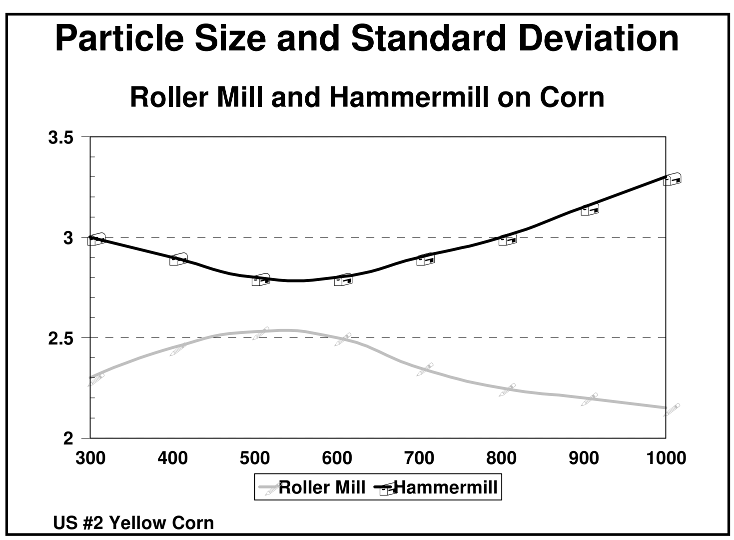
Why process at all?

Why process at all? Of course, the answer is ultimately feed efficiency, producing the *most* milk, eggs, meat or fiber at the *lowest* possible cost. Particle size reduction as the first step in the feed manufacturing process works toward the goal of improved feed efficiency by increasing the surface area of the materials being processed. This increases the amount of materials exposed to the animal's digestive system and ultimately leads to more complete digestion, thus better feed efficiency. Particle size of ground feed ingredients also has a direct influence on subsequent processing and handling. To produce pellets or extruded feeds of acceptable quality the particle size of the ground materials must be correct. Generally speaking, finer grinding will result in a better quality pellet or extruded feed, increases the capacity of the pellet mill or extruder, and reduces wear of the pellet mill or extruder working parts such as dies, rollers, and worms.

Because animal needs vary considerably, the degree of processing for various diets also must vary. Ruminant animals such as cattle and sheep have rather long, complex digestive tracts and so require a less processed feed material. On the other hand, many of the ingredients used in ruminant feed pellets consist of low protein, high fiber material so fine grinding may be required in order to achieve a reasonable pellet quality. Swine have a fairly short, simple digestive system (much like humans) and therefore benefit from a more highly processed feed. Poultry have a short but rather complex digestive system and, depending on the make up of the diet, can efficiently utilize feedstuffs less highly processed than swine. The size and the age of the animals also affect the dietary requirements so far as particle size is concerned. Generally speaking, younger animals require a finer, more highly processed feed than do older, more developed livestock.

How fine do you grind?

Determining and expressing fineness of grind has been the subject of study as long as feed ingredients have been prepared. While appearances or feel may allow an operator to effectively control a process, subjective evaluation is inaccurate at best and makes objective measurement and control virtually impossible. Descriptive terms such as coarse, medium and fine are simply not adequate. What is "fine" in one mill may well be "coarse" in another. Describing the process or equipment is also subject to wide differences in terms of finished particle size(s) produced. Factors such as moisture content of the grain, condition of the hammers and/or screens (hammermill) or the condition of the corrugations (roller mills) can produce widely varying results. In addition, the quality of the grain or other materials being processed can have a dramatic impact on the fineness and quality of the finished ground products.



The best measurement of finished particle sizing will be some form of sieve analysis, expressed in terms of mean particle size or percentage (ranges) on or passing various test sieves. A complete sieve analysis will not only describe the average particle size but will also indicate peculiarities in the distribution, such as excessive levels of fine or coarse particles, etc. Typical descriptions that lend themselves to objective measurement and control might be "corn ground to 750 microns" or "75% < 14 mesh".

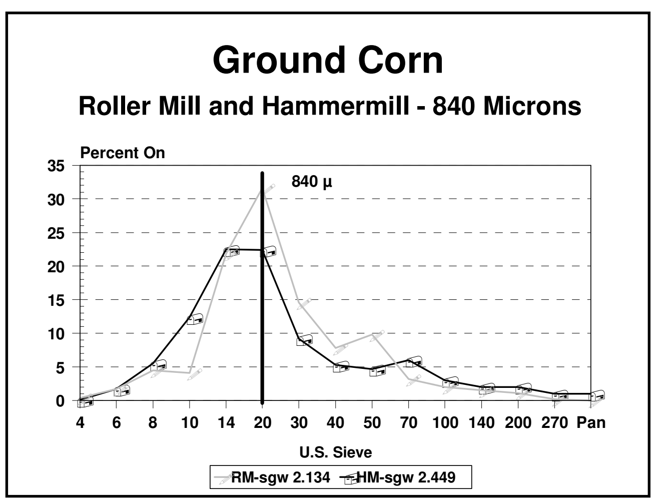
Particle Size and Distribution

The most common way to analyze ground feed materials for particle size and distribution (uniformity) is to perform a complete a sieve analysis. The particle size distribution of common ground feed materials is skewed when plotted on normal – normal graph paper; when plotted on log-normal graph paper, the curve becomes more like the typical bell shaped curve. In order to make reasonable comparisons between samples, the American Society of Agricultural Engineers (ASAE) has defined a procedure, ASAE S319.1 based on a log-normal distribution of the ground particles.

This method involves sifting a sample of ground material through a set of 14 test sieves, weighing the fraction on each sieve, and computing the "geometric mean particle size". This figure represents the mid point (mean) of the distribution, where 50% of the material by weight is coarser, and 50% of the material by weight is finer. Although technically it is not correct, the mean particle size (in microns or µ) is commonly referred to as the "average" or the "micron size". Another common calculation performed in the size analysis procedure is to determine the "log-normal standard deviation". For most feed materials ground through a roller mill, the log-normal standard deviation will be in the range of 2 to 2.5. For most feed materials ground through a hammermill the log-normal standard deviation will be from 2.5 to 3.5.

U.S. Standard Sieve	Nominal Opening	
	mm	inches
4	4.76	0.187
6	3.36	0.132
8	2.38	0.937
12	1.68	0.0661
16	1.191	0.0469
20	0.841	0.0331
30	0.594	0.0234
40	0.420	0.0165
50	0.297	0.0117
70	0.212	0.0083
100	0.150	0.0059
140	0.103	0.0041
200	0.073	0.0029
270	0.053	0.0021
Pan		

In order to obtain an accurate description of the ground material, the sieve analysis must thoroughly separate the fine particles. In order to achieve this separation the sample size must be correct (100g as prescribed by the ASAE procedure) and normally a sieving agent will be added to insure fine particles are completely separated and sifted. The sieving agent serves to keep smaller particles from sticking together and insures a complete separation of the sample into the various fractions.



Grinding equipment

Both roller mills and hammermills have been applied to the task of particle size reduction or grinding in feed milling applications. Hammermills have traditionally been used to produce the finer grinds commonly used for pelleting and for many mash (meal or non-pelleted) feed applications as well. The hammermill is a relatively simple machine and requires a fairly low degree of skill in regards to both the operation and maintenance.

However, recent significant changes in the industry have caused many to reassess their approach to particle size reduction. Increasing energy costs, increasing customer awareness of feed quality and environmental concerns all challenge the validity of the hammermill as the only choice for particle size reduction (grinding) applications. In the following discussions, both roller mills and hammermills will be looked at in terms of equipment selection, operating conditions and parameters, and relative costs to acquire and to operate.

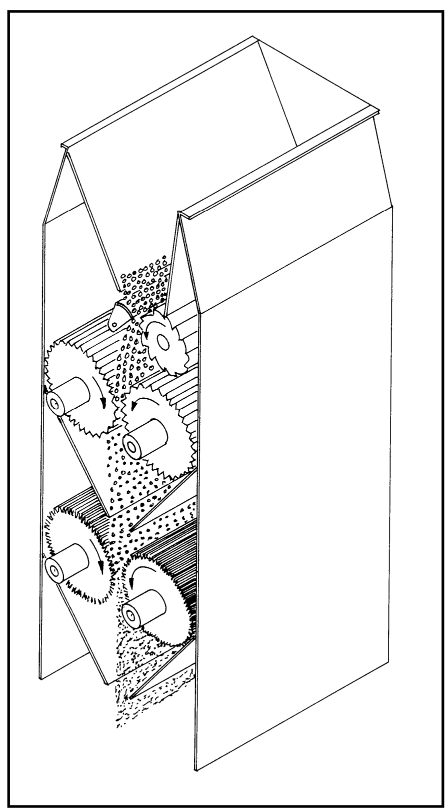
Roller Mill Grinding

Roller mills have been used in the processing of common feed materials for years. The earliest roller mills used in the feed milling were abandoned flour milling roll stands, used primarily to produce coarse granulations of friable materials. Over time, roller mills have been used to perform a wide variety of tasks related to the production of animal feeds.

