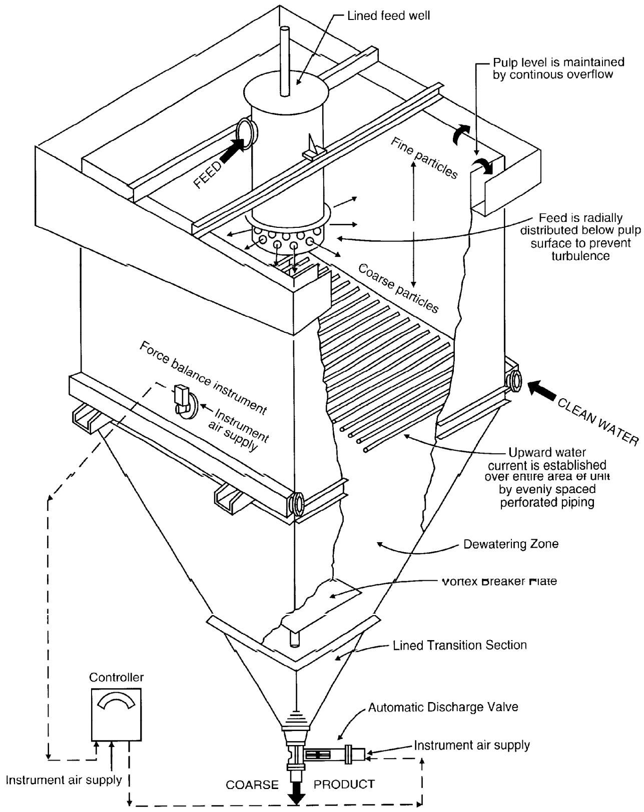


figure 1

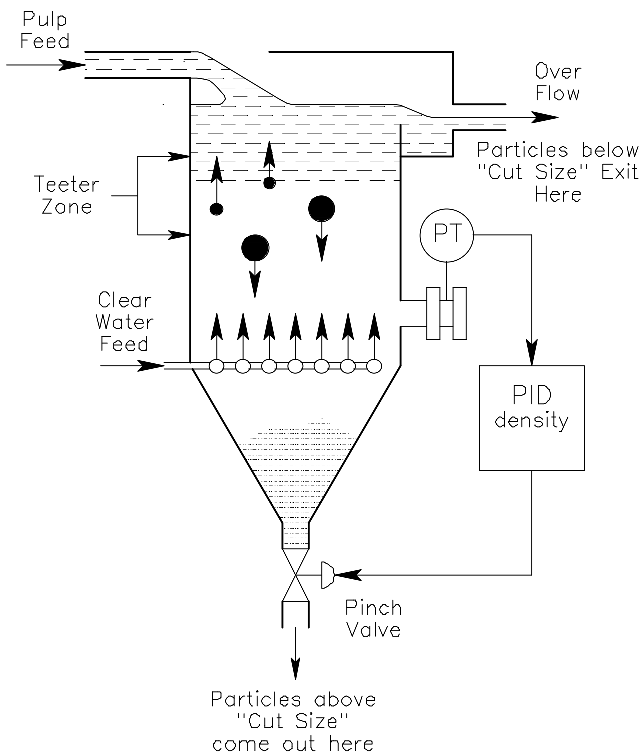
The particles are classified with the coarser material reporting to the bottom of the teetered mass while progressively finer material is bouyed up into the upper portion.

Pulp level is maintained by a continuous overflow.

How do we determine the 'cut size'?

A pressure sensing transmitter is located in the wall of the upper unit immediately above the rising current water piping. Since the level above the transmitter is held constant by the continuous overflow, this signal is proportional to density. This density signal goes to a process controller which manipulates a pneumatically operated discharge valve.

For a pre-set upward current of water, the specific gravity of the mineral suspension at the level of the pressure transmitter is indicative of the average particle size of material above the instrument.



When a specific gravity value is set in the controller, the discharge valve operates to maintain the set value, and thereby maintain an equilibrium condition of the teetered mineral suspension

The diagram on the left shows a basic schematic of the device. Raw pulp (water, sand, clay,etc) is pumped from a bog by a dredge equiped with a pump. The pulp is introduced to the classifier through the top.

We measure the density of the solution at the base of the teeter zone. Direct connection of a pressure transmitter to the mineral slurry would quickly result in plugging of the device. A diaphragm isolator might work for a while, but this too would foul in short order.

The solution is to use an annular pressure isolator ring between the process fluid and the pressure transmitter as shown in figure 3.

