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TYPES OF MILLS AND LININGS

TYPES OF MILLS

A pebble Mill is any Mill in which flint pebbles or porcelain balls are used as the grinding media, and the inside of the cylinder is lined with either porcelain, burrstone, rubber, or some other non-metallic lines. (In the ceramic industry especially, these lined Mills are referred to as Ball Mills, and porcelain balls are used for grinding. However, throughout this handbook, lined Mills with porcelain balls will be considered Pebble Mills.)

The Pebble Mill is the purest grinding machine, and it is possible to grind and mix the most delicate types of products without fear of contamination.

The common classification of Ball Mill is any Mill in which steel or iron balls are used as the grinding media. In most cases the cylinder of such a Mill is made of an alloy steel, or has some type of special metal liner.

Steel ball mills grind faster due to the use of steel balls, which weigh more than three times as much as flint pebbles or porcelain balls. This heavier weight makes it possible to use very small sizes of balls – thereby providing more grinding contacts for each revolution of the cylinder. Materials that are affected by metallic contamination generally cannot be handled in a steel Ball Mill.

KINDS OF LININGS

BELGIAN BURRSTONE – (imported silex). This pure flint lining is noted for its exceptional durability. It is one of the toughest lining materials available for Pebble Mills. There are many case histories of Burrstone lined mills running on a continuous production schedule for more than 25 years without repairs.

Aside from its exceptional wearing quality, Belgian Burrstone has a natural rough surface which helps prevent the charge from sliding or slipping thereby insuring a more efficient grinding action.

Many operators believe they can only use flint pebbles with Burrstone. This is not true. There are many installations where porcelain balls or high density grinding balls are being successfully used in Burrstone lined Mills.

Belgium is the only country in the world where these blocks are commercially available.

DOMESTIC BURRSTONE – This material is not to be confuses with the imported Burrstone. It has a coarse granular texture unlike the dense smooth texture of the Belgian block. It is easier To cut and fit so that a lining of this material will set up closer and more uniformly than is possible with the imported block.

Domestic Burrstone has served well on many jobs but it will not last as long as the imported material. It is also a cheaper lining than the imported.

PORCELAIN – This is a pure white ceramic lining which has a dense, tough structure especially developed for Pebble Mill service. It will stand up for many years under the most severe kind of service, and is highly recommended where requirements call for a white lining.

HIGH DENSITY PORCELAIN – made with a high alumina content, it is the toughest and most abrasion resistant of the synthetic linings and, under normal conditions, it will outlast the standard porcelain lining several times.

High Density Porcelain is especially useful where jacketed mills for temperature control are required. Because of the nature of the material, the thermal-conductivity oh this lining is approximately 7 ½ to 8 times that of standard porcelain, and 4 to 5 times that of Burrstone. In many cases when changing from Porcelain or Burrstone to our High Density Lining, it has been possible to cool with chilled water instead of brine, thereby creating a sizeable saving in the cost of the cooling medium.

Standard porcelain and high density porcelain linings are made up to 3" thick and are available for any size mill from 1' and longer. Baffles can be furnished for either type of lining, when required, to prevent the charge from sliding.

RUBBER LININGS – Rubber linings are usually vulcanized to the shell, but it is also possible to obtain these in removable sections. Natural rubber appears to provide the greatest resistance to abrasion and is most generally used. Synthetic rubber, like Neoprene or Hycarr, can be furnished when required. We advise using rubber linings only on wet grinding operations. When dry grinding, the rubber has a tendency to abrade excessively.

METAL LINERS – The cylinders of batch type steel Ball Mills are usually made of an abrasion resistant alloy steel like chrome manganese. It is also possible to obtain them in a range of other metals including chilled iron, manganese, high carbon, stainless steel, bronze, monel, etc.

Removable liners, common in continuous type steel Ball Mills, are not generally used due primarily to the danger of material getting behind the liner plates, thereby making it difficult for thorough cleaning when changing products, or in paint grinding when changing from one color to another. It is possible, however, to obtain metal liners for batch type Mills when required, and these are made in the range of metals listed above.

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GOOD MILLING PROCEDURES

DISCHARGING WET MATERIALS

When discharging wet materials, the usual procedure is to allow the product to drain from the Mill through a slotted discharge which retains the grinding media inside the Mill.

Several types of discharges are illustrated. Each type has its particular advantages and the most applicable model for a given job depends on individual conditions.

Although most discharging is by gravity, there are frequent occasions when it is more economical or more desirable to speed up the discharging process. The usual methods of doing this are by pumping, or by blowing the material out.