Roller Mill Equipment Description

Roller mills are commonly referred to by the type of service they perform. A mill used to crack grain or other types of friable materials may be called a cracking mill. Mills used to flake grains or other products may be called flaking mills or flakers. Roller mills used to grind in a feed mill are commonly referred to as a roller mill or roller mill grinder.

Double pair (two pair high) roller mills may be utilized in feed milling operations when two distinctly different grains are processed through one mill. A machine processing both corn and oats, for example, requires one set of coarse grooved rolls to crack corn and one set of fine grooved rolls to be able to effectively process the oats. A double pair mill equipped with differential roll speeds (one turning faster than the other) can be utilized as a grinder to reduce all kinds of friable materials, including grains, pelletized products, oilseed and by-product meals, and many other common feed ingredients. Double pair mills are usually referred to as roller mills or roller mill grinders.



Triple pair (three pair high) mills are used for special applications requiring a finer finished product or when a wide range of materials will be processed through the same machine. A triple pair mill may be employed to achieve a variety of finished products from different feed stocks such as whole grain, mixed meals, or other combinations. Occasionally, three pair high roller mills will be used to permit one machine to serve as both a two pair high grinder and a single pair cracking/crimping mill.

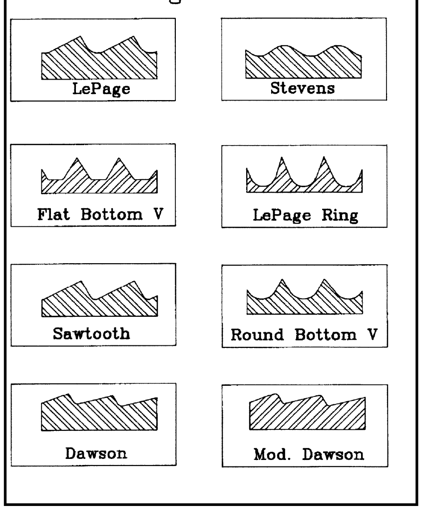
Basic Machine Characteristics

Roller mills used in various feed processing applications will have some common characteristics as well as certain features peculiar to specific tasks such as machines used to flatten (crimp) small grains or crumble pellets. All roller mills will have some kind of framework to house the rolls and contain the roll separating forces experienced in operation. This basic frame must be robust enough to hold the rolls securely in position during operation, yet allow easy access to the rolls for normal service. In any roller mill, the rolls will need to be removed periodically for recorrugation. This very important detail must be carefully studied when roller mill selection is made and the installation is laid out.

Generally, one roll is fixed in the frame and the opposing roll can be adjusted to set the clearance or gap between the rolls. This roll gap adjustment needs to be quick and easy and must accommodate the requirement of maintaining the rolls in parallel. Common systems employ screws, cams, or fluid-operated (hydraulic or pneumatic) cylinders to achieve this roll adjustment. Adjustment can be manual or remote operated and may feature some means to display the roll gap setting at a remote location. Roll corrugations (also described as roll cut or fluting) will vary depending on the material to be processed, initial and finished product sizes and the product quality (amount of fines) desired. Coarse grooving will produce a coarse finished product at high capacities while finer grooving produces a finer finished product at lower capacities.

While flour milling may require many different corrugation styles to produce the desired finished products, feed processing can usually be accomplished with less sophisticated roll corrugations. The most commonly employed corrugation styles for roller mill grinding will be Round Bottom Vee (RBV). For certain special applications such as high moisture grain, some form of a raked tooth with different leading and trailing angles, commonly known as Sawtooth may be beneficial. Occasionally, crumbler rolls (roller mills dedicated to the reduction of pellets) will feature a classical LePage cut, with one roll corrugated longitudinally and one corrugated circumferentially. The circumferential roll will often be equipped with a groove known as the LePage ring cut.

Roll Corrugation Profiles

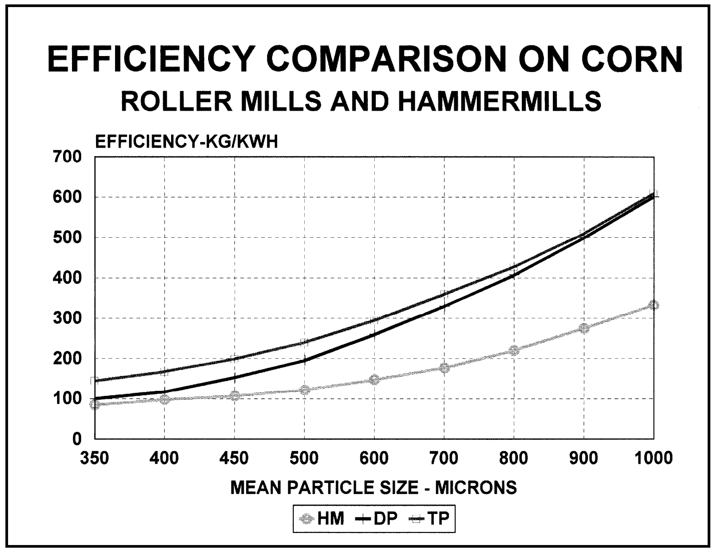


Rolls may operate at differential speeds depending on the task the mill is called to perform. Cracking, crimping and flaking use lower roll (peripheral) speeds - 1,000 Ft/min (5 M/sec) up to 2,200 Ft/min (11 M/sec) and no roll speed differentials. Mills used to grind will operate with higher roll speeds - 1,500 Ft/min (7.5 M/sec) up to 3,000 Ft/min (M/sec) with roll speed differentials. Roll speed differentials simply means one roll turning faster than the other and is usually described in the form of a ratio, slow roll speed expressed as 1. For example, rolls operating at 1.5:1 differential with a fast roll speed of 1,000 RPM would have the slow roll turning 667 RPM.

Grinding with a Roller Mill

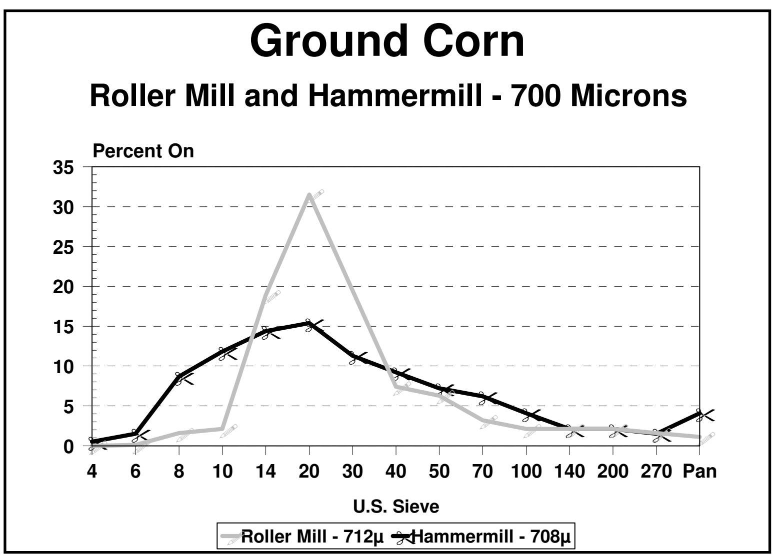
In recent years, more attention has been given to the roller mill set up to function as a grinder. Several important factors have contributed to this including energy costs, product quality concerns, and environmental issues.

Energy costs have escalated dramatically in the last 20 years and, at the same time, margins in feed manufacturing have decreased. As a result, cost savings of \$0.10-\$0.40 per ton for grinding can mean a significant difference in the bottom line of a feed manufacturing operation. Because of an efficient reduction action, roller mill grinders will product 15-40% more tons/hour at a given horsepower than traditional “full-circle” hammermills when producing the same finished particle size. Roller mill energy savings advantages will be even greater when compared to older half screen hammermills with direct connected fans. In many instances, the energy savings potential of a roller mill grinder will justify the capital expenditure.

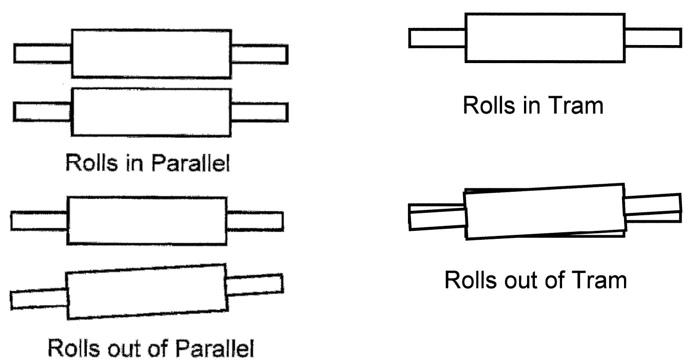


Product quality concerns have always been a part of feed manufacturing and there are many quantitative methods for measuring feed quality. Nonetheless, the physical traits (appearance, feel, handling characteristics) will always influence the feed buying customer. Because the grind produced by a roller mill is very uniform, the finished product(s) have an excellent physical appearance. The low level of fines and lack of oversize particles make a feedstuff with excellent flow and mixing characteristics. This is especially important for mash or meal type feeds where the flow from the bins and feeders can be difficult to regulate and where segregation and separating may occur in shipping and handling. Because the product is not heated significantly in the grinding process, less moisture is driven off and the finished product is not prone to hanging up in the bins, spoiling in storage, and other maladies related to heat and moisture.

