A Guide to the Proper Application of Classifiers

by H. W. Hitzrot

SEPARATING a mixture of particle sizes of material suspended in a liquid medium is by no means an exact science. Selecting machines for individual classifying operations is even more difficult. The plant operator's own background is of course invaluable, and considerable help may be obtained from technical articles, talks with sales engineers, and handbooks on ore dressing. These several sources of information, however, are difficult to marshal in proper perspective for the major decision on classification units that an operator may be called upon to make. To the present writer's knowledge this assembly of facts is not available in handbooks, and technical papers are scarce on classification equipment developed in the past five or six years. It is believed that this paper will be helpful to users of classification equipment at this particular period in the development of hydro-classification.

For easy reference the following classification units now available and in use in metallurgical and industrial operations are listed below, with a brief description of each.

Unit-type classifiers, bowl classifiers, and *bowl desiltors* are all rectangular tanks, slightly tilted, with reciprocating rakes or screws to remove settled sands. The unit-type classifier, Figs. 1 and 2, is available in widths from 14 in. to 20 ft and lengths up to 40 ft. The shallow bowl of the bowl classifier, Fig. 3, equipped with rotating rakes, is superimposed on the lower end of the tank. Reciprocating rake compartments for this design range from 18 in. to 20 ft wide. Bowl diameters vary from 4 to 28 ft. The flat-bottomed bowl of the desiltor, Fig. 4, of relatively large diameter, is equipped with rakes rotating outward and partly over a pit, which is created by extension of the rectangular tank into and under the bowl section. Bowl desiltors are available with reciprocating rake sections 4 to 20 ft wide and bowls from 20 to 50 ft in diam. The bowl desiltor is used for applications beyond the range of the bowl classifier.

The *hydroseparator,* Figs. 5 and 6, is a circular tank equipped with slowly rotating rake arms, set on a slope, with interrupted rake or spiral blades to move the settled solids to a central discharge cone. Tank diameters vary from 4 to 250 ft. Tank depths at center are 2 to 3 ft for small units and up to 25 ft for larger units.

Hydraulic classifiers of the sizer and super-sorter types, Figs. 7 and 8, are narrow, deep, rectangular tanks divided by vertical baffles into a series of pockets. Hydraulic water is added near the bottom of each pocket. Perforated constriction plates, spiral flow arrangements, or jets are used to disseminate the water under pressure (hydraulic water) throughout the bed of material in the pocket. Discharge valves on each pocket are operated automatically by a pneumatic mechanism, a pincer-type mechanism, or a pressure control and motor combination actuated by a hydrostatic tube within the pocket. Hydraulic classifiers are available in 4, 5, 6, and 8-pocket units of varying constriction plate areas to suit conditions. There is now a jet sizer of unit pocket design that can be made up in 1 to 25 sections or more to accommodate sizing requirements.

The *hydroscillator,* Fig. 9, is a rectangular tank set on a slope of 3 to 4 in. per ft. A bowl is superimposed on the lower end. The bowl bottom is an oscillating rubber-covered disk, perforated to allow hydraulic water introduced beneath the disk to set up a teeter bed and thus produce an oversize or rake product exceptionally free of slimes, and material minus the mesh of separation.

A shallow dam at the periphery of the bowl allows the coarse or oversize fraction to spill over and drop down into the tank compartment, where it is moved up the deck by reciprocating rakes. The material, minus the mesh of separation, overflows a circular and stationary weir which is several inches higher than the dam on the oscillating disk. It is carried off in a circular launder in the usual manner.

These units are available in bowl diameters from 4 to 14 ft and with reciprocating rake compartment widths to suit the tons per hour to be handled.

Centrifugal classifiers include the solid bowl centrifuge and the cyclone classifier. The *solid bowl centrifuge,* Fig. 10, consists of a truncated cone fixed to a horizontal shaft and rotating at high speed. An internal spiral rotating at slightly less speed continuously removes solids deposited on the inner surface of the cone, or bowl.

Feed enters the cone by means of the hollow center shaft. Overflow leaves through ports at the large end of the cone, and oversize solids, moved by the spiral, exit through ports at the small end.

Centrifugal classifiers of this type are available in cone diameters from 18 to 54 in.

The *cyclone classifier,* Fig. 11, is a stationary cone having a cylindrical upper section and a lower cone section. Feed is introduced tangentially into the upper cylindrical section under pressure from a hydrostatic head or by means of a pump. Centrifugal force thus induced effects a classification within the cone, the fine sizes being carried off in the overflow through an opening at the top of the cylindrical section. Coarse solids at relatively high pulp density exit through a control valve at the apex of the lower cone section. Cyclone classifiers are available in 3, 6, 12, 14, 24, and 30-in. diam.

The *cone classifier,* Fig. 12, is a steel-plate cone with sides usually about 60° from horizontal. It contains no rotating mechanism. Feed enters a feedwell at center and classification is effected by gravity and pulp density. Fines are carried off in the flow over a peripheral weir at the top of the cone. Settled solids exit through an opening at the apex. An apex valve actuated through levers and rods by the pulp density in the lower cone section is usually supplied. Diameters are usually maximum at 8 ft.

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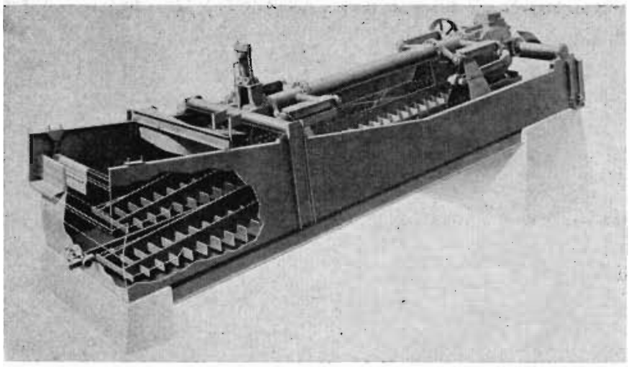


Fig. 1—A unit-type classifier utilizing reciprocating rakes.

