Cracking and Flaking Mill Maintenance

Frank Boling

Foreword

Maintaining any type of process equipment is obviously a desirable part of plant operations. Unfortunately, in today's modern, high-speed oilseed crushing facilities that operate around the clock and usually at over-capacity rates, it is more difficult to properly maintain equipment than at previous times when the world turned a little slower. The statement "If it ain't broke, don't fix it!" says a lot about our industry's attitude toward routine maintenance.

For many reasons, the process industry has expanded internally, especially in the last 20 years. Only in the past several decades have we seen significant numbers of greenfield plants being built. Internal expansion has a lot to do with maintenance because many sites have had capacity upgrades so many times that now there is no more room to grow internally or externally. Maintaining equipment under these crowded, jumbled-up conditions is in many cases challenging, to say the least.

Given the fact that equipment is chosen for its proven endurance and lack of maintenance, it is also a fact that sooner or later the very best equipment requires maintenance. Cracking mills and flaking mills are very important to both the production rate as well as the quality of meal and oil being produced. In generic fashion, the following is a brief study of some of the finer points of maintaining these two significant areas of the process.

Cracking Mills

No other process equipment in a soybean plant is exposed to the amount of wear and tear that a cracking machine is. Whole soybeans are crushed in this machine, usually a two-pair high stand, for further processing and hull removal. The cracker that runs six months between roll changes is very rare. Most machines run four months or less.

For process considerations, the industry has more or less standardized on either 10- or 12-inch diameter cracking rolls. At least one manufacturer has designed the frame to receive either of these sizes or to start with a deep chill 12 inches and use it until the diameter wears and is recorrugated to below 10 inches. In either diameter, capacities that exceed 50 tons/day/square foot of single roll surface will incur roll changes more frequently than is practically desired.

While roll corrugations are normally a function of roll speed and whole-bean size, it should be obvious that the more course a cut is, the longer it will last. The area where this idea may be somewhat invalid is where the cracking mill is part of a hot dehulling system. Roll wear is physically less in these hybrid types of flow, but there is an offsetting requirement here for the roll to be as sharp as possible because the hot beans are softer and will have more of a tendency to mash rather than break cleanly into several pieces as the sharp points wear.

Maintaining the cracker feeder in good order is important to the entire operation of the plant. In many plants it is these feeders that ultimately set the rate through the plant. The device, either vibratory or traditional roll feeder, should be equipped with a positive shut off that stops feed flow completely when the machine is stopped. The positive stop prevents beans from dribbling into the roll nip. Failure to do so will almost always cause the rolls to lock up and burn either the differential of the main-drive belts off the machine when it is next started.

Many vibratory feeders operate on a free-mass principle. In this system, the vibrator and feeder pan are suspended from flexible points and are tuned with counterweights to a predetermined natural frequency. It is extremely important when maintaining this type of equipment, neither to add nor take away weight from the pan or vibrator. To do so will either cause the excited frequency (60Hz) and natural frequency to resolve too close together resulting in damage to the vibrator or in reduction in capacity. If it is necessary to repair the pan due to wear, check with the respective feeder supplier for guidelines regarding additional weight to the pan.

