Operators of high volume, low grade ore bodies are always striving to improve plant profitability by increasing mill throughput and recovery.

In most mills, closed circuit grinding systems function as the primary size reduction process, with hydrocyclones serving as the basic classification device. A typical cyclone installation in a ball mill is shown in Figure 1. The cyclones are vertically mounted in a radial arrangement.

Grinding mill efficiency is strongly influenced by the quantity and quality of the circulating load. When a mill is initially equipped, the cyclones are selected to produce a desired grind at a given circulating load and overflow density. In order for operators to increase mill throughput, a coarser grind must be acceptable.

To produce a coarser separation, cyclone feed density must be increased. In a conventional, vertically-mounted cyclone configuration, however, this reduces cyclone efficiency resulting in an increase of bypass fines to the cyclone underflow. The resulting lower quality circulating load can limit throughput due to volumetric constraints in the grinding circuit.

In recent years, several operators processing low-grade ore have replaced their conventional vertically-mounted cyclones with horizontally-mounted cyclones and flat bottom cyclones. Both horizontal and flat bottom cyclones coarsen the separation allowing for higher cyclone efficiency and increased throughput.

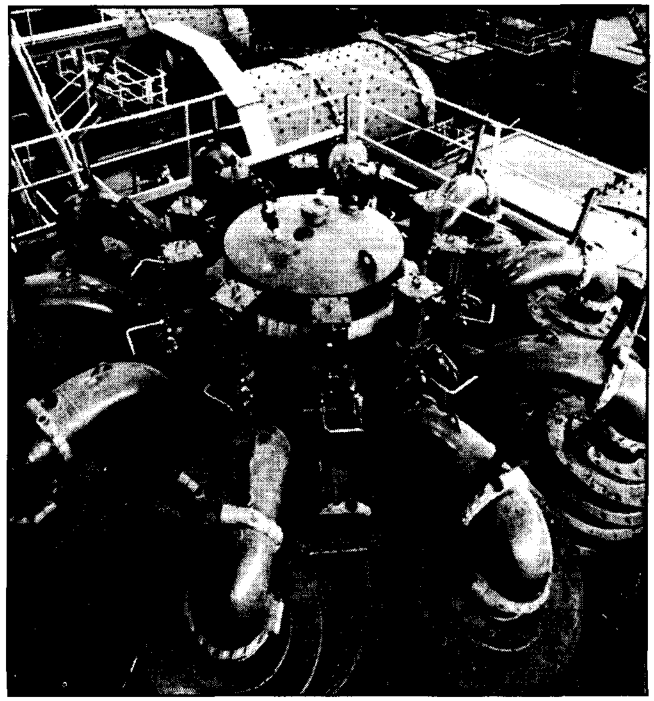

Fig. 1: Vertically mounted cyclones arranged in a radial configuration.

Flat Bottom or Horizontal Cyclones

....Which is Right For You?

By Mark P. Schmidt and Patrick A. Turner*

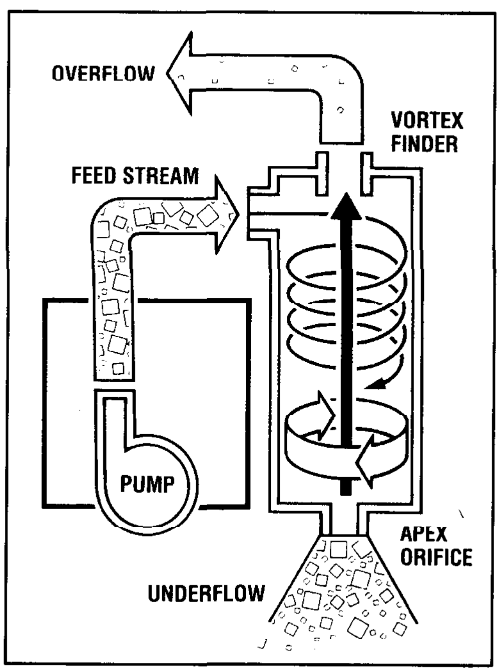

Fig. 2: Diagrammatic of flat bottom cyclone operation.