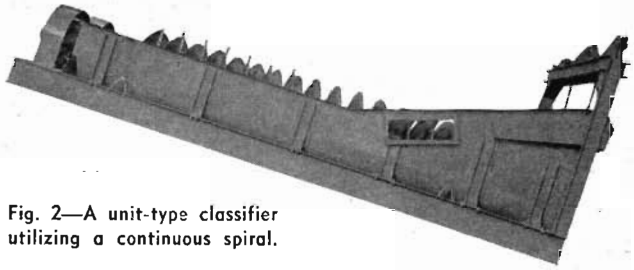


Fig. 2—A unit-type classifier utilizing a continuous spiral.

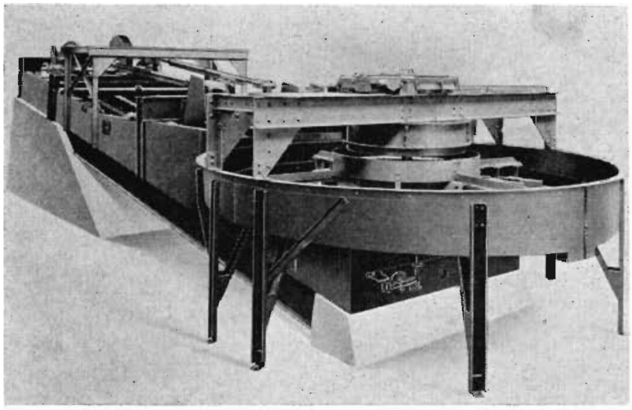


Fig. 3—The bowl-type classifier.

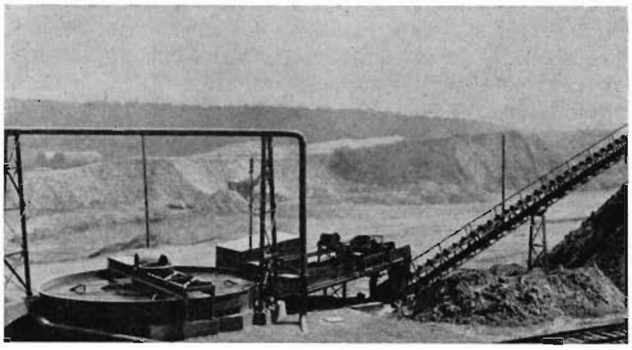


Fig. 4—A typical bowl desiltor installation.

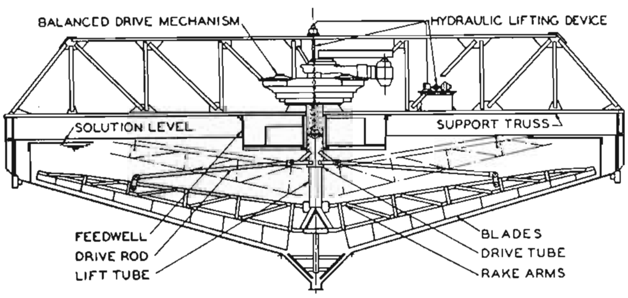


Fig. 5—Illustrative sectional elevation of hydroseparator utilizing interrupted rake blades.

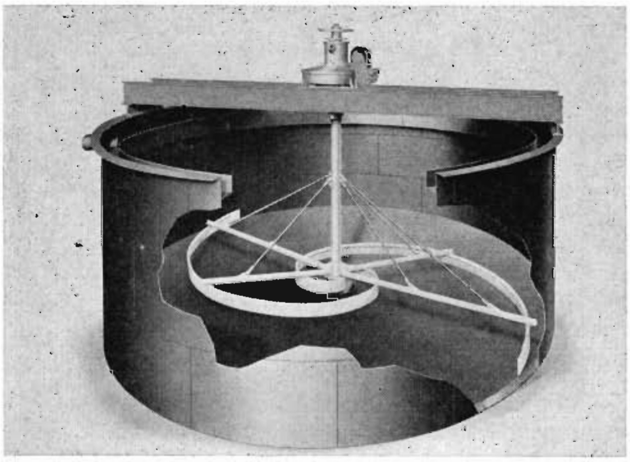


Fig. 6—The hydroseparator, showing spiral blade construction.

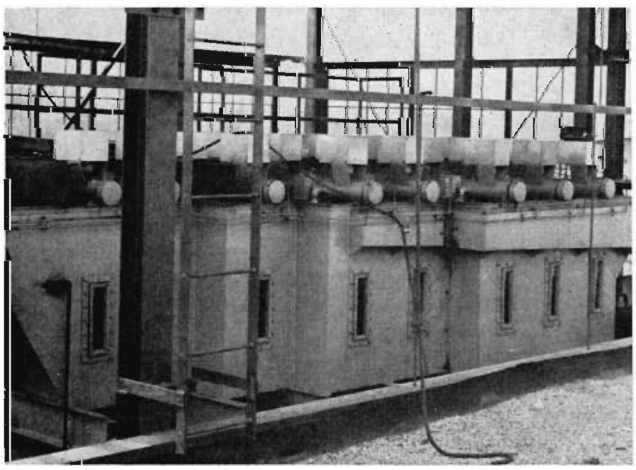


Fig. 7—Installation view of a sizer hydraulic classifier.

