

## Lime Slaker Selection

There are two types of lime slaker commonly used today: *paste* type slakers and *detention* type slakers. The principal difference between paste slakers and detention slakers is the ratio at which water and lime are mixed during the reaction phase of the slaking process; paste type slakers react quicklime with water at a ratio of approximately 2.5:1 whereas detention slakers react quicklime with water at ratios of 3.5:1 or greater. Paste and detention type slakers come in a variety of different configurations and sizes, each suited to specific applications.

The first aspect to consider in slaker selection is the quality of available quicklime. In areas where high quality quicklime is available, both paste and detention type slakers may be considered. In areas where high quality quicklime is not available, paste type slakers may not be considered and certain configurations of detention type slaker may be unsuitable also. In areas where only poor quality quicklime is available, a special type of detention slaker, the grinding mill, may be the only suitable selection. Other principal factors which determine slaker selection are the control method (batch or continuous) and the desired maximum slaking rate.

Other factors, which may determine slaker selection, include desired quality of the hydrated lime product, turndown ratio, space constraints, power consumption, grit disposal costs, and operator experience. All slaker types require periodic operator attention and maintenance, however the resources required for these functions are comparable between slaker types and need not be considered as a criteria for slaker selection.

### *Paste Slakers*

Paste slakers automatically control the water to quicklime ratio and rely on the heat released from the reaction as energy to complete the slaking. By controlling this ratio the slakers are able to effectively handle frequent changes in the quicklime feed rate for both batch and continuous process applications. Optimum paste slaker performance is designed for short reaction times and maximum utilization of the lime. For these reasons, the paste slaker is best suited for applications using high quality quicklime. Paste slakers also consume substantially less power than comparably rated detention type slakers.

As shown in Figure 1, the paste slaker consists of two horizontal paddle shafts, which counter-rotate to mix water with quicklime. The mixture is driven toward the discharge (weir) end by means of pitched paddles attached to the shafts. Water to lime ratio in the slaking compartment is automatically maintained at an user adjustable ratio between 2.5:1 and 2.8:1. Beyond the weir end, slaked lime is further diluted by means of manually controlled spray jets integral to the slaker assembly. Grit (inert material in quicklime) is removed either by screening or inclined classifier.

Paste type slakers are available in quicklime slaking capacities of 1000, 2000, 4000 and 8000 lbs/hr. They operate at water to lime ratios (in the slaking compartment) between 2.5:1 and 2.8:1 which produces specific surface area (hydrated lime) of approximately 53,000 cm<sup>2</sup> per gram. Typical operating temperature rise of a paste type slaker is approximately 140 deg F above the temperature of the incoming water and steady state is usually reached within 5 minutes of startup. Standard slurry discharge is 18-20% solids at the slakers rated maximum capacity.

### *Detention Slakers - Conventional*

Conventional detention type slakers are best suited to applications in which the lime quality is medium to high and the lime feedrate changes neither frequently nor automatically. They are the least expensive of the slaker types and are well suited for batch type operations where lime quality less reliable.

As shown in Figure 2, a typical detention slaker consists of two slaking compartments, each agitated by a conventional slow speed mixing impeller. Water and lime are fed into the first compartment and then overflow a weir into the second compartment. Additional agitation takes place in the second compartment after which the product discharges into the grit removal system. The water to lime ratio in the slaking compartment is adjusted and monitored manually with the hand valves and flowmeters integral to the slaker assembly. Grit is removed either by screening or inclined classifier.

Conventional detention type slakers are available in a variety of quicklime slaking capacities up to 16,000 lbs/hr. They operate at water to lime ratios (in the slaking compartment) between 3.5:1 to 6.0:1 which produces specific surface area (hydrated lime) of approximately 47,000 cm<sup>2</sup> per gram. Typical operating temperature rise of a detention type slaker is approximately 100 deg F above the temperature of the incoming water and steady state operation is usually reached within 15 minutes of startup. Standard slurry discharge is 18-25% solids at the slakers rated maximum capacity.

### *Detention Slakers - Grinding Mill Type*

Grinding mill type detention slakers are best suited to applications where the lime quality is poor, grit handling is costly or when the processing rate exceeds that achievable in a conventional slaker. Grinding mill slakers operate on the same principle as conventional detention slakers, however they have the ability to grind inert materials (grit) contained in the quicklime and generally require little or no grit removal or disposal facilities. Grinding mill slakers are horizontal or vertical ball mills (as commonly used in the mineral processing industry) modified to withstand the temperature of lime slaking. They have the advantage of being relatively simple and rugged. However, grinding mill slakers are the most expensive of the slaker types, have limited capacity for turndown, and consume the most energy.

As shown in Figure 3, a typical grinding mill slaker (horizontal type) consists of a rotating drum supported by external rollers. The mill contains a grinding media (typically steel balls) agitated by means of horizontal lifting bars attached to the interior of the drum assembly. Slaked lime product discharges from the drum and is pumped to a hydrocyclone, which classifies the slurry to recirculate oversize particles to the mill inlet. As with a conventional detention slaker, water to lime ratio in the slaking compartment is adjusted and monitored manually with hand valves and flowmeters.