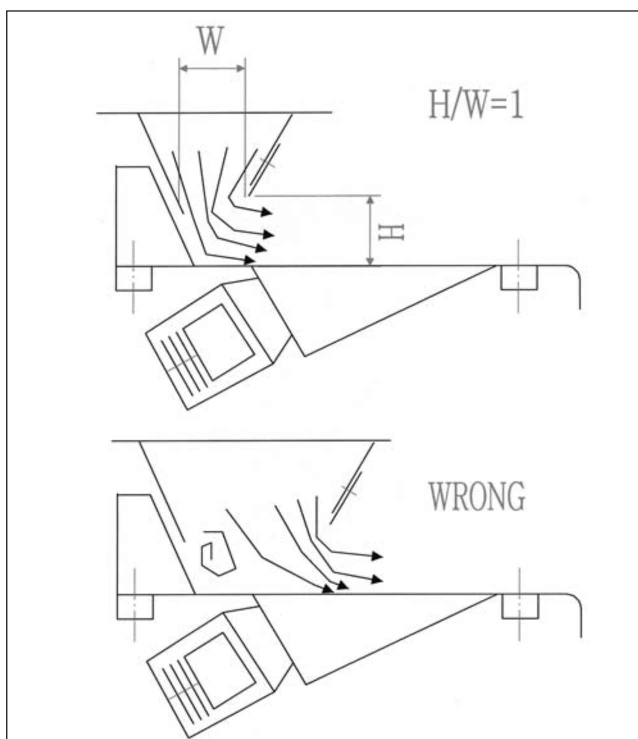

Figure 1. Diagram of a vibrating feeder showing the proper ratio between the height of the internal chute and the horizontal opening, and also an out-of-balance ratio.

All vibrating feeders have an internal chute that directs the feed material onto the pan. This chute fits inside the pan and is sometimes equipped with a movable flap at the front to set the bed depth on the pan. With the free-mass type units, there is a special relationship that must be maintained between the height of this internal chute above the bottom of the pan and the horizontal opening width of the chute (See Fig. 1). If this ratio is out of balance in favor of the chute opening, the feeder capacity will greatly suffer. Material will build up at the back of the pan and become part of the free-mass which in turn will reduce the capacity of the unit.

Base-mounted feeders have in almost every case been furnished with multiple drive magnets. These (usually three units) are individually controlled by rheostats for synchronization purposes, and then the range is set by a master rheostat. It is very important for the life of the pan and other components that the three vibrator drives are adjusted to the same mechanical stroke. This may require replacement of suspension elements or simply setting the individual rheostats correctly. Consulting the factory recommendations is advised here.

With either type of vibrating feeder, it is important to preserve the original angle of repose for the feed material that was designed for that particular machine. (See Fig. 2) This angle may be different on different makes of machines but should in all cases be adequate to stop all but the finest dribble from the pan when the vibrator is turned off. Whole beans naturally have a lower angle than other material such as cottonseed meats, sunflower meats, or even cracked soybeans in the case of flaker feeders. The most common problem here is that the whole feeder system has been inadvertently moved backward in relation to the inlet spout, and therefore the angle is too great to prevent free flow of the material. (See Fig. 3)

Vibrating feeder pans should be level in both directions. Tilting forward will increase capacity but can also cause loss of control by freeflowing.

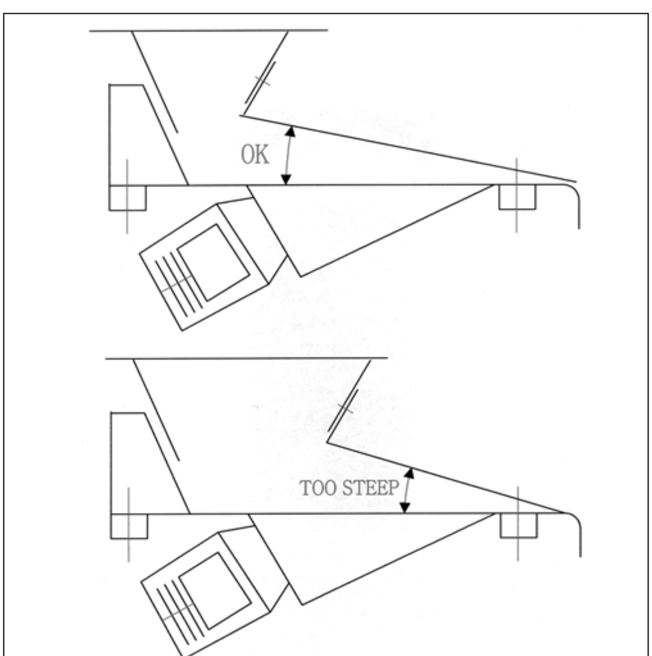

Figure 2. Diagram of a vibrating feeder showing the angle of repose for the feed material.