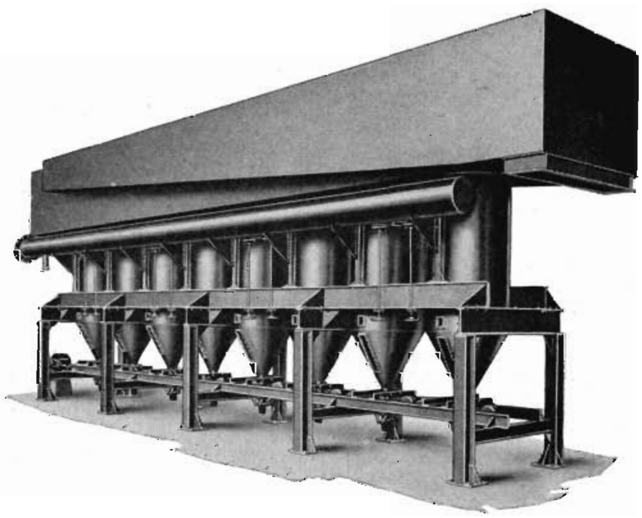


Fig. 8—A super sorter hydraulic classifier.

In the *sand washer,* Fig. 13, a set of buckets is attached to a circular frame rotated slowly on an inclined deck, which forms the bottom of a circular tank. The top of the tank side extending up from the heel becomes the overflow weir. Feed under pressure is introduced toward the center of the inclined bottom. Sand washers are available in 7, 9, and 12-ft diam.

Below what mesh of separation are classifiers more efficient than vibrating screens? Allowing for some latitude of opinion, 20 mesh is about the limit for a two-product separation on a mixed-size material of 2.65 sp gr. For separations coarser than 20 mesh, for example, 10 or 14 mesh, screens are preferable. On mixed-size materials having greater specific gravities, in the range of 3.5 to 5.0, classifiers should be limited to a separation at 28 to 35 mesh. Screens will be more efficient and should be used on two-product separations for 20 mesh and coarser.

Particles coarser than 20 mesh can be made to report in the overflow from unit-type classifiers when the ground ore or material contains a high percentage of true slimes. Such materials are cement rock and ores containing talc and clay. But these coarse particles, sometimes as large as ¼ in., are more in the nature of tramp oversize carried in suspension in a high-density classifier pool. The basic mesh of separation is more nearly at 20 mesh.

In hydraulic classifiers of the *sizer* and *supersorter* types it is possible to make a split at 6 or 8 mesh, but this is done at the expense of about 4 tons of hydraulic water per ton of feed handled and generally would not be practicable for big tonnage operation.

So much for the limitations of mechanical-hydraulic and centrifugal classifiers in general. For each of the nine types of classifiers described in this paper there are individual limits of application, as shown in Table I.

Mechanical-hydraulic classifiers, equipped with either reciprocating or spiral rakes, are the most widely used and have countless applications.

Unit-Type Classifiers

Limitations: Unit-type classifiers are commonly employed for two-product separations, overflow and rake product, with overflow solids ranging between 20 and 100 mesh. Maximum size of feed particle is normally 1 in., occasionally 1½ to 2 in. When specific gravity of the feed solids is 4.0 to 5.0, overflow should be limited to a top size of 28 to 35 mesh.

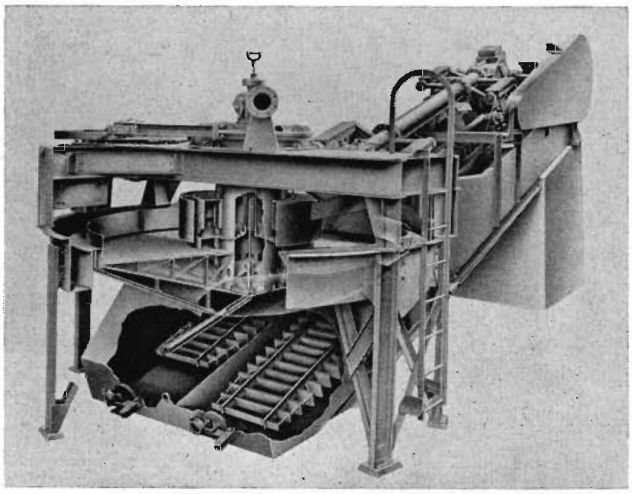
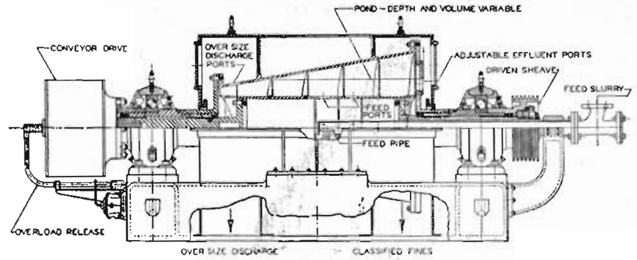


Fig. 9—A cutaway view of the hydroscillator.



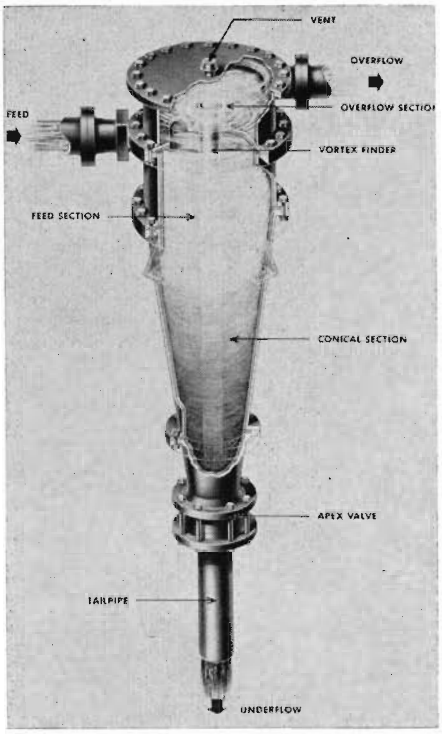


Fig. 10 (above)—A sectional elevation of the solid bowl centrifuge.