When pumping, the suction line may be attached directly to the discharge valve or cover. A safety screen should be provided to positively prevent damage to the pump by a pebble or ball chip which might be sucked through the discharge grate by the pump. The vent plug should always be removed so that the pump may do its work without being hindered by the vacuum which would build up in the Mill if the vent were left closed.

When blowing, the air line is connected to the vent opening and the air pushes on top of the material forcing it out the discharge opening. The Mill manufacturer should be notified when the use of pressure is desired unless the Mill has been especially designed for pressure operation.

THIXOTROPIC MATERIALS

When discharging extremely dense materials or some materials which exhibit thixotropic properties, the usual methods of discharging may not work. In these cases, it has been found that a similar method to that used when discharging dry materials may be made to work satisfactorily. A dry discharge grate similar is put on in place of the grinding cover and the Mill is run until the material has all been thrown out. A trough around 270° of the Mill circumference, catches the discharged material and controls its flow into a suitable receptacle. Care should be used when discharging that the Mill is not run longer than necessary. Undue contamination and war may result from running the Mill without material.

BUILT-IN DISCHARGE VALVES

Built-in discharge valves are generally located in the cylinder directly opposite the manhole opening. When the Mill is spotted with the valve on the bottom to discharge, the manhole opening will automatically be at the top. After the finished material is unloaded the discharge valve is closed, the manhole cover is removed, and a new batch of material may be dumped into the cylinder without having to turn the Mill.

No wet discharge cover is required, thereby eliminating the necessity for handling an extra cover. The grinding cover can be hinged so there is no lifting to be done by the operator.

During discharging, the grinding cover is not disturbed and, consequently, any unground material that lodges in the open space between the manhole frame and cover cannot fall onto the finished batch.

DISCHARGING DRY MATERIALS

Dry grinding Mills are usually equipped with dustless discharge housings which fit tightly either around the Mill shaft, or around machined rings on the cylinder.

To discharge dry products, the grinding cover is removed and exchanged for a slotted cover. Then, after the housing is shut tightly, the Mill is revolved until all the fine grindings sift through the grate into the dust-proof housing while the grinding media are retained in the Mill by the slotted cover. The finished product then may fall into a drawer or bin in the lower part of the housing for immediate removal. Sometimes it is dropped into a storage hopper for bagging, while the next batch is grinding in the Mill above. Other times it may fall from the housing into a dust-proof chute to the floor below.

The Mill should not be allowed to run longer than it takes to unload the material. Any additional running causes excessive wear to the grinding media and the lining, and possible contamination in the same or succeeding batches.

JACKETS

The use of a jacket on a Ball or Pebble Mill makes possible control of the batch temperature while the Mill is in operation.

If Mill temperatures are too low, many products will run at much higher viscosities than are recommended. This produces pitching of the media with subsequent breakage and slow grinding time.

If Mill temperatures are too high, lower viscosities will usually result. This causes excessive wear on linings and grinding media and, therefore, batch contamination. Another danger of grinding at high temperatures is that of pressure buildup.

The Jacket is usually fitted around the cylindrical shell only, but it can be also extended to enclose both ends of the Mill when occasion demands it. Such fluids as hot water, steam, or hot oil passing through the Jacket maintain fluid consistency of such products as Carbon Paper Coatings, Ointments, Greases and other materials that solidify when cool. Cold water or brine, passing through the Jacket, maintains cool temperatures while grinding. Cooling is especially desirable in the production of Urea Plastics, Paints, Lacquers, Vitreous Enamels, and many other products.

Chemical reaction, drying distillation, gas absorption, and other phases of chemical processing can be accomplished with the addition of vacuum or pressure lines to the inside of the Mill.

VENTING AND PRESSURE IN MILLS

The vent plug in the head of the Mill has two primary functions. The first is to aid in the loading and discharging of the Mill. During loading the use of a vent alleviates surging of the liquids in the batch. During unloading, the vent plug should be removed before the cover or discharge valve is opened. The vent permits more rapid discharging than would be possible if the vacuum created by the discharging action were not destroyed by air rushing in through the vent.

The second use of the vent is for reducing pressure, which may build up in a Mill during operation due to volatile liquids or heat being generated in the Mill.

Ball and Pebble Mills are not normally built for pressure operation. Therefore it is important to make certain there is no excessive pressure built up during the grinding cycle, to avoid damage to the mill end and lining.

Special care should be exercised when grinding volatile solvents, as these are most apt to cause high pressures if heat develops while grinding.