Fluted roll-type feeders have been around since the early days of oilseed processing and are still a prolific choice for feeding crackers and flakers. Maintenance of these is a little more straightforward than with vib feeders.

Roll diameters vary from 8 to 10 inches in diameter and are usually driven by a fixed speed gear motor at about 25 to 30 rpm. The rolls are cut with a round-bottom groove that simply serves to agitate the hopper above the roll.

The element that sets the rate is usually a pivoted gate arrangement that opens a gap of equal clearance all across the roll and allows feed material to flow out with the roll turning. Tests have shown that with free-flowing materials, the speed of the roll has little effect on the rate of feed through the gate.

Maintaining the straight bottom edge of the feeder gate across the full length of the roll is vital to the even feeding and thus even wear of the cracking or flaking rolls. It is easy to see that if the gate is worn or not straight, more feed will be seen at those areas and it may not be possible to stop the feed completely, resulting in beans in the nip of a stopped cracking roll.

Many machines are equipped with either air or hydraulic cylinders that open/close the gates of the positive stops on the vib feeders. On vib feeders, there is no stop bolt, but on the roll feeder, the stop bolt actually limits the opening of the gate and thus sets the rate of the feeder.

Some of the more advanced designs have an air motor on a screw that opens and closes the gate automatically while following an electrical signal proportional to the amps on the main-drive motor or an input signal from a level-control device. Obviously these high-tech systems must be well maintained to provide their designed function.

Newer cracking and flaking mills are provided with several safety devices that must be maintained in accordance with OSHA and Plant Safety Management requirements. These usually are electrical devices that prevent operator access into the danger zone without stopping the machine. It is extremely important that after roll changes, normal maintenance or cleaning, all guards, access covers, sample doors, protective grates etc. be replaced before the lockout is removed from the Motor Control Center (MCC).

Cracking mill end dams must be replaced when worn to prevent whole beans and/or course cracked beans from bypassing the rolls.

There is no substitute to hand packing when it comes to bearing lubrication. This is the only way to insure each roller or ball and each race has adequate lubrication from the beginning. Do

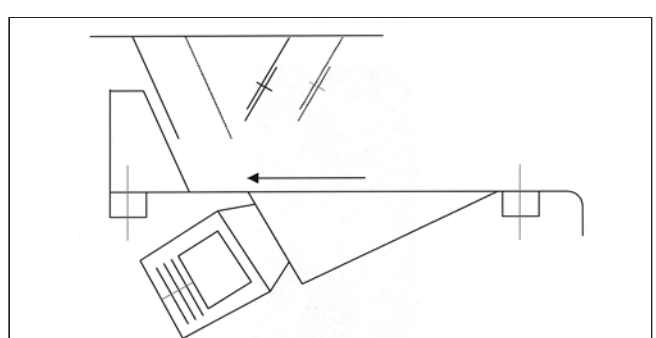

Figure 3. Diagram showing the feeder system moved backward in relation to the inlet spout, causing an angle too great to prevent free flow of material.

not overlubricate bearings. Use the same type of grease recommended by the supplier of the equipment.

Straight bored drive and differential pulleys must be properly prepared for reinstallation. Overcleaning the bore or the shaft will result in a loose fit that will eventually cause failure of the key and perhaps damage the roll shaft at the same time. Care should be taken to ensure that proper sheaves are reinstalled in the correct place. Many crackers have different-size pulleys on the top and bottom pair of rolls.

Be sure rolls are in the right place. Several cracker manufacturers use a universal shaft design that will allow any roll to go into any position and any orientation. (See Fig. 4)

Anchor bolts on mills and motors must be kept tight. Machines that employ a separate motor base not physically connected to the main mill frame should not set on flexible isolation material.