Fig. 11 (right)—Cutaway view of a cyclone classifier.

Control of water into these classifiers is very important, as separation at whatever mesh, 35, 48, 65, or 100, is made largely by the buoyancy or viscosity of the mixture of water and solids in the pool. Agitation of the sand-raking mechanism also affects mesh of separation. Excess water, contrary to the opinion of the uninitiated, ruins the separation by allowing too many particles of the desired size to drop down into the rakes or screws. Too little water, conversely, allows oversize particles to remain in suspension and contaminate the overflow.

When unit-type classifiers are used for scrubbing and dewatering, however, the amount of water entering with the feed is not critical. In most cases the products handled are preponderantly granular and hence fast-settling in character, for example, concentrates and silica sand. The pool area then determines the amount of water that can be handled. Fresh water in the form of wash water is frequently added up on the drainage deck section further to clean the rake product of contaminating slimes.

In both reciprocating and screw types, this classifier produces a rake product of consistent moisture content hour in and hour out, even with some variations in the feed volume. On dewatering operations carried out before further processing this is of great advantage. For instance, in the dewatering of phosphate rock prior to oiling ahead of tabling or prior to the addition of flotation reagents, the content of consistent low moisture solids in the rake product is highly valued.

Applications: Unit-type classifiers are used most frequently with mills for closed-circuit grinding of

Table I. Sizes, Limitations, and Major Applications of Unit Classifiers, Bowl Classifiers, Bowl Desiltors, Hydroseparators, Hydraulic Classifiers, Hydroscillators, Centrifugal Classifiers, Cone Classifiers, and Sand Washers

Type of Classifier	Normal Size Range: Width	Normal Size Range: Diam	Normal Size Range: Max. Length	Mesh of Separation, Ranges	Relative Classifier Efficiency	Normal Feed, Tonnage Range	Max. Oversize Handled	Normal Overflow, Pct Solids, Range	Normal Feed Density Range, Pct	Normal Underflow or Rake Product, Pct Solids	Motor Range, HP	Hydraulic Water Required	Typical Applications
Unit Classifier	14 in. to 20 ft	—	40 ft	20 to 100	Medium	1 to 350 tph	1 to 1½ in.	5 to 65	Not critical	80 to 83	½ to 25	Spray wash optional	Closed circuit grinding Washing and dewatering Process feed control
Bowl classifier	18 in. to 20 ft	4 to 28 ft	38 ft	65 to 325	Medium plus	1 to 300 tph	½ to ¾ in.	5 to 25	Between 10 and 75	75 to 83	Bowl: 1 to 7½ Recip. rakes: 1 to 25	Water added with feed or in classifier for correct overflow density	Closed circuit grinding, usually in secondary circuit but sometimes in primary. Washing and dewatering
Bowl desiltor	4 to 16 ft	20 to 50 ft	38 ft	100 to 325	Medium	5 to 250 tph	½ in.	1 to 15	Not critical	75 to 83	Bowl: 1 to 10 Recip. rakes: 5 to 25	Spray wash optional	Recovery of fine sand, limestone, coal and fine phosphate rock from large flow volumes.
Hydroseparator	—	4 to 250 ft	—	Usually 100 to 325. Special cases 35 to 325	Low	Few lb per hr to 500 to 700 tph	¼ in.	1 to 20	Not critical Generally 5 to 20	30 to 50	Fractional to 15	All water enters with feed	For fine separation where large feed volumes are involved
Hydraulic classifiers Sizer	Varies with no. of pockets	—	Varies with no. of pockets	6 to 150	High	2 to 100 tph	⅛ to 3/16 in.	5 to 20	40 to 60	40 to 60	1 to 2 for air pressure	Up to 4 tph feed	Gravity concentration of metallic ores Preparation of table feed Sizing of homogeneous materials
Super sorter	6 ft	—	About 40 ft	¼ to 150 ¼ to 150	High High	40 to 150 tph	¼ to ⅜ in.	5 to 20	30 to 60	40 to 60	1 to operate pincer valves	Up to 4 tph feed	Gravity concentration — preparation of table feed —coal Sizing of homogeneous materials
Hydroscillator	4 to 12 ft	4 to 14 ft	30 ft	20 to 200	High	5 to 250 tph	½ to 1 in.	15 to 30	40 to 80	75 to 83	Bowl: 3 to 10 Rakes: 5 to 20	Up to 1.5 tph per ton of feed	Used where exceptionally clean rake sands are needed Closed circuit grinding
Centrifugal classifiers Cyclone	—	3 to 30 in.	9 ft	100 mesh to 5 microns	Medium	10 to 1500 gpm	14 to 20 mesh	5 to 30	1 to 30	55 to 70	Power for pressure head	None	For fine separations in variety fields
Solid bowl centrifuge	—	18 to 54 in.	70 in.	100 mesh to 5 microns	Medium plus	Up to 500 gpm	¼ in.	5 to 30	1 to 30	40 to 70	10 to 50	None	For fine size fractionating down to 5 microns
Cone classifier	—	2 to 12 ft	—	28 to 325	Low	Up to 100 tph	¼ in.	5 to 30	Not critical	35 to 60	None	None	For desliming and primary dewatering
Sand washer	—	7 ft 9 ft 12 ft	—	28 to 65	Medium	25 to 125 tph	1 in.	5 to 20	About 30 to 35	80 to 83	5 to 10	None	For desliming and dewatering large tonnages of bulk material

nonferrous and ferrous ores, cement rock, silica, and pigments. In fine grinding, straight classifiers are often used for single-stage grinding and as the primaries in two-stage grinding. Not infrequently they function as classification units in the secondary stage of two-stage grinding. As would be expected, the width of the unit to be selected depends on the 24-hr tonnage handled, the mesh of separation, and the specific gravity of the material.