Operators should be instructed to vent the Mill about one-half hour after starting a new batch and follow this up with such periodic venting as experience indicates. Removing the vent plug is not a difficult job and entails no more than a few minutes of the operator's time.

There are instances in some industries where periodic venting to prevent pressure buildup has resulted in increased grinding efficiency.

It is possible in many cases to withdraw air from the interior of the Mill, causing a vacuum. This draws air from the bubbles in the batch, thus removing them. With the air bubbles eliminated, easier and quicker grinding has been accomplished.

The new Paul O. Abbe "All Steel" Mills are ruggedly designed and will stand the maximum pressures of 14.7 P.S.I. permitted for non-coded unfired pressure vessels. Where greater pressures are involved, and then code construction is mandatory and our mills can be built for any desired pressures.

FLASH FIRES AND EXPLOSIONS

The static or friction spark is the most dangerous type of fire or explosion hazard since it may Strike without warning at any time unless completely controlled.

Static electricity is generated by any moving parts such as rotating or reciprocating machines, hand trucks, or other equipment which moves. In order to have a static discharge, there must exist a difference in electrical potential between two surfaces.

Static electricity is also generated by flowing liquids. Most all of the solvents and diluents used in the paint, varnish and lacquer industry are poor conductors of electricity and when they break up into small droplets (as when poured from one container to another) they generate a static charge which may be of enough intensity to fire a vapor-air mixture present in the Mill or in the area around the Mill charging opening.

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Employees performing regular duties can easily build up electrical potential, and are probably the most overlooked sources of static electricity. Provisions should be made for grounding all employees in hazardous areas.

In order to combat static electricity, a device is necessary to ground the surfaces, thereby allowing any static charge which may be built up to flow off. A simple copper wire grounded to a water pipe is usually all that is needed for effectively grounding a machine. However, the ground must be attached to that part of the machine where the static charge is built up. On a Ball or Pebble Mill this would be the cylinder and countershaft. Some people have believed they obtain effective grounding of their Mills through the motor, and others ground from the supporting pedestal. Neither of these ideas is entirely satisfactory because the moving cylinder and countershaft are insulated from the rest of the machine by the grease in the bearings. Effective grounding of these Mills can only be accomplished by connection to the moving shafts. This also applies to any other machine having stationary and moving parts. All grounding should be done to a water pipe, or some equally effective conductor. Electrical conduits should not be used unless there is absolutely no other ground available.

To guard against the occurrence of accidents caused by flowing solvents or diluents, they should Be introduced in the Mill in a manner which will avoid break-up. This could be by means of a non-sparking metal hose or a charging chute of a suitable metal, either of which would carry the solvent well down into the Mill. In some instances inert gas (co2) is used during the charging period. This is a practical and effective safeguard and one which is not very expensive. It is recommended that either of these two methods of charging or others equally safe be used; also the solvent or diluents should be kept "solid" when charging other Mixers, Mills, and Vessels, in order to minimize the "static spray" hazard. Unless such precautions are practiced, other accidents are almost certain to occur-probably resulting in additional fatalities and burns.

Employees should be compelled to wear non-insulating type clothing. Rubber soled shoes, unless the "conducting" type, are extremely hazardous, and employees working in any kind of a hazardous atmosphere should be compelled to wear leather shoes. It was discovered in one plant, that a woman caused several small fires because she was working on a wooden platform. The static charge of her body built up until it discharged across the inflammable material with which she was working. Another woman wearing elastic stockings was the cause of numerous fires.

Humidifying the air surrounding the potential source of static electricity is a very effective deterrent. Static charges will leak off through moist air, whereas dry air acts as an insulator thus allowing charges to be built up until they are strong enough to break down the insulation and cause a spark. Plant humidification is not too costly and such an installation would pay for itself, not only through the elimination of fire hazards, but also in creating better working conditions for the operators.

The elimination of all fire potentials is always important, whether this involves the more hazardous occupation of paint manufacturing, where low flash solvents are always being used, or in other fields where fires through manufacturing activities are fairly remote.

CLEANING THE MILL

Good cleaning procedure is one of the most important factors in avoiding batch contamination. Where cleaning is necessary, the established procedure is to run the Mill with a solvent or other liquid so that any of the product remaining around the media or sidewalls of the Mill may be picked up and subsequently discharged.

A good method of cleaning is to dump a small quantity of solvent into the Mill, run it for 15 to 30 revolutions and dump it immediately. If necessary, the cycle can be repeated two or three times. In this way thorough cleaning is generally accomplished, and most important, batch contamination is avoided.