Never attach a welding machine ground wire to any part of a cracking or flaking mill and weld in such a place that electrical current of the welding operation can flow through the bearings of the machine. This is a very common cause of premature bearing failure.

Proper air aspiration must be maintained in cracking and flaking mills. Cracking mills sometimes have openings on the back side of the machine to facilitate this operation. When changing rolls out, be sure to reconnect air ducts. Each machinery manufacturer has its own requirements for air based on the method air is allowed to enter the machine.

Spare rolls should be stored indoors and away from any source of moisture. Never store new or recorrugated rolls with the roll body resting on a concrete floor. This will allow moisture to attack the surface with rust which will of course shorten the life of the roll. For the shortest roll change time, it is recommended to pre-install bearings on the rolls' shafts. Any inside housing covers or seal rings must be installed first. Bearings should be wrapped in protective plastic and be pre-lubricated to prevent oxidation.

V-Belts and sheaves must be maintained and replaced as needed. Many cracking mills utilize a single set of belts to drive both upper and lower sets of rolls. On some designs, the motor must be located at the exact center point between the upper and lower drive shafts. Failure to do so will result in one set being over- or under-tightened. Other machines use a double v-belt in a serpentine drive system. Most of these drives employ some type of idler which usually will contain bearings requiring lubrication periodically.

The v-belt differential on cracking mills is very important to proper operation of the machine. Keep in mind that these v-belts actually act as a brake to the slow roll. (See Fig. 5) Be careful on cracking and flaking mills not to get the roll pulley switched. This is easier on flakers because there is only 4 to 8% difference in size, and this is not always easy to see with the naked eye. Switching these pulleys can be a big problem on flakers. (See Fig. 6)

Using safety while maintaining cracking mills is a major issue in most companies. Records show that in soybean plants, many injury accidents occur while cracking rolls are being maintained. This is most probably because of the frequency with which rolls are changed out, but also because of the nature of the rolls. Keep in mind that newly corrugated rolls can have very sharp edges and are best handled with gloves. OSHA and PSM practices absolutely forbid opening and/or exposing corrugated rolls

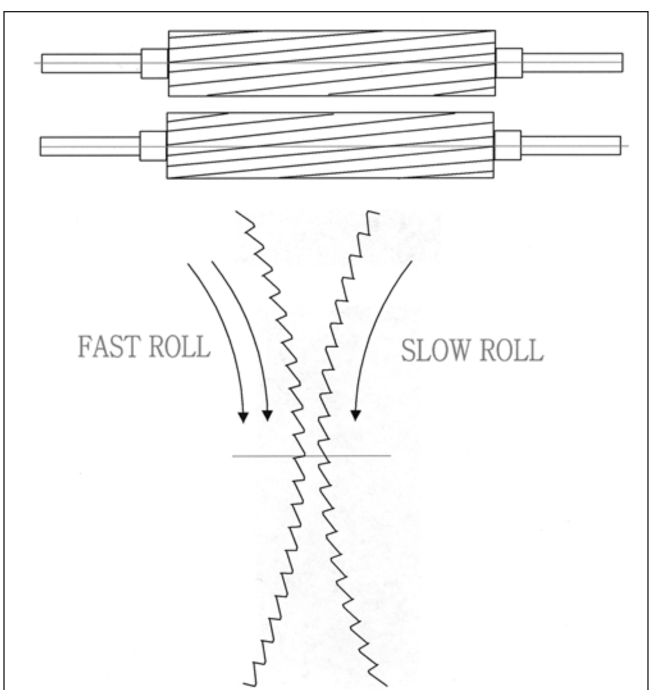

Figure 4. Diagram showing cracker rolls with universal shaft.