Unit-type classifiers are also employed for final scrubbing, washing, and dewatering of granular products such as phosphate rock, ground silica, concrete sand, fine coal, limestone, precipitated alumina, and mineral concentrates from flotation and gravity concentration milling. Occasionally these classifiers size, wash, and dewater granular organic-chemical products in plastics and related fields.

Reciprocating rake-type units have wide application as grit-removal devices on *detritors,* which remove coarse solids in municipal sewage-disposal plants. They also function as grit and unburned core removal devices in continuous slaking of burned lime. These combination units are known as *slakers.*

Another application of reciprocating rake units is the washing of coarse ore: gold ores, bauxite, iron ores, and marls in cement-manufacturing processes. These units, called *washers,* are reciprocating rake classifiers with separately driven wire mesh or punched plate trommels superimposed over the pool end and partly submerged in it.

A machine of this type can produce three products: a washed coarse material about −3 in. from the trommel, a −3⁄8 or ½-in. rake product, and finally an overflow −48, 65, or 100 mesh to dust, all of which is carried off with the overflow water.

Employment of unit-type classifiers in the field of ore concentration by the heavy-media process is most worthy of mention. They are used as separatory vessels for both coarse and fine ore fractions. The screw or spiral-equipped unit is particularly applicable as a densifier unit: the screw can be lowered into a bed of heavy media (finely ground magnetite or ferro-silicon) and stored in the classifier pool. Density in the heavy-media circuit is thus periodically raised.

The Bowl Classifier

Limitations: The bowl classifier has been designed and developed for separations finer than are generally attempted in the straight or unit-type classifiers. For the more usual 2.65 to 3.0 sp gr materials, a two-product separation at 65 mesh is the generally accepted top limit. Separations within the range of 100, 150, 200, and 325 mesh are, however, more common. The raking mechanisms of this unit can handle a feed containing particles as large as ½ to ¾ in. For materials of 3.5 to 5.0 sp gr, the top limit for a two-product separation with the bowl classifier is about 100 mesh, and because of the heavier gravity, fineness of separation can be extended below 325 mesh (43 microns) or down to about 20 microns (750 mesh).

At this time diameter of the bowl section does not exceed 28 ft. This limitation is imposed by design difficulties of balancing and rigidity for the overhanging rake section extending underneath the midpoint of the bowl and about 2 ft beyond it.

As with the unit classifiers, water entering the bowl classifier must be controlled. Whereas unit classifiers generally overflow at 25 to 40 pct solids, bowl classifiers overflow at 5 to 25 pct solids; the finer the mesh of separation, the lower the percent of solids in both unit and bowl classifiers.

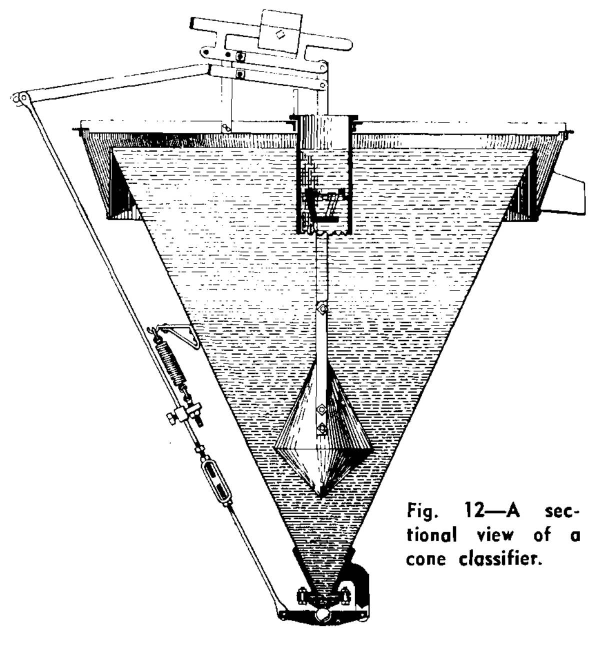


Fig. 12—A sectional view of a cone classifier.

A bowl classifier, when used in closed-circuit grinding, must handle a large tonnage of circulating sands in addition to the new feed. In such cases it is essential to equip the classifier with a reciprocating rake section of a width approximately 80 pct of bowl diameter. Thus for a 20-ft diam bowl the reciprocating rake section should be 16 ft wide, with four rakes 4 ft wide. Reciprocating rakes are standard in 2, 3, and 4-ft widths and an even number of rakes must be used. Hence a 15-ft diam bowl with reciprocating rake section 12 ft wide would have four rakes 3 ft wide.

Applications: The bowl classifier is used most commonly in the secondary or final grinding stage in the closed-circuit grinding of nonferrous and ferrous ores, cement rock and marls, silica sand, and pigments. It is less frequently used in the single-stage fine grinding of these same materials and in the regrind circuits for middlings and concentrates.

The bowl classifier also has wide application as a deslimer. This is by virtue of the fact that any water added into the reciprocating rake compartment has but one means of escape up through the opening in the bowl bottom. Solids collected in the bowl enter the reciprocating rake compartment through this same opening and lose much of their slimes and fines content in the rising stream.

The Multi-Deck Washing Classifier

In some processing operations it becomes desirable to wash a contaminating chemical solution from the rake product of a bowl or a unit-type classifier. In most instances more than one washing stage is required, and one, two, or three additional raking sections are added in cascading fashion to make a unit-type or a bowl classifier with multidecks for the counter-current washing of the sand product. Fresh water is added on the final deck and progresses downward counter-currently to movement of the solids. The wash water flows from one raking section to the next lower section by means of interconnecting launders.