Environmental issues of concern to the feed manufacturer today include particulate emission, employee exposure to noise, and the risk of fire and explosion. Because roller mill grinders create fewer fines, less material is likely to be lost to the atmosphere. Additionally, high efficiency hammermill installations require air assist to achieve the rated performance. Cyclones and bag filters are not 100% effective in removing the particulates from the air streams and so some emissions occur. Whether or not these emissions are a problem will depend on widely varying local conditions and regulations. Because roller mill grinders operate at lower speeds and with a different kind of reduction action, less noise is generated in the grinding process. In many cases, this reduction in noise means a roller mill grinder will not require a separate enclosure to limit employee exposure to high noise levels. Lower operating speeds in roller mill grinders mean less frictional heating and less inertial energy (such as thrown hammers) in a hammermill. This reduction in ignition source, combined with less dust in the product steam, greatly reduces the risk of fire in the grinding operation.



Because the roll clearances need to be maintained under demanding conditions, the mill housing and roll adjustment mechanism of the roller mill grinder must be more robust than for older design cracking and crimping mills. More precise roll position adjustments must be made and better control over the feeding is necessary in order to achieve the full benefits of the roller mill grinder through its range of capabilities. Rolls must be operated in parallel and tram to reliably produce quality finished products. For these reasons, many of the existing cracking and crimping mills cannot be made to function effectively as a roller mill grinder. The illustrations here show roll conditions of tram and parallel.

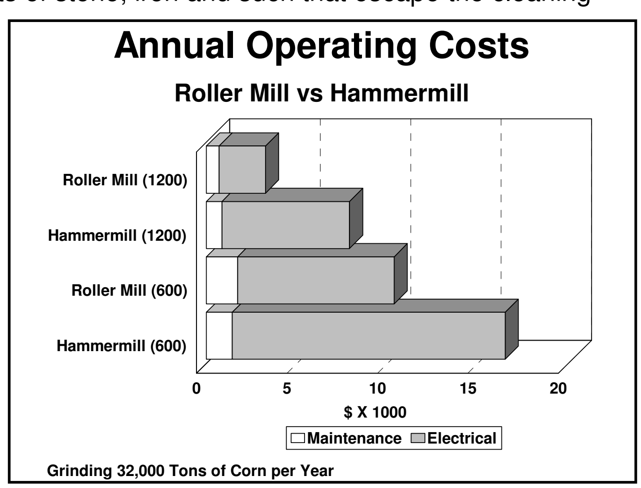


Rolls – Top View   Rolls – Front View

Roll feeders or pocket feeders are generally preferred for a roller mill grinder to insure a uniform feed across the full length of the rolls. Pocket feeder have the inherent advantage of utilizing conventional inverter (Variable Frequency Drive) technology to control the feed rate, and simplify automation where required.

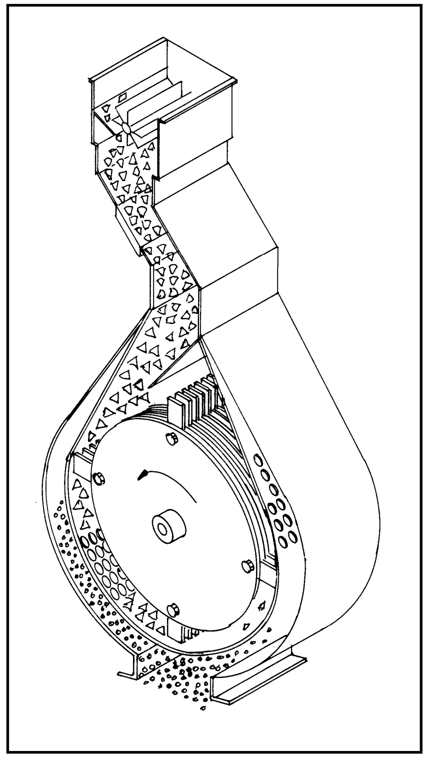
Because roller mill grinders do more work and use more horsepower than cracking and crimping mills, roll wear rates will be greater. Rolls will require recorrugation when the capacity of the mill drops by 20-30% or when finished product quality is no longer acceptable. Because they do not effectively reduce fibrous materials, roller mill grinders are best applied to grinding friable products such as corn, wheat, milo, soybean meal, and similar products.

Cleaning grain ahead of a roller mill can improve the roll life and the quality of the finished product(s). Normally all that is required is some form of scalper to remove gross oversize pieces - stalks, cobs, clods, stones and the like. Magnetic protection ahead of the mill will insure a minimum amount of tramp metal enters the rolls. While grain for a roller mill grinder does not require any more cleaning than grain going to a hammermill, some objectionable fibrous materials may be passed unprocessed through a roller mill grinder. Rolls tend to be self-limiting in so far as the size of materials that will be pulled into the nip. Rolls cannot get a purchase on large stones, etc. and, though roll wear may be accelerated by the presence of such objects, the mill is not likely to suffer acute failures. Grain sized bits of stone, iron and such that escape the cleaning system will generally pass through the machine without any significant impact on the processing as the rolls can open (with spring protection) and close again.



The primary claims against the roller mill grinder are high initial cost, maintenance hours to change rolls, and the need to carry spare rolls in stock. Roller mills are generally more expensive than hammermills of equal capacity, but total installed costs for the two systems are not so different when all factors are considered. Items such as larger motors, starters, and wiring, air assist systems (including fans and bag filter units), and additional labor to install the more complex material handling systems of hammermills tend to offset the differences in the basic equipment costs. Because roller mill maintenance (roll change) occurs in a concentrated block, the actual time required appears to be significant. In fact, when compared on a "maintenance hours per ton" basis, roller mill grinders are quite competitive with hammermill grinders. Finally, spare rolls may amount to a fair capital investment but, again comparing the actual cost on a "per ton" basis, the maintenance costs of recorrugation and roll replacement are within $0.01-$0.03 per ton of hammermill maintenance costs. Due to the significantly lower energy cost per ton, the roller mill offers an overall lower cost per to grind corn and similar feed materials.

Hammermill Processing



Hammermills have long been used for particle size reduction of materials used in the manufacture of animal feeds. At the same time, it is not far from the truth to say that the hammermill has been the most studied and least understood piece of equipment in the feed manufacturing plant. Much of this confusion has come about over the years as a result of hit or miss problem solving, changing several variables at once when testing or problem solving, and by treating symptoms rather than addressing the root causes when treating operational problems.

On the other hand, a well-designed hammermill grinding system will offer good long term performance and require a minimum amount of attention if a few basis considerations are made at the time the equipment is selected. The following discussion will explore both the theory of hammermill operation as well as supply the good, hard engineering principles on which systems may be successfully designed.

While hammermills are primarily applied to the task of grinding (significant particle size reduction), they are also used at times to produce coarse granulations, crack grain and even, in some cases, to homogenize mixtures of materials. Every effort will be made to explore these alternative applications and to offer the best information available dealing with each peculiar task.

Equipment Description

A hammermill consists of a rotor assembly (two or more rotor plates fixed to a main shaft) enclosed in some form of grinding chamber. The actual working mechanisms are the hammers, which may be fixed or swinging and the screen or grinding plates that encircle the rotor. The rotor may be supported from one end only (overhung) or supported on both ends by the shaft and bearings. For modern, high capacity machines in widths of 12" (305 mm) up to 56" 1422 mm), the rotor is normally supported on both ends. This provides a more stable running mill and reduces the tendency for a rotor shaft to "wind up" or run out of true under load. The hammers are simply flat metal bars with a hole at one or both ends and usually have some form of hardface treatment on the working end(s). The hammers may be fixed, fastened rigidly to the rotor assembly, but much more common is the swinging hammers, where the hammers float on pins or rods. This swinging hammer design greatly facilitates changing hammers when the working edges are worn.

Reduction in a hammermill is primarily the result of impact between the rapidly moving hammer and the incoming material. There is some attrition (gradual reduction by particles rubbing) between the particles and between the hammers and the screen.

The efficiency of the grinding operation will depend on a number of variables including, but not limited to, screen area/horsepower ration, screen (hole) size and open area, tip speed, hammer pattern (number of hammers), hammer position (coarse or fine), uniform feed distribution, and air assist. In addition, the nature and quality of the material(s) being processed will affect the performance of the hammermill.

Basic Machine Characteristics

Hammermills used in feed processing have some common characteristics but equipment manufacturers differ significantly in how they achieve those same characteristics. For the purpose of this discussion, here a number of basic design principles will be reviewed as they apply to maximizing the performance and minimizing the cost of operating a hammermill system.

Full Width Top Feed

The modern hammermill design must include a full-width top feed in order to achieve maximum efficiency and minimize the cost of operation. A full width top feed insures the entire screen area can be utilized and that the work being accomplished will be evenly distributed across the full hammer pattern. The full width top feed also permits the direction of rotation to be changed, allowing two corners of the hammer to be utilized before a physical change of the hammer is required.