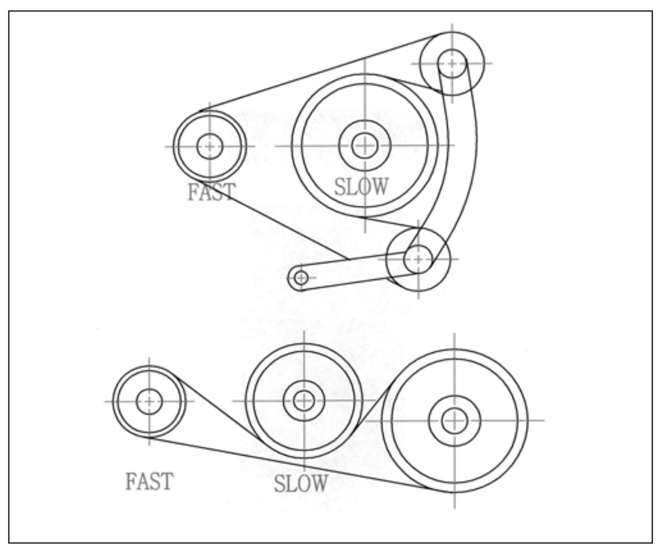

Figure 5. Diagram of v-belts on cracking mills.

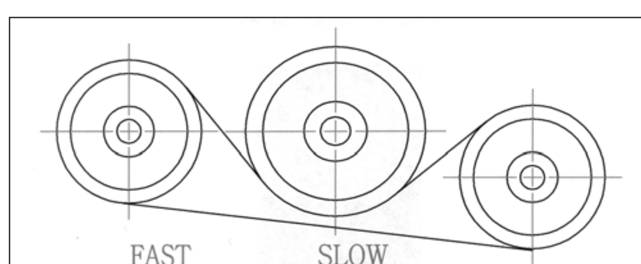

Figure 6. Diagram of flaker roll pulleys showing the similarity in size.

without stopping the mill and following lock-out, tag-out procedures.

Even though cracking rolls are much lighter and easier to handle than flaking rolls, the larger sizes are still quite heavy, and proper lifting rigging should be provided with plenty of safety margin built in. Spreader bars are a must for single lift points and will greatly assist in getting rolls out of and back into machine frames.

Proper mechanical pullers should be used to remove straight bored sheaves, and hammers never should be used for *assistance*. The same is true when reinstalling this type of drive system on a shaft. In some cases it may be desirable to heat the hub of the sheave to get enough installation clearance.

Bearing installation is a maintenance step that often is not done correctly. In the case of tapered bearings using a sleeve and lock nut, most mechanics don't take the time to tighten the lock nut until the correct clearance is set by a feeler gauge. This is the only way to ensure maximum bearing life and to prevent the sleeve from turning on the shaft eventually.

Bearings that are shrunk-fit on shafts require special consideration for the installation. Obviously, all surfaces must be clean and free of burs or other surface problems. Do not overheat bearings. Most bearings will be permanently damaged if they are heated over 225°F because the materials of construction can expand and not retract to the same dimensions. With today's new electric inductance heaters, overheating is very quick and easy and should be carefully guarded against by using either a surface pyrometer or the melt sticks provided for different temperatures. The use of an infrared pyrometer is not advised unless the emissivity has been corrected and the unit has been tested against an accurate surface pyrometer.

Maintenance of cracking mills is not an easy job. Ideas and suggestions in this writing are very general and should not take the place of a good factory-supplied maintenance manual. Maintenance personnel should be well trained and have as much experience as possible before attempting to change rolls in a cracking mill. As with most maintenance projects in a plant, good planning and careful attention to detail will result in the highest quality job.

Flaking Mills

Flaking mills have evolved over the last three decades of the twentieth century from the ancient five high roller mills still being used in some cottonseed processes to 30-ton giants having rolls up to 32 inches in diameter and almost 80 inches long. The oilseed-crushing industry has demanded and is still demanding higher capacity machines. Actually what they want and need is more flaking capacity per square foot of floor space.