Multi-deck washing classifiers have widest application in the chemical processing field for the counter-current washing of nickel compounds, chromium ores and compounds, alumina, abrasives and abrasive intermediates, tri-sodium phosphate, zeolite sands, and some other chemical compounds. Acid-proof construction must be used for some operations.

The Bowl Desiltor

Limitations: The bowl desiltor is a classification unit of fairly recent design and usage that bears some semblance to the old *Clabowl* used in the china clay and filler clay fields. Its use is limited to operations involving large flow volumes and fine separations where the former goes beyond the range of the maximum diameter (28 ft) of bowl classifiers, or where the relatively small amount of solids in the large volume of flow does not justify the heavy duty construction of bowl classifiers.

The bowl desiltor makes a two-product separation with the mesh of separation in 150 to 200 or 325 mesh range. Usually the tonnage of coarse or rake product is relatively small and more often than not, duplex rakes will handle it. This machine neatly combines in one unit the use of a hydroseparator for the fine separation and a unit-type classifier to dewater the dilute hydroseparator underflow.

The top size for the coarsest particles in the feed to this unit should not exceed ½ in. Certainly there would be few occasions when any solids coarser than about 6 mesh would be in the feed, but the rakes will handle a limited amount of ½-in. pieces.

Applications: At the present time the bowl desiltor has widest application in the recovery of extremely fine sand overflowing the various washing units in concrete sand, foundry sand, glass sand, and limestone-processing plants. Such recovered fine sand is delivered in a drained condition by the reciprocating rakes and is used as a special product or is blended into the coarser product to increase the fineness modulus.

It is conceivable that in the future the bowl desiltor will be used whenever it is desirable to remove a small amount of finely divided solids from a large volume of flow, that is, for the recovery of fine coal, phosphate sand, blast furnace flue dust, or fine mineral concentrates.

The Hydroseparator

Limitations: In the hydroseparator a widening in the line of flow allows the coarser particles to settle out from the suspension. Only the cone classifier is simpler in construction. The hydroseparator is frequently misused because its limitations are not fully recognized.

Classification efficiency of the hydroseparator is appreciably lower than that of the unit-type and bowl classifiers. It depends entirely on gravity settling for the separation, and the overflow can be set to contain around 1 pct or less of particles plus the mesh of separation. This is done at the expense of allowing a relatively high separation of particles minus the mesh of separation to settle into the underflow, resulting in low classification efficiency. The underflow will always contain about 40 to 60 pct of the material minus the mesh of separation, the higher percentage being approached when coarse separations in the 35 to 65 mesh range are adopted.

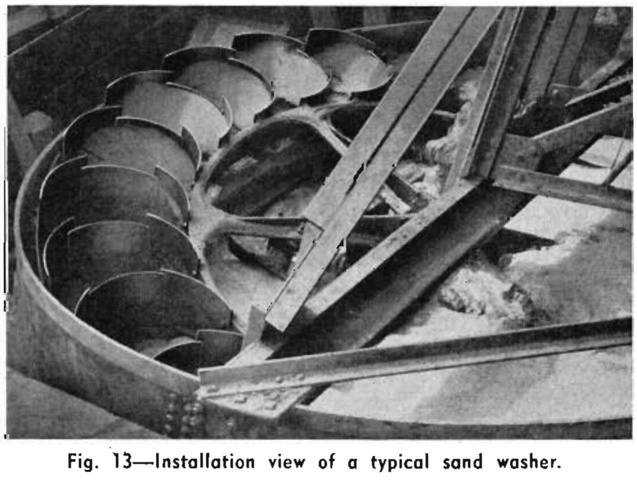


Fig. 13—Installation view of a typical sand washer.

The hydroseparator is generally used for separations finer than 100 mesh, except when the feed flow is so great that the cost of the multiplicity of bowl or unit-type classifiers required makes a coarse separation by means of a hydroseparator attractive. Feed to a hydroseparator should not contain particles much over ¼ in., and when there is an appreciable amount of 28 mesh to ¼-in. material present, as in concrete sand, then heavy duty mechanisms with arms at a slope of 2 to 3 in. per ft should be used.

There is no limitation on the handling of heavy-gravity material in hydroseparators, but the steep rake arm slopes mentioned above should be used.

The size or diameter of a hydroseparator is a function of the feed volume and the separation desired. The tonnage of solids to be handled does not directly affect the size but must be taken into account in selecting the design and height of raking mechanism. The tonnage handled can range from a few pounds up to 500 to 700 tons per hr.

Applications: The comparatively low classification efficiency of the hydroseparator restricts its use to situations where the volume of flow is beyond the range of unit classifiers, bowl classifiers, and the bowl desiltor. It is used, however, for small feed flow volumes where no great importance is attached to the poor classification feature.

The hydroseparator is appropriate when a large volume of water is to be sloughed off prior to further processing of the granular fraction, and units of 75, 100, and 150-ft diam are applicable. Under special conditions units of 200 to 250-ft diam might be used for such problems. Typical applications are the primary hydroseparation of phosphate rock matrix, primary dewatering and scrubbing of concrete sand or other silica sand products following wet screening, and recovery of fine coal in coal washing operations, both in the anthracite and bituminous fields. Further classification or dewatering of the granular solids settled in the hydroseparator is carried out in subsequent operations in all the above cases, so that the limited classification and dilute underflow of the hydroseparator are accepted because of its capacity to handle high flows.

In past years hydroseparators have been used to size abrasive products and to process clays and pigments and a variety of chemical precipitates. In view of the recent development of centrifugal classifiers and the bowl desiltor, it is the author's opinion that hydroseparation problems in the fields mentioned above will be solved in the main by these two types of classifiers.