FLAT BOTTOM CYCLONES

Flat bottom cyclones, which are also known as circulating bed cyclones or circulating bed classifiers, have a cylindrically-shaped body and a completely flat or "bowl"-shaped bottom as shown in Figure 2.

Centrifugal force causes the coarser solids to move down and along the cylinder wall forming a circulating bed in the bottom bowl section. Finer solids drawn to the center of the cyclone in the uprising air/slurry core discharge out of the overflow. The coarse solids discharge out of the underflow through the apex which is located in the centre of the bowl.

The flat bottom cyclone produces a coarser separation than a conventional vertical cyclone due to the abrupt directional change of the slurry in the bottom section. Thus smaller diameter flat bottom cyclones perform like larger diameter conical cyclones.

Figure 3. overleaf compares typical actual recovery curves for a vertical cyclone, and a flat bottom cyclone of the same diameter on the same cyclone feed. The separation of the flat bottom cyclone is coarser and the recovery curve is flatter than the vertical cyclone.

The coarser separation for the flat bottom cyclone requires additional dilution water. The resulting lower cyclone feed density improves cyclone efficiency since it decreases the amounts of bypass fines material in the cyclone underflow.

The flat bottom cyclone reduces the quantity of bypass fines, improving the quality of the circulating load. This can relieve volumetric bottlenecks in the mill, pump, and cyclones allowing increased mill throughput.

Flat bottom cyclones produce consistently high density cyclone underflow. Apex sizing is not as critical, therefore eliminating most apex plugging, choking, or roping. In addition, higher

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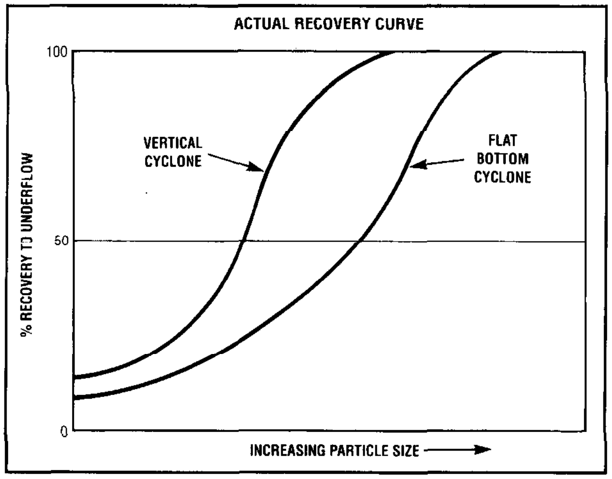

Fig. 3: Actual recovery curve showing performance data for vertical and flat bottom cyclones.

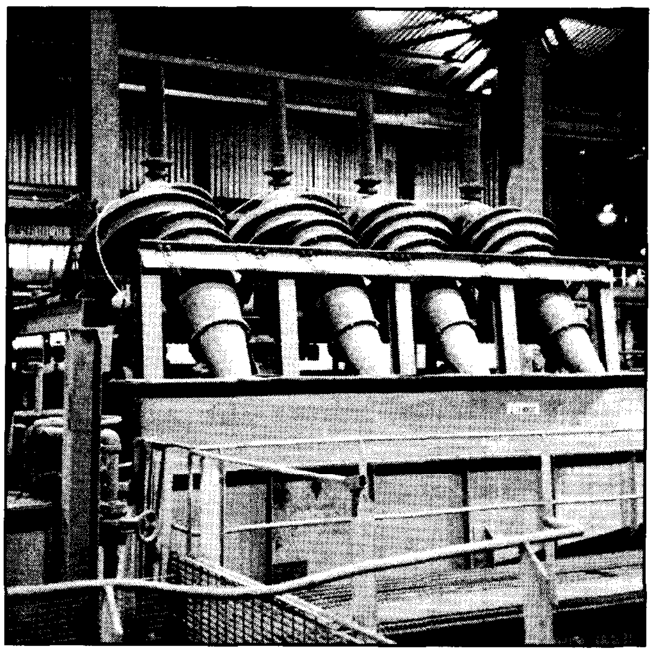

Fig. 4: A typical horizontally-mounted cyclone installation, arranged in an inline configuration.