Tear-Shaped Grinding Chamber

A tear-shaped grinding chamber is necessary to prevent material from merely circulating within the grinding chamber. Most well designed modern hammermills have some sort of flow director or diverter in the top of the hammermill to properly feed the hammermill (right relationship of incoming grain to the direction of the hammers) and to positively stop any materials that are circulating within the grinding chamber. Hammermills with circular screens lack this important action and so are more prone to near size material traveling around with the hammers, increasing product heating and reducing capacity.

Split Screen/Regrind Chamber

The tear-shaped screen should be split in two pieces, with some device at the bottom of the mill to disrupt the flow of materials within the grinding chamber. This device must be large enough to take products out of rotation and redirect them back into the path of the hammers, but should not be so large as to subtract from the screen area available for grinding. The application of a split screen design will permit the user to adjust the screen sizing on the down side and up side to maximize productivity and product quality.

Outboard Supported Rotor

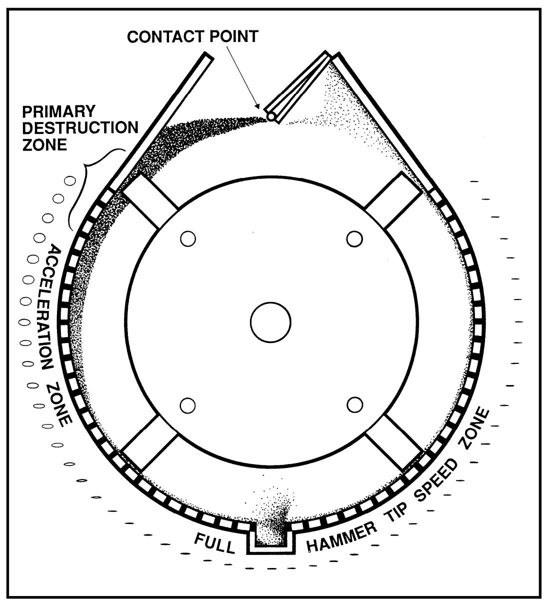
As noted earlier, the rotor should be supported at each end, preferably with standard bearings and bearing housings. This will provide a degree of rigidity not available with an "overhung" rotor design and reduce any problems with rotor shaft "wind up", even if the mill operates with an out of balance rotor. Adequate support for the rotor is particularly important with today's increased capacity demands, requiring wider machines. The use of standard bearings and housings is an added benefit to the customer by increasing the availability of replacement parts should the need arise.

Rigid Rotor Support

In order to maintain the relative position of the rotor to the grinding chamber (screens and supporting mechanisms) the foundation of the mill must be extremely rigid since, even under normal circumstances, a hammermill will be subject to vibration and shock. A rigid structure positively maintains the clearances between the hammer tips and the screen through the full rotation for consistent, efficient processing. This must be accomplished without sacrificing the accessibility to the grinding chamber, as routine maintenance of the hammers and screens will be required.

Replaceable Wear Items

One final rule for a good hammermill design is "if it can wear, it should be replaceable". Beyond the hammers, screens and pins, every component within the hammermill will be subject to wear. Accordingly, these components should be fabricated from wear resistant materials, heavy enough to provide good service life and ultimately should be reasonably simple to replace.



Basic Operational Concepts

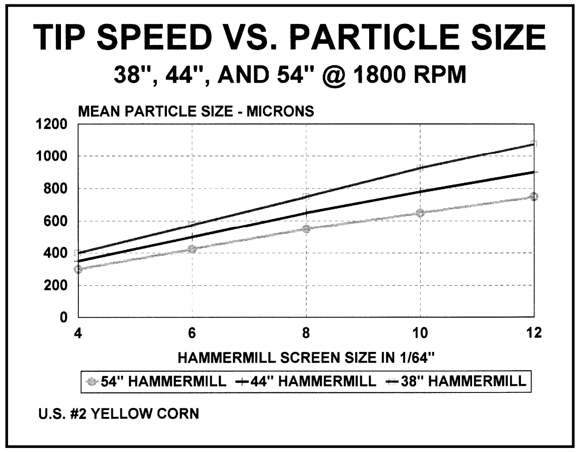
What is intended to take place inside a hammermill is the uniform, efficient reduction of the material introduced into the grinding chamber. This particle reduction occurs as a result of the impact between a rapidly moving hammer and a relatively slow moving particle. If sufficient energy is transferred during the collision, the particle breaks and is accelerated towards the screen. Depending on the particle size and the angle of approach, it either passes through the screen or rebounds from the screen into the rapidly moving hammers again. As materials move through the grinding chamber they tend to approach hammer tip speed. Since reduction only occurs when a significant energy is transferred from the hammer to the particle (large difference in velocities), less grinding takes place when the particles approach hammer tip speed. Many manufacturers incorporate devices within their mills to interrupt this product flow, allowing impact and reduction to continue. Tear circle hammermills have a more positive, natural redirection of product at the inlet than "full circle" design machines.

While the basic operational concepts are the same for all hammermills, the actual unit operating conditions change rather dramatically depending on the materials being processed. Grains such as corn, wheat, sorghum and various soft stocks, like soybean meal, tend to be friable and easy to grind. Fibrous, oily, or high moisture products, like screenings, animal proteins, and grains like oats and barley, on the other hand, are very tough and require much more energy to reduce.

Consequently, the hammermill setup that works well for one will not necessarily work for the other. The following discussion covers such factors as tip speeds, hammer patters and position, horsepower ratios (to hammer and screen area), and air assist systems. Little space is devoted to screen sizes (perforation or hole size) since processing variables would make any hard and fast statements nearly impossible.

Tip Speed

Tip speed, in addition to the screen size, has a significant influence on finished particle sizing. High tip speeds (>18,000 Ft/min / >90 M/sec) will always grind finer than lower tip speeds. Low tip speeds (<13,000 Ft/min / <65 M/sec), on the other hand, produce a coarser granulation with fewer fines, all other factors being equal. As a rule, smaller holed screens should only be used with higher tip speeds and large holed screens with lower tip speeds. Refer to the figures here for general guidelines for screen sizing in relation to tip speeds.



LOW TIP SPEEDS

< 13,000 FPM (3,900 METERS/MIN)

- **COARSE GRIND ONLY**
- **FRIABLE MATERIALS**
- **12/64" (5mm) SCREEN AND LARGER**

INTERMEDIATE SPEEDS

13,000 TO 18,000 FPM

(3,900 TO 5,400 METERS/MIN)

- **COARSE AND FINE GRIND**
- **FRIABLE OR FIBROUS MATERIALS**
- **6/64" (2.5mm) SCREEN AND LARGER**

HIGH TIP SPEEDS

> 18,000 FPM (5,400 METERS/MIN)

- **FINE GRIND OF ALL MATERIALS**
- **FRIABLE OR FIBROUS**
- **8/64" (3mm) SCREENS AND SMALLER**

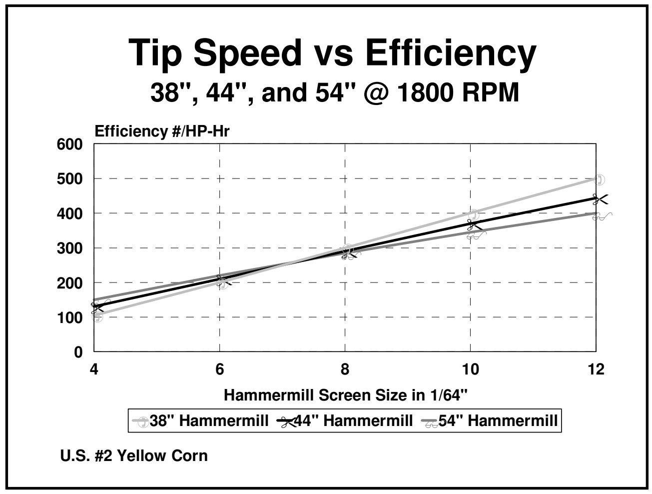
Tip speed is simply a factor of mill diameter and motor RPM and is not easily changed on direct coupled machines. There are a few v-belt drive hammermills on the market today but the time and expense involved in maintaining those machines makes them impractical for normal applications in feed manufacturing and oilseed process plants.