The Mill should not be run during cleaning for any longer period of time. Where no protective film is around the grinding media they will wear down very quickly. During a long cleaning run, a considerable amount of contamination is picked upon the surface of the grinding media. When the cleaning material is dumped out, a lot of this contamination remains in the Mills. When a new batch of material is loaded, this dirt is absorbed and will show up in the finished product. At the same time the grinding media wear away, needing more frequent replenishing, or dumping and sorting and excessive wear can also be expected on the lining. Therefore, when cleaning, running time should definitely be kept to a minimum.

MAINTENANCE OF MILLS

A well made Ball or Pebble Mill will give many years of service with a minimum of maintenance costs and trouble. However, as with any equipment having moving parts, a few minutes spent occasionally in periodic maintenance checks will be well repaid by continued smooth performance and low operating costs.

Some items should be given routine checkups. It is impossible to recommend specific intervals because individual conditions vary so widely. These checkups take very little time or effort and are suggested to prevent any trouble from developing. Some of these checks include:

1. Gasket surfaces of the manhole frame and cover should be kept clean.

2. Material should not be allowed to accumulate on the outside of the cylinder. This adds Weight and throws Mill off balance
3. Threads on the tightening bolts of the cover should be kept clean and occasionally oiled.

4. Lubricants recommended by the manufacturer should be strictly adhered to.

5. Lubricating periods are best determined by the operator and are generally controlled by existing conditions. However, it is wise to remember that most Mills are run on a twenty-four hour day, which is three times as much as other equipment.

6. The level of the grinding media should be frequently checked. We suggest every three to six months depending upon existing conditions. There are also occasions, such as grinding enamel frit, where the abrasive nature of the material causes excessive ball wear.

   If it falls below the correct operating level, the required grinding media should be added.

At longer intervals the charge should be dumped and inspected. All grinding media which are excessively worn or damaged should be removed and replaced with new media.

7. Even though a Mill may be perfectly aligned when new, occasionally it will settle after being in operation a while, due to the floor sag or settling of foundations. For this reason the alignment should be checked occasionally.

8. The lateral adjustment bolts and bearing hold-down bolts on the counter-shaft should be checked to see that they are kept tight.

9. The foundation bolts should be examined periodically to see that they are secure.

10. When a V-Belt or Silent Chain Drive is used, the belt or chain tension should be Checked occasionally.

"SLIP" IN BALL MILLS and PEBBLE MILLS

The term "slip" means relative motion between the layer of grinding media nearest the lining, and the surface of the lining itself. Slip may be caused by several factors: a smooth inside surface on the lining – a low viscosity batch of material-material with a very low co-efficient of friction- or a very light weight charge of grinding media and material.

The effects of slip are detrimental to efficient and economical grinding. The angle of break drops sharply when excessive slip occurs and as a result, the grinding media break away from the periphery of the mill too soon, thereby developing less grinding energy. Grinding time and attendant power costs increase considerably, in many cases.

Some grinding does occur between the shell and the grinding media, but this action is considerably less than that which accompanies the rolling, cascading, sliding, and relative motion in the center of the charge which occurs when the correct angle of break is maintained.

The most detrimental effect of slip, however, is that the grinding media in contact with the lining slide around the entire weight of the charge forcing them down onto the lining. As a result, the mill interior becomes full of ruts and ridges and wears away very rapidly. Then the lining must be replaced- a costly, time-consuming operation. Furthermore, all the time this slipping is in effect, the wear on the lining results in excessive batch contamination.

Slip is most prevalent in steel Ball Mills but it has also created quite a problem in porcelain lined mills. Imported Burrstone lining, with its inherent rough surface has not presented a slip problem.

In some cases, where slip occurs, it may be alleviated by increasing the viscosity of the batch. In most cases, however, a mechanical means of controlling slip is recommended- BAFFLE BARS.

In steel Ball Mills baffle bars are made of special, chip-proof, hardened steel. In porcelain-lined mills, regular or high density, the baffle bars are made of high-density material. The bars are

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spaced equally in a horizontal position around the inner circumference of the lining. The quantity used is dependent upon the diameter of the mill and the type of operation involved. They project above the inside lining surface just enough to prevent the first layer of grinding media in direct contact with the lining from slipping backwards on the smooth lining while the mill is turning.

We have found, thru experience, that a baffle bar with relatively, flat sides is more effective than any other design. These flat sides secure the maximum locking effect along the cylinder wall with the first layer of grinding media held stationary relative to the lining surface until they reach the angle of break. Backward slipping of the media and material is completely eliminated.

The outer edges of the baffle bars in contact with the media charge should be smoothly rounded to prevent excessive wear and chipping.

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