The root of the problem is the same as that of the cracking mill. Expansion has occurred inside the plant, and now there is no more room. This makes maintaining flaking mills in today's plants more difficult and time-consuming.

Generally speaking, the greater the capacity that a machine is able to flake, the greater the need for maintenance. Also compounding the whole situation is the fact that maintenance intervals are shorter and current safety regulations add to the time required to perform the maintenance task.

Although flaking mills are very different than cracking mills, they share some common areas. Flaker feeders, for instance, are almost identical to those on crackers. V-belt drives, although normally heavier with more belts, basically require the same care and attention as their counterparts on cracking mills. These items have been covered previously.

The major requirement on flaking mills is roll end maintenance. To completely understand this fact, it must be understood how rolls wear and also a little about the failure mode in case maintenance is not performed soon enough.

Every flaking mill ever made has had the phenomenon of uneven wear on the rolls. To prevent unflaked material from bypassing the ends of the rolls, most flakers have a metal plate that is shaped to the exact contour of the rolls and located only a few thousandths of an inch above the roll end surface to ensure no material gets under. This plate, regardless of how thin, covers up some of the flaking surface. Many attempts have been made to find other ways to handle this problem of sealing the roll ends, but even when the end dams are completely removed and internal chutes are placed under the roll to collect the bypassed material, the rolls still eventually wear more in the middle than on the ends. Therein lies the problem.

Most modern flakers run with up to 60,000 pounds per square inch surface loading between the two rolls when the mating surfaces are completely parallel. This figure is well within the limits of the roll design, but it is very important to keep in mind that because of the thermoplasticity of oil-bearing seeds, when making very thin flakes like most operations require, the two roll surfaces may only be half the flake thickness apart. In other words, if a 0.015″ flake is being made, the rolls are probably less than 0.008″ apart due to product rebound.

This fact also explains why "hot spots" on rolls cause flakes to be very thin in that affected area as the roll expands only a few thousandths of an inch. The very narrow gap between the rolls is the reason a relatively small amount of wear on the diameter of the roll can cause big problems.

End dams that cover the end of the rolls prevent any wear in this area. Even mills equipped with the overflow system and without end dams still experience more wear in the center of the rolls than at the edges due to the natural tendency for less product to flow at the edge of the feeder. The net result is low centers and high ends. (See Fig. 7)

The above condition causes a redistribution of forces on the roll surface so that instead of 60,000 psi equally distributed across the roll face, the pressure at the high roll ends is greatly multiplied to the point of exceeding the shear strength of the

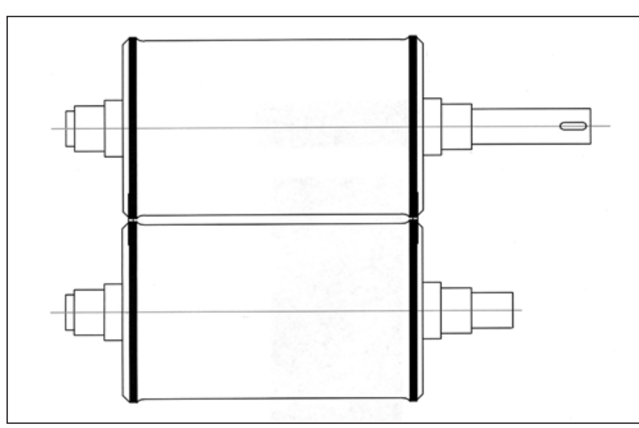

Figure 7. Diagram of rolls showing more wear in the center than on the edges.