Grinding mill type detention type slakers are made to order in quicklime slaking capacities up to 60,000 lbs/hr. Operating parameters and characteristics are similar to conventional detention slakers.

### *Product Quality*

Surface area of the hydrated lime product is of paramount importance in many applications. Tests show a correlation between the diameter of slaked lime particles and the water to lime ratio used during slaking. As the water to lime ratio is reduced, the diameter is reduced also, resulting in a substantial increase in surface area of the slaked lime product. Due to the difference in water to lime ratios, paste type slakers deliver more neutralizing capacity (as measured by free base titration) than comparable detention slakers. For certain applications, this difference can result in substantial improvements to the process as well as chemical cost savings.

### *Grit Disposal Costs*

The cost of grit disposal can be a significant factor in the selection of lime slakers. The inert portion of quicklime which is captured by a screen or inclined classifier is relative to the purity and particle size quicklime. This grit must be transferred from the grit removal device to a bin, which is emptied periodically. While the grit itself is not a hazardous material (as defined by EPA), however, the pH exceeds 12.0 and caution must be exercised in handling and disposal. The grinding mill slaker eliminates 90-100% of the inert material to be disposed, and should be considered where grit disposal costs are high.

### *Slaking Water Quality*

For reliable operation of any lime slaker type, water used for lime slaking should be at a temperature not less than 55 deg F. For slakers which are expected to start and stop frequently, the time to reach operating temperature (with associated hydrated lime quality) may be a factor. Paste type slakers reach their steady state operating temperature in approximately 1/3<sup>rd</sup> the time required by comparable detention type slakers. Please see comments regarding water quality in "Lime Slaking" paper. In general, paste slaker performance is less susceptible to cold slaking

water [less than 55 deg F] than detention and grinding mill slakers. Water heaters may be added to raise the temperature of the slaking water for all types of slakers.

### *Space Constraints*

Like all process equipment, lime slakers require regular cleaning and maintenance. They are often placed within the skirt support structure of the quicklime storage vessel where space is at a premium. The size and shape of the slaker may be a determining factor in slaker selection; in general, paste slakers are the most compact (in plan view). Some conventional slakers are configured with vertical mixing chambers and require less horizontal space, however headroom requirements are greater. For grinding mill slakers, the vertical type require the least space in plan view, however they can be up to 30 ft in height depending on the processing capacity.

### *Capital Cost*

Budget constraints frequently determine slaker selection. Conventional detention type slakers are the least expensive of the three type considered, with paste slakers priced approximately 15% higher for comparable capacities. The higher price of the paste slakers can often be recovered quickly by the more efficient slaking and lower chemical usage. Grinding mill slakers are typically 3-5 times the price of comparable conventional slakers, however this premium can also be offset by the reduction in grit disposal cost.

### *Operator Experience*

The user's level of experience with lime slaking and prior experience with specific types of slakers should be a factor in slaker selection. For safe and effective lime slaking, operators should have knowledge of the theory and practice of lime slaking. In general, detention type slakers are more forgiving of inaccuracies in lime and water feedrate; however manual slaking water control requires calculation of slaking/dilution water flowrates each time the lime feed rate is changed. In cases where quicklime feed rate is changing frequently, the automatic water proportioning system in paste slakers should be considered. In addition to knowledge of lime slaking, grinding mill slakers require a knowledge of the grinding process and related equipment. For this reason; grinding mill systems require more operator knowledge than conventional slakers and appropriate consideration should be made in the selection process.

A summary of selection criteria and comparative features is presented in Table 1 below.

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**TABLE 1. Lime Slaker Selection Criteria and Comparison**

Condition	Paste Type	Detention Type Conventional	Detention Type Grinding Mill
<b>Maximum Quicklime Slaking Rate (lb/hr)</b>	8000	16,000	60,000
<b>Minimum Quicklime Quality*</b>	85% CaO with high reactivity OR 80% CaO with medium reactivity	85% CaO with medium reactivity	75% CaO with low reactivity
<b>Process Applications</b>	Batch or Continuous	Batch Only	Batch Only
<b>Water to Lime Ratio (Typical)</b>	2.5:1	4.5:1	4.5:1
<b>Slaking Water Control Method</b>	Automatic	Manual	Manual
<b>Turndown Ratio (Typical)</b>	20:1	5:1	2:1
<b>Horsepower Required</b>	0.5 Hp per Ton/hr of Quicklime	1.7 Hp per Ton/hr of Quicklime	10 Hp per Ton/hr of Quicklime
<b>Percent Free Base (Typical)</b>	81%	75%	75%
<b>Ca(OH<sub>2</sub>) Product Surface Area (Typical)</b>	53,000 Cm <sup>2</sup> /Gram	47,000 Cm <sup>2</sup> /Gram	47,000 Cm <sup>2</sup> /Gram
<b>Capital Expense</b>	Typically 15% higher than conventional detention type slakers	Least	2-5 times higher than conventional detention type slakers
<b>Grit Disposal</b>	Screen or Inclined Screw	Screen or Inclined Screw	Not normally required
<b>Operator Experience</b>	Medium	Medium (batch operation only)	High

<sup>1</sup>Definition per ASTM C 110 slaking rate test procedure.