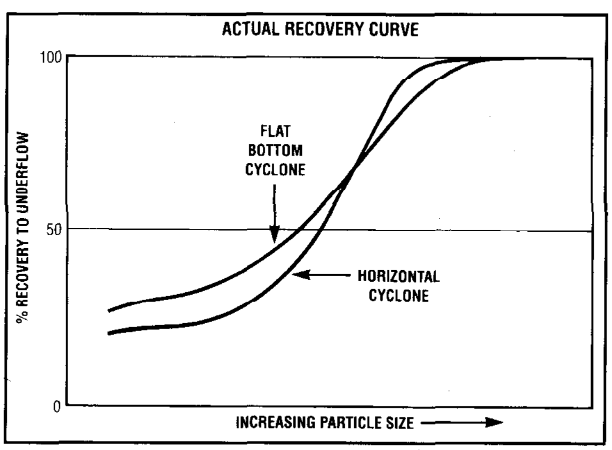

Fig. 5: Actual recovery curve showing performance data for horizontal and flat bottom cyclones.

cyclone underflow density improves milling efficiency due to greater control over mill density.

A disadvantage of flat bottom cyclones is that the rotating bed of coarse solids circulating in the bowl section causes grooving in the bowl and apex. Flat bottom cyclones also have flatter efficiency curves than vertical cyclones in a coarse grinding circuit. This lower efficiency leads to more coarse material in the cyclone overflow, which can result in lower recovery in flotation.

HORIZONTALLY-MOUNTED CYCLONES

Horizontally-mounted cyclones, shown in Figure 4, also produce coarser separations than vertical cyclones of equal diameter. The reduced vertical head of the horizontal cyclone allows for a consistent underflow density similar to the flat bottom cyclone.

In a horizontal cyclone, the apex discharge is not a forced spray, but rather a discharge that seems to effortlessly flow in a lazy swirl. The apex sizing is not critical, allowing for installation of larger diameter apexes which eliminate roping or plugging of the apex.

As with the flat bottom cyclones, additional cyclone feed dilution water is required to produce the same separation as the vertical cyclone. Adding more water improves the cyclone separation efficiency.

Horizontal cyclones have reduced fines in the underflow resulting in higher quality circulating load, relieving volumetric capacity in the mill, pump, and cyclones. They also have consistently high underflow density and reduced risk of apex plugging and roping.

The lazy swirl discharge of the horizontal cyclone reduces wear in the lower cone and apex sections by 80%, and the horizontal mounting reduces pump head requirements. This, combined with lower circulating load, reduces pump energy and maintenance costs.

HORIZONTAL VERSUS FLAT BOTTOM CYCLONES

Both flat bottom and horizontal cyclones make coarser separations. This allows the operator to increase throughput and coarsen the grind while maintaining a high quality circulating load. Both types of cyclones also maintain consistently high underflow densities.

The main advantage of horizontal cyclones over flat bottom cyclones is improved cyclone efficiency. Figure 5 illustrates the steeper actual recovery curve of the horizontal cyclone. The overflow of the horizontal cyclone will contain less coarse solid than the flat bottom cyclone.

CONCLUSIONS

Horizontal or flat bottom cyclones can be considered for ball mill circuits with a grind of 80% -150 microns or coarser. In most cases, horizontal cyclones will be the optimum choice. Vertical cyclones will still be recommended in coarse grinding circuits with high overflow density requirements or to meet other special design needs.

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