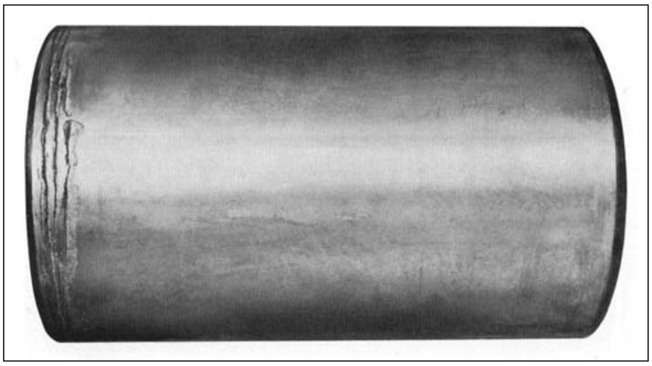

Figure 8. Photograph of roll ends showing spauling and cracking.

material. The first visual sign on chilled iron rolls that this is happening is the appearance of a polished surface at the roll ends.

If no action is taken, very soon, spauling and cracking of the roll end will occur. (See Fig. 8) To relieve this pressure, the roll end will finally break off in large random length pieces. As if this were not destruction enough, pressure ridges may soon appear if they are not already present.

Of all major disasters that can and have happened to flaking mills, untreated pressure ridges have the most damaging potential. These bars, or corrugations as they are sometimes called, will cause heavy vibration to the complete flaker. Bolts are vibrated loose, bearings are destroyed, and many times the huge roll shafts will snap off at the barrel. Adjacent flakers may even be damaged in this case.

All major suppliers of flaking mills and roll foundries as well as most oilseed processors agree that this is the failure mode. They all agree that at all costs, end problems must be dealt with as necessary to prevent the damage described above.

Several foundries have developed special alloys for oilseed flakers that have proven very successful in preventing rolls from breaking off the ends and surface pitting. Basically the material is a nodular iron formation instead of the chilled iron. Nodular iron has a much higher shear strength, and the surface is more malleable and does not work-harden with use.

Unfortunately, the prevention of end breakage has allowed high roll ends to run longer with the eventual formation of pressure ridges. Considering the higher thermal expansion rate of nodular iron rolls, it may even be possible that pressure ridges will form quicker on this type of roll, indicating roll end grinding may be needed on a more frequent basis.

With these things in mind, it should be clear that roll-end grinding is probably the most important step in flaker maintenance.

Scrapers, that clean the rolls, play an important part in the flaking process. On almost all flaking mills, scrapers are located under the rolls so that the scraped product will be directed down into the hopper after it is removed from the roll. This location facilitates the use of weights to hold the scraper against the roll even as each wears.

Weights should be designed to have several positions, in turn, giving several different scraper force values to be most flexible. More scraper force is required when new scrapers are installed. As they take the exact contour of the roll by wear, the lightest force that will get the job done is the best choice for less scraper maintenance.

When end plates are set over for whatever reason, scrapers should be shortened to the inside width of the end plates. Failure to do this will eventually cause more roll-end damage by grooving.

Always blank off the discharge hopper whenever possible, before working under or on the flaking rolls. If this is not possible, the conveyor should be stopped and locked out anytime maintenance people are in this area.

Some flaking mills are equipped with HTD main drives. These have proven their value for many years by the fact that once they are set, it is not necessary to tighten the belts since their stretch is very limited. It is very important to get these drives in correct alignment, or otherwise they will jump off the pulleys. Also, it is important to handle the belt guards with care so as not to damage the sound-deadening material required when using the HTD system.

One thing that shouldn't have to be said to a good maintenance crew, but we will say it anyway: Don't use excessive force on any piece of equipment!! In most cases, excessive force is used to substitute good surface preparation, cleaning, etc. In many cases it is used to substitute a clear understanding of how parts fit together. Sometimes it is necessary to use a great deal of force to overcome rusting or gauling of metal parts. Make sure this large force is understood and is controlled so that if the assembly breaks loose or if parts fail nobody will get hurt.

Maintaining the equipment in a plant is probably of equal importance as operating it. Taking pride in the job and doing it to the best of one's ability reduce the overall amount of work to be done and makes the oil mill a more profitable operation.

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