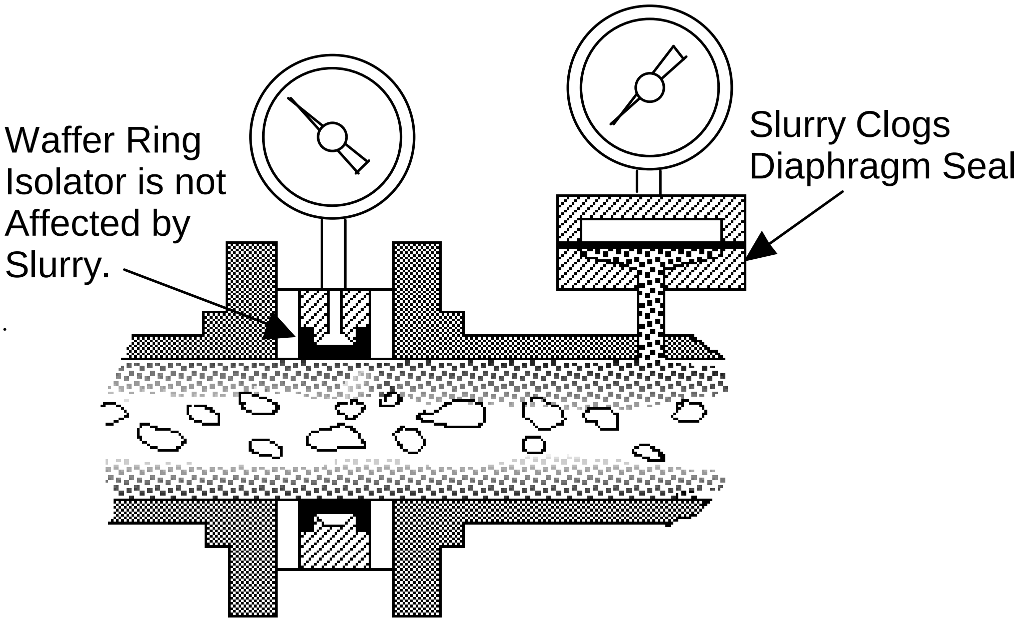


figure 3 Diaphragm seals provide temporary solution, but stop working when slurry solidifies in the seal chamber.

Isolator ring offers a practical method to obtain pressure readings on slurry. The device consists of a rubber 'inner tube' clamped in a steel ring. The assembly is installed between flanges in the process pipe. Clear instrument fluid behind the rubber membrane transmits pressure to the gauge. The ring is continually cleaned by the motion of the process fluid.

In the sand classifier, the fabricator welds a short pipe nipple, usually around a 4 inch diameter, with a flange to the side of the device. A pressure isolator ring and transmitter are attached to the stub and flange assembly and these are capped off with a blind flange.

A 4 inch isolator ring has 25 in^2 of membrane surface area, compared to less than 5 in^2 for a 2.5 inch diameter diaphragm seal; thus, the iso-ring provides a five-fold improvement in the accuracy of the pressure measurement.

Figure 5 shows an isolator ring fitted with a conventional gauge, but for the classifier, an electronic transmitter is fitted in place of the gauge.

This signal is transmitted to a conventional PID controller configured as a density controller. We input a setpoint (we 'tell' the controller) to maintain a certain density at that point.

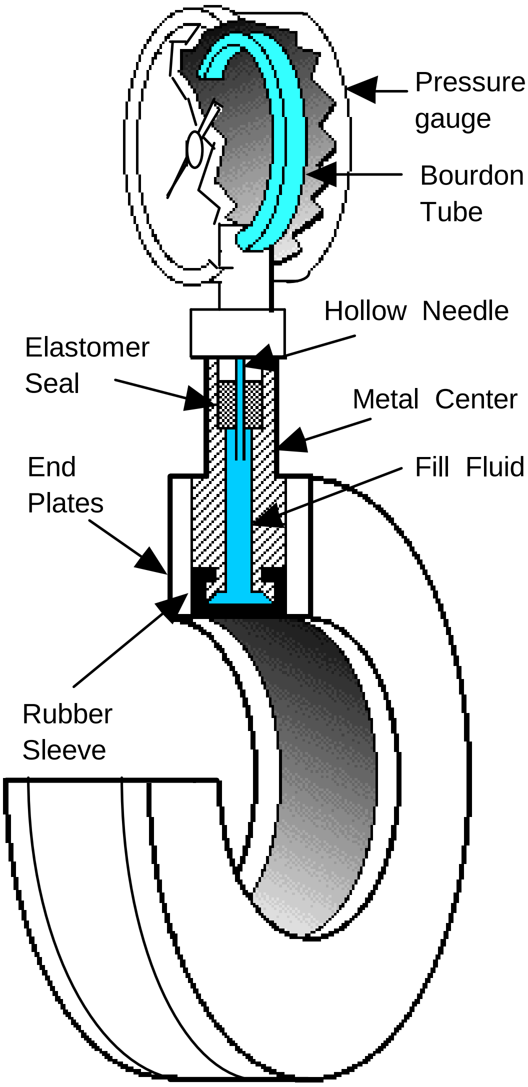


figure 5 Internal configuration of isolator ring.

Now, as average sand particle size in the teeter zone increases, the solution density at the base of the teeter zone increases.

If we start the cycle with clear water, the controller closes the valve at the base of the unit and all of the solution flows up through the over flow at the top.