Hydraulic Classifiers: Sizers and Super Sorters

Limitations: All classifiers thus far discussed except the washer (unit-type) have been two-product machines, coarse and fine. Eight of the nine main types, in fact, are limited to two products.

The sizer and super sorter are multi-pocket units and, therefore, multi-product. Thus for any problem requiring more than two sizes of products from one machine, the multi-pocket hydraulic classifier is the only one available. It is made up with varying constriction plate areas to meet tonnage requirements, and the number of pockets used depends on the range of products to be made and the weight distribution in the screen analysis of the feed.

Feed to any hydraulic classifier should not contain particles coarser than ¼ in., preferably not over ⅛ or 3/16 in. The classification pockets in series each served by hydraulic water under low pressure will each make a relatively clean size split combining roughly two screen sizes. That is to say, the first pocket on a −14 mesh feed will entrap practically all the +20 and a good part of the +28. The second pocket will entrap the remaining +28 with the bulk of the +35 and some of the +48, and so on down through the several pockets.

The −100, +150 mesh particles are about the finest that can be entrapped and cleaned free of the −150 with any degree of efficiency. Thus all particles −150 mesh will report in the overflow of the sizer and must be further provided for if they are to undergo additional classification or are to be saved.

All hydraulic classifiers operate best when receiving a fairly constant volume of feed somewhere between 40 and 60 pct solids. A unit-type classifier, particularly of the rake type, is ideal for feeding one or more sizers or super sorters.

Another limitation of hydraulic classifiers is the high moisture underflow discharge from each pocket, ranging from 40 to 60 pct solids. Frequently provision must be made for further dewatering.

The super sorter is made up with equal-sized pockets in line with mechanical pincer-type underflow valve controls actuated from a single drive. The latest design of *jet* sizer also is made up of equal-sized pockets, but they can be arranged in line or in pyramid as the underflow valves are actuated by an individual pneumatic control.

Hydraulic classifiers are widely used to prepare sized products for gravity concentration by means of tables or similar devices embodying free settling or hindered settling. This is the major application of sizers and super sorters.

An important field for this type of classifier is the beneficiation of iron, tin, titanium, tungsten, vanadium, chromium, zinc, and lead, and such nonmetallics as coal, phosphate rock, and silica sand. It should be mentioned at this point that the super sorter was especially designed as a high-tonnage unit for use in the cleaning of fine coal.

Another less prominent but increasingly significant field of application for sizers and super sorters is the separation of homogenous products into various size fractions. Natural silica sand is an example. Foundry and glass sands are sold according to grain sizes or grades, and concrete sands frequently require one or more size fractions.

In a few instances the sizer has been used to retreat smokeless powder and to size chemical compounds such as sodium aluminate crystals.

The Hydroscillator

Limitations: Separation with the hydroscillator ranges between 20 and 200 mesh inclusive. That is to say, operating conditions can be set to overflow from the oscillating bowl 20 mesh at the coarse limit and at any mesh on down through 28, 35, etc., to 200. Coarse particles up to ½ or 1 in. in the feed can pass through the oscillator compartment without difficulty.

Hydraulic water at the rate of 0.5 to 1.5 tons per ton of feed is necessary to effect the highly efficient separation. For the required separation with a reasonable amount of hydraulic water, feed should be in the form of a thick slurry for separations in the coarser meshes. For separations in the finer meshes a dilute feed is permissible. The oversize fraction of the feed as delivered by the reciprocating rakes will be dewatered to 79 or 84 pct solids.

Applications: It is safe to say that the hydroscillator is applicable to any problem requiring a clean rake product with the minimum amount of hydraulic water. It is a relatively new development in mechanical-hydraulic classifiers, and the range of applications, limited at present, is being expanded. The hydroscillator is well established in the closed-circuit grinding of ores and minerals and is a unit of relatively high capacity. This is evidenced by the fact that at Tennessee Copper Co. a 10-ft diam hydroscillator handled the entire mill tonnage of 2200 tons per 24 hr and overflowed this tonnage at 2 pct +48 mesh and approximately 54 pct −200 mesh. It is also interesting to note that the rake product contained only 1.0 to 2.0 pct −200, as compared to 9.0 to 10.0 pct for the conventional classifier. It is further significant that the average percent oversize in the grinding mill was 81 pct for the hydroscillator, in contrast to 68 pct for the conventional classifier circuit.

Although the hydroscillator is more expensive, it will find increasingly wide application not only for closed-circuit grinding but also for sharp two-product separations in beneficiation of iron ore and processing silica sand, to name but two of the prominent fields. A classifier that decreases the amount of undersize remaining in the rake product from the 130 tons left by the conventional classifier to 24 tons is bound to have many applications.

Centrifugal Classifiers

Limitations: 1—The solid bowl centrifuge. This unit can develop centrifugal forces up to 1000 times gravity, and with such characteristics it is the only commercial unit that will accomplish reasonably efficient separations down in the low micron range. Ordinarily the solid bowl centrifuge is limited to relatively fine separations from about 100 mesh to as low as 5 microns.

When the solid bowl centrifuge is used for dewatering, it cannot be expected to give a complete split of water and solids; the very fine material will be carried out with the overflow. In this connection it must also be kept in mind that as the removal of fines with the spiral product is increased the amount of moisture in this product will also increase, as it will in any of the mechanical-hydraulic classifiers. The feed volume must be kept to conservative proportions: the largest unit, 54x70 in., is limited to about 500 gpm.

2—The stationary cone or cyclone classifier. In this type of classifier the centrifugal force is set up by injection of the feed tangentially under pressure. Pressure is generally maintained at 15 to 20 psi but is raised up to as much as 80 to 100 psi when extremely fine separations are necessary.