Tip Speed - Friable Products

For producing a uniform granulation with few fines on friable products like corn, wheat, grain sorghum, pelleted ingredients, and solvent extracted meals, an intermediate tip speed is normally desired. Hammermills with a tip speed of 13,000-18,000 fpm will produce a high quality finished product with excellent capacity and efficiency. 38” diameter mills with 1800 RPM motors (17,800 fpm) and 44” mills with 1200 or 1500 RPM motors (13,500 or 17,250 fpm) are both used extensively in the processing of all kinds of feed ingredients

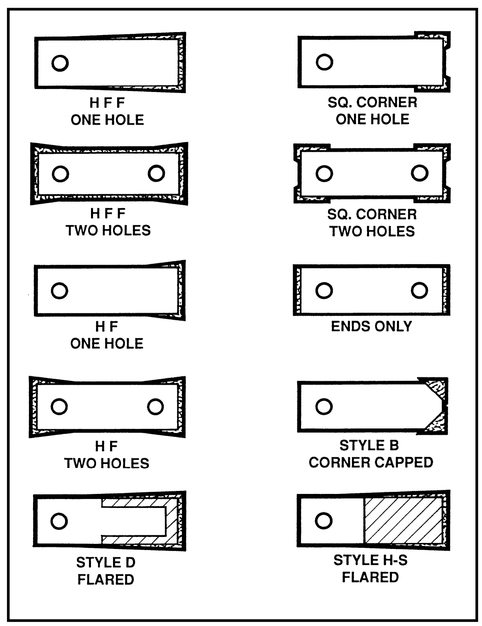
Tip Speed - Fine Grinding and Tough-to-Grind Materials

For fine grinding friable products and tough-to-grind materials, like soybean hulls, mill feed, and mixtures with animal protein products, a higher tip speed is indicated. More energy is required to grind these kinds of materials, so more tip speed is needed to impart sufficient energy when the hammer to particle impact takes place. Normal tip speeds for fine grinding and fibrous materials are obtained on larger diameter hammermill (44” or 54” / 1.1 or 1.4 M diameter) operating with 4 pole motors, or smaller diameter hammermills (22” or 28” / 0.5 or 0.7 M diameter) operating with 2 pole motors. Recent developments in hammermill grinding have included the use of 54” (1.4 M) diameter mills operating at 1800 RPM. This very high tip speed >25,000 Ft/min (125 M/sec) is particularly well suited to fine grinding at high capacities and high efficiency. Because a larger screen (holes) size can be used while maintaining the fineness of grind, operating costs are reduced as well.



It should be noted while discussing tip speeds that, even though two different hammermills with different sized screens can make the same finished particle size, they will achieve those results with different efficiencies. Conversely, hammermills with different tip speeds will produce different finished products (lower speeds = coarser products) even though they are fit with the same sized screen. This is one reason it is important to include particle sizing specifications (mean particle size or % passing a test sieve) when identifying hammermill performance requirements.

Hammers



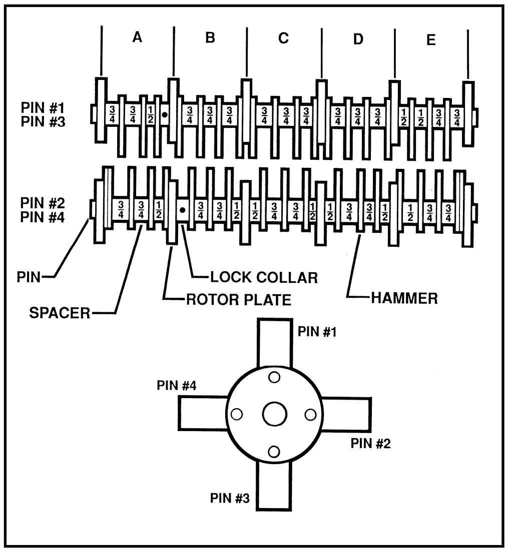
There are many hammer styles available from suppliers around the world. At the same time, there are distinctly different types of hammers used in different regions of the world. Europeans feed processors tend to favor a plain two-holed hammer with no hardfacing or edge treatment. North and South American feedmillers tend to favor a hammer with a flared hardfaced end (or ends). Each market finds a hammer type that best suits their particular needs.

As a rule, most of the variety of hammer styles that have been developed have been modified to meet a specific operational problem. In many cases, a better design of the hammermill grinding system would have eliminated the need for the “special” hammer style.

Hammer patterns and positions have a profound effect on the performance of any hammermill. Because different materials grind differently, the ideal number of hammers (pattern) and clearance to the screen (position) will need to be adjusted according to each application. At the same time, it is important to make sure the hammer pattern completely covers the working screen without having hammers trailing, that is hammers on adjacent pins in line with the preceding hammer. Complete screen coverage insures maximum process efficiency as well as controlling operating costs by getting the most out of each screen set. Trailing hammers will tend to cause accelerated wear in one area of the screen and may actually cut grooves in the screen material.

In most cases, the hammer pattern should include double hammers on the outside rows of at least two opposing pins. Because the material in the grinding chamber near the sides of the mill moves more slowly (dragging on the sides), the outside rows of hammers must do more work and are subject to more wear. Other means of dealing with this problem are also implemented by some manufacturers, including thicker, longer or even shorter hammers on the outside rows.

The hammer pattern described below depicts a typical hammer arrangement with good coverage of the screen area, no trailing hammers and double hammers on the outside rows of two opposing pins. Note that good coverage does not necessarily mean completely covering the screen with hammers but does mean distributing the hammers as uniformly as possible across the available screen area.



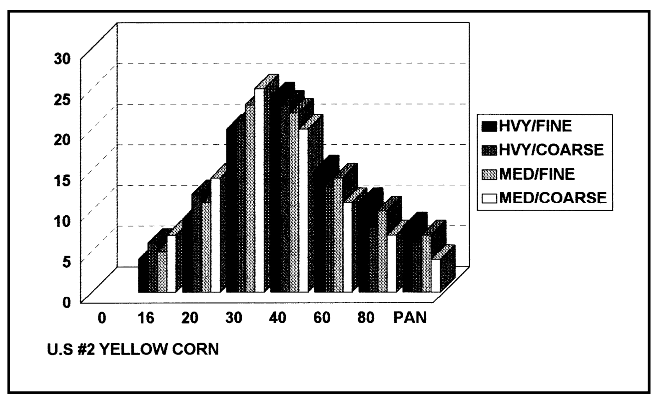
The hammer pattern (number of hammers used) and the position (coarse or fine) will affect the capacity of the hammermill and the quality (fineness) of the ground products. For friable products more hammers (heavier pattern) will reduce capacity and make the grind finer. Fewer hammers (lighter pattern) will increase capacity and make the grind slightly coarser and more uniform.

Many types of fibrous or tough-to- grind products will require heavier hammer patterns just to process at all. Indeed, for some very difficult to grind products the hammermill will be fit with hammers on all eight pins, with some coarse and some fine.

The graph below shows the relative affect of the hammer pattern and position on the quality (coarse and fine material produced) of corn when tested with different patterns and settings.

Hammer Patterns and Positions for Friable Products

When a relatively coarse, uniform finished product is desired, a “light” hammer pattern is selected. This means that there are fewer hammers per pin so fewer collisions will occur with particles in the grinding chamber. Light hammer patterns will demonstrate higher efficiencies than heavier patterns because less work is done. In many cases, hammermill efficiency can be improved from 5-10% simply by reducing the number of hammers used in the mill. While the grind will be slightly coarser, the difference is not noticeable without the benefit of a full sieve analysis. For maximum capacity and minimum fines, the hammers should be in the coarse position with maximum clearance between the hammers and the screen.



When lighter hammer patterns are employed, the horsepower per hammer ratio is also affected. For grinding friable materials in large diameter hammermills (over 36” / 0.9M diameter) with 1/4” (6.4 mm) thick hammers, the ratio should be in the range of 2.5-3.5 HP/hammer, ideally about 3. For small diameter hammermills (22” to 28” / 0.5 to 0.7 M)) with 1/4” (6.4 mm) thick hammers, the range is roughly 1-2 HP/hammer, with 1.5 HP/hammer ideal for mills up to 22” (0.5 M) and 2

HP/hammer for 28” (0.7 M) diameter hammermills. Hammers will typically be mounted on four pins only when processing friable materials to a coarse, uniform finished product. This allows maximum product into the mill with minimum number of contacts being made.

Normally, hardface flared hammers will be used for the efficient reduction of friable products. Either one-hole or two-hole hammers will provide satisfactory results though good maintenance is required to be sure the two-hole hammers are turned in time to effectively use the hardfacing on both ends. It is also important to note that the second hole on two-hole hammers is exposed to the grinding operation and so is subject to some wear before it is ever used to mount the hammer to the pin.

Hammer Patterns and Position for Fibrous and Tough-to-Grind Products

As materials become tougher to grind, an increasing hammer load is employed to maximize contact between hammers and particles. Where increasing the number of hammers used to grind friable products may decrease mill capacity, increasing the number of hammers for tough-to-grind products will often improve mill capacity. In some cases, it is desirable to add hammers to all eight pins for maximum grinding efficiency and to improve screen coverage and utilization.

Because more work is done by the hammers and screens on tough-to-grind products, reducing the clearance between the hammer and screen improves grinding results. This is more true as the screen opening and grind size become smaller. The “fine position” puts the end of the hammer 3/16”-1/4” from the screen and maximizes the work done to the product. While wear to the screen and hammer is increased, the work done increases as well, making a more efficient process.

With heavier hammer patterns, the HP/hammer ratio naturally declines. For tough-to-grind materials in large diameter hammermills (over 36”) with 1/4” thick hammers, the ratio should be in the range of 1.5-2.5 HP/hammer under normal circumstances, going as low as 1:1 for particularly difficult-to-grind materials or when grinding to very fine particle sizes as in aquaculture feeds. For small diameter mills (up to 28”) with 1/4” thick hammers the ration will be roughly 1:1 (1 HP/hammer) for normal applications, going as low as 1:2 (1 HP/2 hammers) for very fine or difficult grinding. Placing hammers on all eight pins tends to reduce surging in the mill and improves screen coverage without overloading either hammer pins or rotor plates.