As mineral slurry is introduced to the classifier, the density increases. As soon as particles over the cut size accumulate near the bottom of the teeter zone, the controller senses the desity rise, and it gradually opens the valve at the base of the unit. These 'over sized' particles drop through the pipe array, where they slide down the sides of the pyramidalical section and accumulate at the entrance of the valve.

As soon as this cycle starts, you can load the machine with pulp at full flow rate, and the density controller will maintain a stable cut point, seperating individual particles by size. If a 'slug' of larger, heavy particles enters the machine, the density controller opens the base valve further, decreasing the upward velocity of the water in the teeter zone. Likewise, the sudden introduction of smaller, lighter particles will decrease the solution density forcing the controller to close the base valve. This increases upward velocity of water in the teeter zone, washing the particles up over the over flow.

Valves:

What kind of valve is used to control this flow at the base of the unit? Many types of valve have been tried here. Ball valves get sand particles between the ball and the seats and jam. Gate valves erode in a matter of a few days and fail to maintain accurate flow. Butterfly valves are cheap, but the edges of the disk erode completly away in a few weeks of service. Diaphragm valves suffer erosion of the weir in a few weeks of service.

So far pinch valves are the only ones that can operate in this environment. They provide accurate, repeatable flow control and drop tight shut off for long periods of time. The only attention they require is replacement of the rubber sleeve about every year or so.

However, any valve must be sized for its application. If the valve is too small, you won't be able to get the required flow necessary to maintain operation of your process.

Well we can make the valve extra big, right?

Not so fast. Buying bigger valves than needed wastes money on the initial installation. Another problem is that oversized valves operate too close to the seat. A valve that can pass maximum required flow when it isonly 10% open provides poor control (a 1% change in valve stem position changes flow rate by a whopping 10%) and creates turbulence that accelerates sleeve erosion. **Correct valve sizing improves accurate flow control and extends sleeve life.**

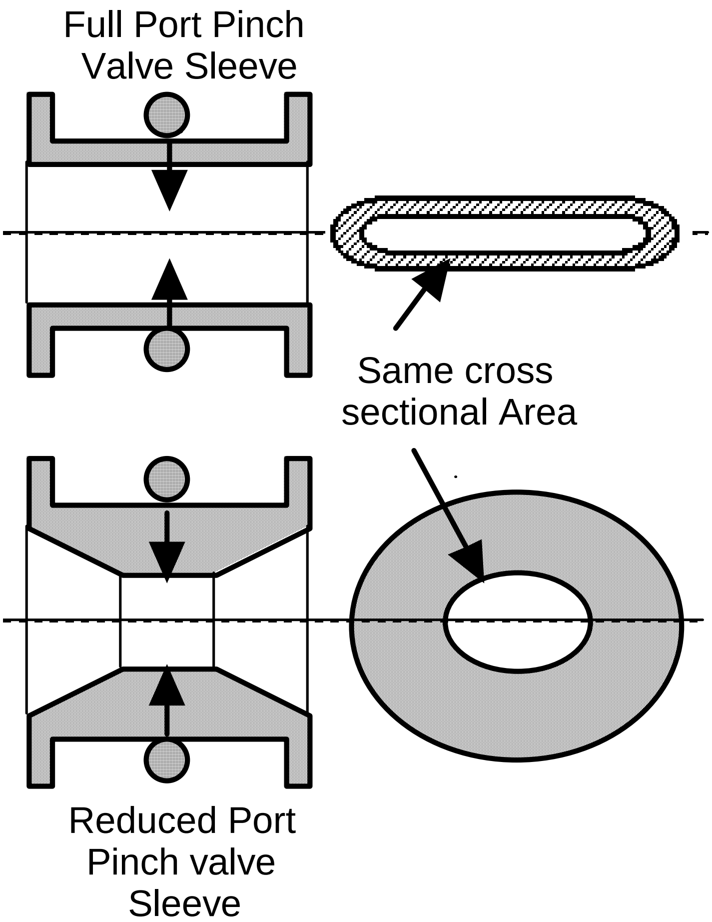


figure 6 pinch valve sleeves

If you are a little nervous about your sizing accumen, pinch valves offer a wonderful compromise: the reduced port sleeve.

In this configuration, the rubber sleeve which lines the inside of the valve is molded in a Venturri shape as shown in figure 6.

By way of example, you could have a 6 inch valve with a 3 inch port. This would have a Cv (capacity number) of 336.

If you needed more flow through the valve, instead of discarding the valve and buying a bigger valve, as you would have to do with a ball, butterfly, gate or diaphragm valve, you simply pop in a new sleeve.

In our 6” valve for example, if you changed to a 6x4 sleeve, your capacity would more than double to Cv = 680. Putting in a full port sleeve would increase capacity even further, up to Cv = 2212, a 6 fold increase over the original configuration.

Reducing the port size also puts more rubber into the valve right where it's needed most, yielding even further increases in sleeve life.