The cyclone, having a steep-angle cone section of 20°, is in its present design usually limited to separations between 147 microns (100 mesh) on the coarse side and 10 to 20 microns on the fine side. It is limited in that abrasive action of any appreciable amount of coarse particles in the feed causes excessive wear when high pressures are used.

The stationary cone classifier, like the bowl centrifuge, will not have a clear overflow as long as slimes are present in the feed. A completely granular feed devoid of slimes would permit clear overflow, but such conditions are rare.

It is well to keep in mind that both the cyclone and the solid bowl centrifuge classify at heavy feed densities as compared to any of the other types employing an open pool for classification.

Larger diameter units favor the coarser separations, i.e., the 100 to 150 mesh range, whereas small diameter units are preferred for separations from 150 mesh to 10 microns.

The percent of solids in the feed has little effect on the underflow density, which will range from 55 to 70 pct, depending on the screen analysis fineness range. The finer the material, the lower the percent of solids.

An indication of capacity is a figure of 1000 to 1200 gpm for the 24-in. diam cone when it makes a 150-mesh separation on a material of 2.7 sp gr.

Applications: The stationary cone type of centrifugal classifier is applicable in a wide variety of fields. Undoubtedly it will be preferred in some cases that would require a large hydroseparator, since a combination of cones would eliminate the need for a large tank. There is good evidence of this in the phosphate rock washing operations in Florida.

As intimated above, the stationary centrifugal cone classifier is now accepted as a good primary deslimer. This simple centrifugal classifier has been launched in several other directions which appear to be promising: fine silica sand recovery, beneficiation of low-grade iron ores, and preparation of concentrator mill tailings for mine backfill.

The Cone Classifier

Limitations: An inverted cone with feed entering a centrally located feedwell at the top, the overflow spilling over the outer rim and the underflow discharging at the apex, makes a very simple classification device. Since no provision is made for scraping settled solids from the inside surface of the cone, a steep angle, 60° to 75°, must be used to minimize deposition. Hence the vertical clearance just about equals the diameter, and this may well become a disturbing factor when cones 8 to 12 ft in diam are called for. Probably the most common top size of cone is 8 ft in diam, but units of 10 to 12-ft diam have been installed.

The cone classifier, like the hydroseparator, provides only a quiescent pool for settling solids, and, as would be expected, effectiveness of classification is of low order, approaching closely that of hydroseparator. It is no secret that the operation of cone classifiers is sensitive to the character of feed solids. Any material containing fine particles having a tendency to adhere to a sloping side will build up on the sides of the cone, often plugging it entirely.

The cone works best when fed a solids mixture containing a high percentage of truly granular material which will scour the sides. With this kind of feed, dense underflows in the range of 40 to 60 pct solids can be maintained by any of a number of restricted apex discharge arrangements. The operation under dense underflow conditions is frequently critical. To prevent plugging the practice is to maintain free-flowing discharge at 35 pct solids.

There is practically no limitation on the size range of solids that can be handled in a cone classifier. Classification should not exceed 28 mesh on the coarse side and about 325 mesh on the fine side. Large feed volumes will require a multiplicity of units, thereby imposing some problems for equal feed distribution.

Applications: The cone classifier has one big advantage over the other types in that it is cheaper in first cost and comparatively cheap to install. It uses no power and maintenance is low. On materials of highly granular character it can serve as a primary classifier or dewaterer.

With the improvements in mechanical-hydraulic classifiers, there are no longer many fields in which cone classifiers are extensively used. In the production of concrete sand they are frequently used to sort and dewater small flows of specialty products, the cones being located over bins or storage piles. There are also a number of applications for cone classifiers in certain industrial processing operations handling relatively small volumes of feed flow.

The Sand Washer

Limitations: The sand washer, with its circular line of buckets dipping into the settling pool of a round tank, is a rough and ready unit that thrives on big tonnage. As a classifier it has narrow limitations separation-wise, owing to the pool area afforded by the design.

The sand washer should not be selected for separations except between the range of 28 mesh on the coarse end and 65 mesh on the fine end. It can be used on a feed mixture containing particles as coarse as 1 in. and by special arrangement up to 1½ to 2 in. Ordinarily the feed size range to a sand washer is ¼x0 in., which is typical of a concrete sand, but the buckets can be designed to handle the coarse sizes mentioned.

Capacity limitation for the 12-ft diam unit is about 125 tons per hr of bucket product when a 48-mesh separation is made on material of 2.65 sp gr. This capacity necessitates a feed at 2 to 1 dilution or 33 1/3 pct solids. In other words, the 12-ft sand washer is limited to about 1000 gpm overflow when making a 48-mesh separation.

The washed product as it is discharged from the buckets will contain 17 to 20 pct moisture (83 to 80 pct solids). This product can be handled on an inclined belt conveyor without creating a backwash down the belt.

Under the same conditions of feed and overflow the 7-ft and 9-ft diam sand washers are limited to 25 to 35 tons per hr and 45 to 65 tons respectively.

Applications: Sand washers, as the name implies, have been used almost exclusively for removal of silt and clay from banks and from natural sand deposits under water. The usual flowsheet involves screening the several sizes of gravel with the final −¼-in. sand plus all the water, silt, and clay being directed to the sand-washing and dewatering device. If the sand washer is used, some provision must be made, such as a settling box, to slough off sufficient water to maintain the feed to the sand washer at 2 to 1 dilution or 30 to 35 pct solids.

There is little promise of a wide range of application for the sand washer type of classifier. It is possible, however, that it could be used for high tonnage sand slime separations in mining operations, particularly in the disposal of tailings.

It can be seen that there is much overlapping of functions and that limitations cannot be clearly defined. More often than not information is relative and comparative. It should be emphasized again that classification is not an exact science.