HAMMERS

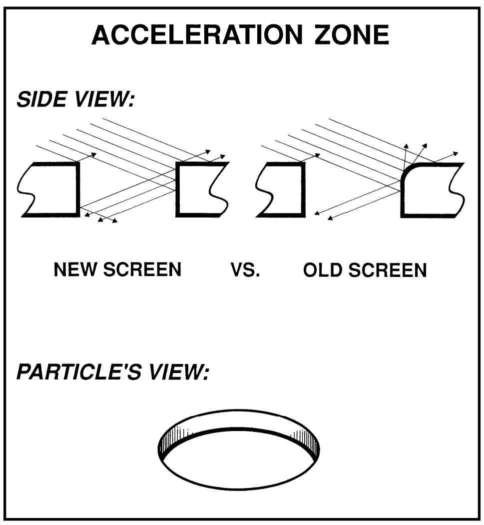
Horsepower per 1/4” Hammer

•For 3000/3600 RPM mills use 1-2 HP (6-8” long x 2” wide hammers)
•For 1500/1800 RPM mills use 2.5-3.5 HP (10” long x 2-1/2” wide hammers)
•Match hammer pattern (light, medium, heavy) to mill horsepower

There is also a relationship between the HP/hammer and the wear on the hammer. Too much HP/hammer will tend to “rock” the hammer each time the hammer swings through a bed of material on the screen, leading to rapid wear of the hammer hole and hammer mounting pin. In extreme cases, the bed may be so deep that the hammer wears above the hardfacing. If this happens, the correct solution is not to use a hammer with more hardfacing extending up the side of the hammer, but to reduce the HP, increase the number of hammers, or reducing the feed rate to the mill. Too little HP/hammer dramatically reduces hammermill efficiency by consuming motor horsepower simply to turn the rotor with its load of hammers. Too little HP/hammer also tends to wear the hammers right on the corner and does not effectively use all the working surface of the hammer. In extreme cases, the rotor may actually run slow, allowing the hammers to rock, causing hammer hole and pin wear.

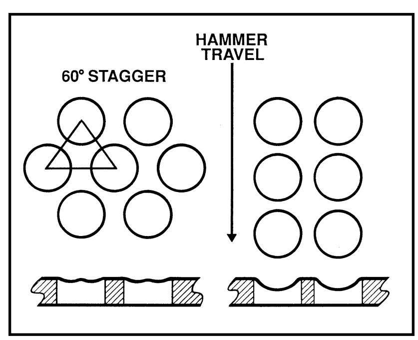
Screens

Hammermill screens are the highest wearing item on the hammermill, and in many cases the most obvious and seemingly expensive maintenance item. However, considering the cost of energy, hammermill screen cost per ton is quite low, and the best way to minimize the cost of hammermill operation is by frequent changing of the hammermill screens to maintain capacity, efficiency, and product quality. Depending on the material being ground and the screen hole size, one set of high quality hardfaced hammermill will normally wear out 2-4 sets of screen before the hammers require replacement. For small diameter screen holes even more frequent replacement may be required. For certain aquaculture and pet food applications it is not uncommon to replace screens with very small holes (3/64” or 1 mm and smaller) as frequently as every 8-24 hours of operation.



It is easy to see how new screens allow more product to escape, improving capacity and grinding efficiency. While thicker screens may last longer, they significantly reduce the tons/hour that a mill can process. When maintenance costs are typically \$0.02-\$0.04/ton and electrical costs range from about \$0.25 to more than \$1.00 per ton, saving money by not changing screens is not cost effective. Normally, screen material thickness will be dictated by the hole size, as it is not possible to punch a hole in material that is thicker than the diameter of the hole being punched

Another screen configuration problem is the amount of open area that a particular screen offers. Factors affecting open area include hole size, stagger, angle of stagger, and land dimension. Screens with fewer holes have less open area, are easier to produce and generally cost less. Screens with inline perforations as opposed to staggered hole patterns are also easier to produce and so cost less. Neither can provide good grinding efficiently and both lead to poor finished quality products because of over grinding. Screen wear is accelerated with inline perforations and screen may actually be cut by wearing the land between the holes in a very short time. Screens with little open area may wear a long time but the actual grinding cost per ton is greatly exaggerated because of the increased energy cost.



Two rules of thumb apply to hammermill screens in relation to applied horsepower:

1. Never have less than 14 In^2 /HP (120 cm^2/kW) of screen area - more is always better

2. Never have less than 4 In^2/HP (35 cm^2/kW) of “open area”

Consider a typical 44” diameter by 30” wide hammermill grinding corn. A tear circle machine will have approximately 3600 In^2 (2.3 M^2) of raw screen area. 3600 In^2 divided by 14 In^2/HP = 250 HP maximum (2.3 M^2/120 cm^2/kW = 190 kW).

If a screen with 10/64” (4 mm) round hole perforation is used, the actual open area is roughly 36% or 3600 In^2 x 36% = 1296 In^2 of actual open area. 1296 divided by 250 HP = 5 In^2 open area per horsepower (2.3 M^2 x36% = .828M^2 actual open area / 190 kW = 4.3 mc^2/kW). This machine would grind very efficiently and produce a high quality, uniform finished meal.

If the same machine were equipped with a 4/64" (1.5 mm) round hole screen and 3/4" (20 mm) back up screen (to prevent the light gauge sizing screen from "blowing out") for fine grinding in preparation for pelleting, or extrusion, the open area would be 3600 In^2 x 30% x 51% = 551 In^2 (.352 M^2). If the same 250 HP (190 kW) motor were applied, the open area per horsepower would be 551 In^2 / 250 HP = 2.1 In^2 open area per horsepower (.352 M^2/190 kW = 18 cm^2/kW). This mill would not grind as efficiently, capacity would be reduced, and the product would be heated considerably and moisture driven off in the process.

SCREENS

Screen Area per Horsepower

- For 3000/3600 RPM mills
  - 10-16 sq.in./Hp typical
  - 12-14 sq.in./HP for grain
  - 14-16 sq.in./HP for fiber
- For 1500/1800 RPM mills
  - 10-21 sq.in./HP typical
  - 14-16 sq.in./HP for grain
  - 16-21 sq.in./HP for fiber

More is always better

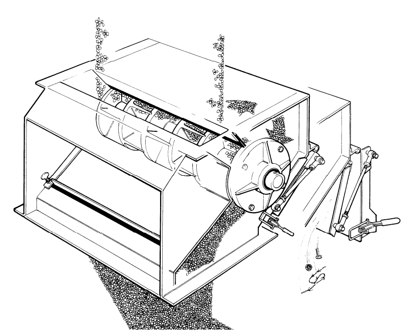
One very simple way of increasing hammermill capacity without significantly affecting the finished grind or adding expense to the grinding system would be to replace the "up" side screen with perforations that are 2/64" to 6/64" (.8 to 2.5 mm) larger than the "down" side screen. This may add 10-15% to the hammermill capacity and produce no noticeable difference in the finished products.

Feeders

Proper feeding of a hammermill is absolutely essential if the system is to operate at maximum grinding efficiency and with the lowest possible cost per ton. Uneven or inconsistent feeding can lead to surges in the motor load. This reduces capacity by causing the feed rate to be set lower than optimal in order to insure the surging load does not overload the motor. Because the load is constantly changing, the motor cannot operate at peak efficiency and so increases the grinding costs. An additional liability of surging feed that is often overlooked is the fact that surges in the feed tend to accelerate wear on the hammers and pins by causing the hammers to "rock" on the pin hammer pins.

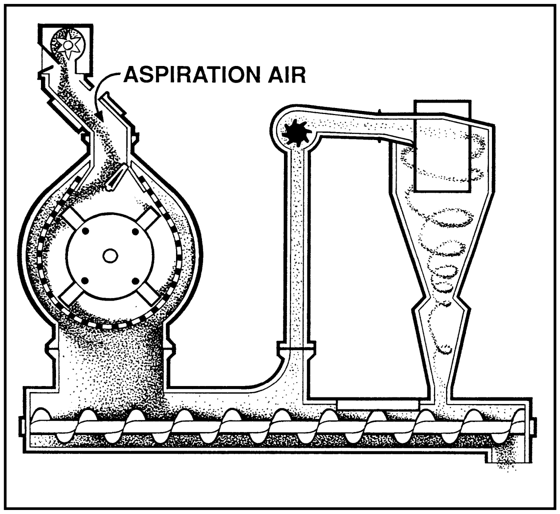
Rotary Pocket Feeders

As the name indicates, rotary pocket feeders utilize a rotor mechanism much like a rotary airlock to evenly distribute the feed to the hammermill. In most cases, the rotor is segmented and the pockets are staggered to improve the distribution of the feed and to reduce surges in the feed rate. Because the rotary pocket type feeders rely on a free-flowing material to fill the pockets they are best suited to granular materials with a density of 35#/Ft^3 (.56T/M^3). or more, such as whole grains and coarsely ground meals.



Air Assist

The final application topic to be considered is the use of aspiration air to improve mill efficiency and performance. A properly designed air assist system will increase hammermill capacity by as much as 15 to 40%. The air assist system controls the environment of the grinding chamber in the hammermill and aids in moving product from the grinding chamber through the screen perforations. A properly designed air assist allows a hammermill to grind more efficiently, producing a more uniform finished product with less heating and controls dusting around the mill. Although hammermill capacity will vary with the type of machine and operational parameters, air assisted grinding systems will out produce non-assisted systems by 15-40%.



Any hammermill acts rather like a large fan, with the rotor and hammers moving air as the blades on the hub would do. Normally this “inherent air” is about 1/2 CFM per square inch of raw screen area for a modern tear circle hammermill. In order to assist the mill, an induced air flow from the inlet of the grinding chamber through the screen is required. Simply venting the discharge of the hammermill may not be adequate to relieve the pressure inside the mill since the air is being forced out in all directions, including the inlet.

A good rule of thumb for the amount of air required to assist produce and control dusting is 1.25-1.5 CFM per square inch of screen area (.33 to .4 $M^3/hr/cm^2$). Pressure drops across the mill may range from 2-5” WC (5-12.5 mB), depending on system operating conditions. In order to make an air assist system work, several items must be factored, including the air flow into the mill, paths for the air and product out of the mill, separating the product from the air stream, and controlling the path of the air in the system.

To aid the product in moving through the grinding chamber and screen, the air must enter with the products being ground. If a sufficient opening for this air is not provided, the hammermill system may suffer from symptoms not unlike asthma. The velocity of the inlet air should normally not exceed 2000-2500 Ft/min (10-12.5 M/sec)

To permit the air assist to convey product through the grinding chamber and screen there must be some place for the air to go when it discharges from the mill. Ideally, the air/product conveyor will be large enough that even when operating at full capacity, the velocity of the air will not exceed 250 to 500 Ft/min (1.25 to 2.5 M/sec). If this critical path does not exist there will be a high static pressure outside the grinding chamber and the desired pressure drop across the screen may not exist. Larger plenums will reduce the velocity even further and improve the air/fines separation. For practical purposes, the plenum cannot be too large.

To make the air assist system work, it is necessary to control the path the air takes through the hammermill. Normally, the discharge end of the take away conveyor must include some kind of airlock to insure the air is pulled through the hammermill instead of back through the discharge system. This may be as simple as a shroud over the take away screw or as complex as a powered rotary airlock at the discharge of the drag conveyor.

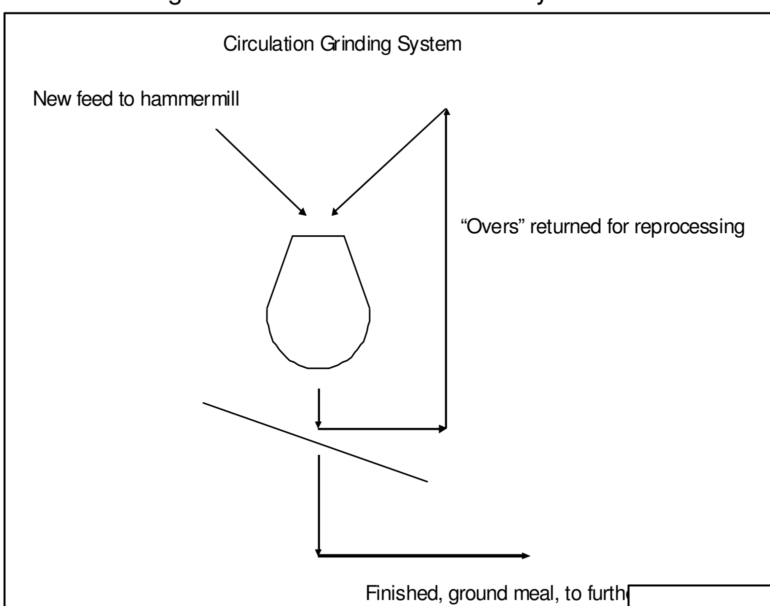
Step Grinding

In many parts of the world attention is being focused again on a concept known as “Step Grinding”. What is “Step Grinding”, why is there such interest returning, and is this a concept that may hold a benefit for you?

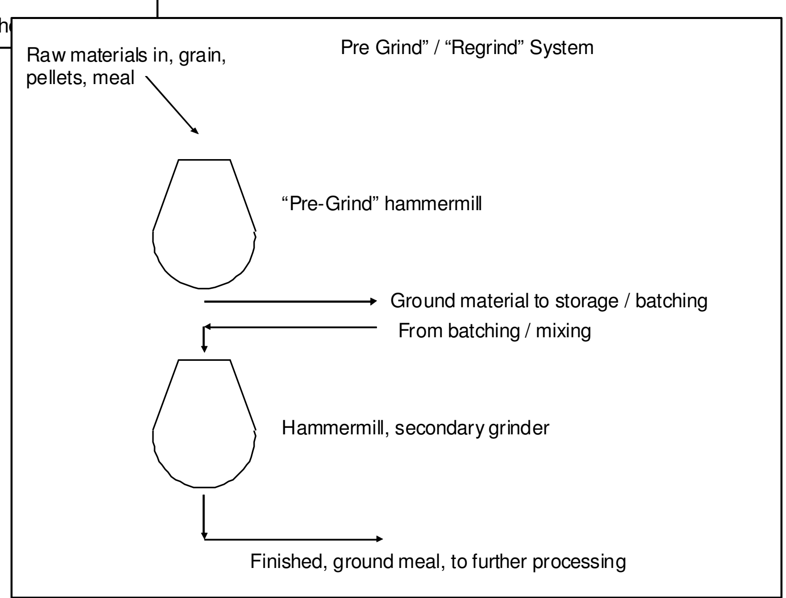
Step grinding in the simplest terms, is size reduction accomplished in steps or stages, usually incorporating two grinding machines (hammermills, roller mills, pulverizers, or some combination thereof). The primary objective of step grinding is to reduce the cost to produce a ton of fine ground finished product. Additional benefits may include improved control of the particle size distribution (more uniform grind with less oversize and fewer fines), reduced product heating and subsequent moisture loss, a reduction in the maintenance cost per ton of ground material, finer finished products, and greater flexibility in the grinding circuit.

As noted above, step grinding may be accomplished in circuits utilizing two machines, though it is certainly possible to “step grind” using a single machine, or more than two machines. With a single machine, a step grind circuit will either involve batch processing (grind a batch coarse, readjust the grinding machine finer and process again) or a continuous operation with a screening stage returning oversize materials for reprocessing (circulation grinding).

The potential benefits of circulation grinding were explored in the March 1994 edition of Feed Management in an article authored by William L. Ritchie titled Increasing the efficiency of particle reduction. This type of system does offer the same potential of reducing energy and improving particle size control, but does not significantly add to the flexibility of the grinding system.

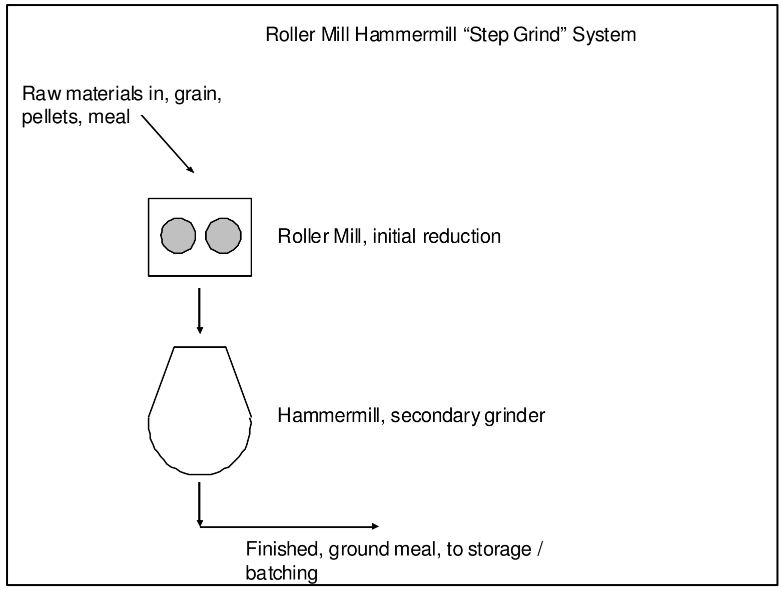


A second approach, and one that is employed in a number of U.S. feed manufacturing plant is the utilization of two grinders in “series”, one performing a pre-break, and the second grinding the total mixed feed ration. This type of system is commonly referred to as a “post mixer” grinding system, or perhaps just “post grind” system but differs from the European “post grind” concept of batching directly to the grinder.



The advantages of this kind of circuit include lower grinding costs, finer finished products, more uniform particle sizing, more uniform finished product mix (lower C.V.), and greater grinding system capacity. The primary disadvantages of this kind of system are the potential for the destruction of some micro ingredients and vitamins, and the higher capital costs to install the system. In most cases, the cost of additional capital equipment is offset in 6 to 12 months in the energy savings of the grinding circuit alone. Additional benefits such as increased (pellet mill) die and roller or (extruder) die life and increased pelleting or extrusion efficiency are bonuses on top of the energy savings.

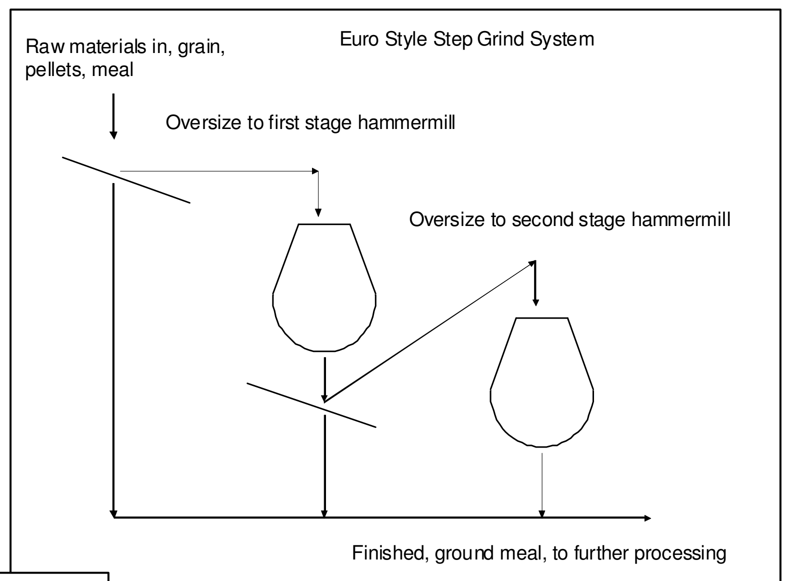
This two grinder system may employ two hammermills, one roller mill and one hammermill, or two roller mills. Additionally, sieving between breaks may be added to further enhance the energy efficiency of the system and reduce operating costs by removing sized materials before the secondary grinder, or by returning oversize materials to the pre-break machine.

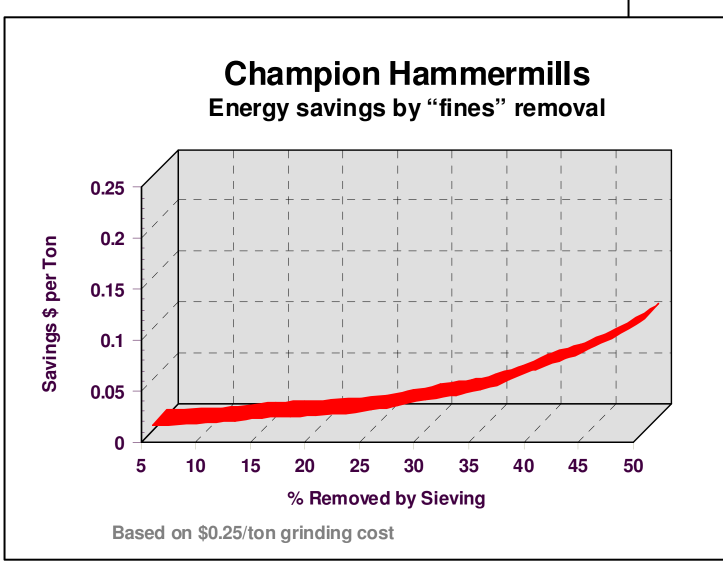


Step Grinding, the European Approach.

More than ten years ago, a step grinding system approach was being presented by European manufacturers of feed milling equipment as a means of reducing operating costs. An integral part of the European approach was sieving before grinding and sieving between grinding stages. Because the European feed manufacturer uses such a wide range of ingredients received in the form of a meal, there is a potential for a high percentage of the raw materials to already be an acceptable particle size for the feed manufacturing process.

By removing these sized materials, the load on the grinding equipment could be reduced considerably. It appears from research and testing in actual applications that the reduction in energy consumption is roughly equal to one half of the amount of the materials removed. In other words, removing 30% of the materials to be ground (as fines) and by-passing the grinder reduces the energy required to grind by about 15%.





Step Grind For Efficiency in the U.S.

Since corn, wheat, sorghum and barley

are the basis for most complete feeds in the U.S., the primary economic benefit of step grinding is an actual reduction in the specific energy required to grind feed materials rather than efficiency gains from sifting. As a rule of thumb for a two shift operation, one horsepower costs approximately $1.00 per day. An energy reduction of 50 horsepower will save about $50.00 per day in energy expenditures.
Where does this savings come from? Power consumption can be expressed in terms of work accomplished over time.

$$\textbf{POWER} = \frac{\textbf{WORK}}{\textbf{TIME}}$$

The step grind approach yields this energy reduction (less power required) since the materials are reduced more gradually, through a slightly longer period of time. By doing the same amount of work (grinding) over a longer period of time (two or three gradual reductions instead of one instantaneous reduction) the total power requirement is reduced.

Because the roller mill offers such significant energy savings over a hammermill when processing grain in the coarser particle size ranges, the use of the roller mill as a pre-break device can offer substantial savings in a typical grain grinding circuit. By substituting a single pair roller mill in place of the conventional hammermill rotary feeder, the feed rate can be accurately controlled and a significant increase in hammermill capacity can be realized. Because the materials are reduced in size prior to being introduced to the hammermill grinder, larger screens may be employed with no significant increase in finished particle sizing.

This combination of finer feed, increased hammermill efficiency, and the possible use of larger screens not only reduces the energy cost when grinding, but reduces other operating costs (maintenance, parts) as well. Since a rotary feeder is not required the cost of a roller mill for use as a feeder is substantially offset in new installations. In other cases where existing hammermills require a boost in capacity, the application of a roller mill as a feeder can boost hammermill capacity by as much as 40 to 50% with no loss in the fineness of the grind.

Equipment/System	**Screen Size**	**Particle Size**	**Efficiency***	**Capacity**
Hammermill	3 mm	650 Microns	5.8 – 5.1	13.5 MTH
Roller Mill and	NA	3000 Microns	RM – 0.55	
Hammermill	4 mm	650 Microns	HM – 2.7	20 MTH

In this example, the potential capacity increase is roughly 46% by utilizing a roller mill as a pre-break/feeder

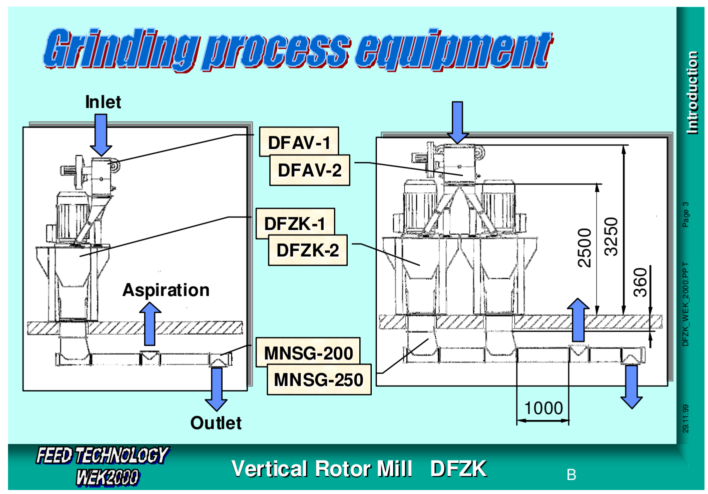
* Efficiency expressed in terms of kWh/T (kWh per Ton)

Other Grinding Equipment

There has been a certain emphasis lately on alternative grinding equipment including the so called “Airless Hammermills”, vertical rotor hammermills, air swept pulverizers, disc mills, and more recently “vibrating screen” hammermills.

“Airless Hammermills” are so called as they are intended to operate without the benefit of aspiration air. Indeed, any hammermill can be operated without aspiration air and function as and airless hammermill, but production and product quality will be affected. In fact, in many dedicated fine grind applications, fine tuning of the aspiration air flow can be used as a technique to help control final particle sizing. Reduced aspiration air flow will naturally lead to a finer finished product produced, but at the cost of reducing through put, increasing the product temperature, and increasing the moisture loss in the grinding process.

Many of the modern vertical rotor hammermills are promoted as being “airless” machines indicating they will operate without the benefit of aspiration air. In fact, all new installations typically include a small fan and filter or cyclone unit to assist the product through the screen, and to help control the temperature in the hammermill reduce the possibility of moisture condensing in the discharge stream.



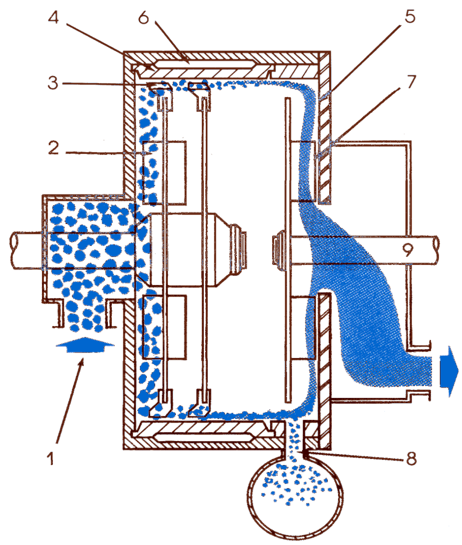
The primary benefits of the vertical rotor hammermill seem to stem from the multiple product inlets. Most machines will have two or three inlets where the difference in velocity between the incoming product and the hammers is maximized, resulting in efficient grinding. Because the inlets are typically small, vertical rotor hammermills will be limited in terms of the maximum particle size they can accept (i.e. solvent extracted meals with larger agglomerations) and less effective on materials with low bulk density as these low density products cannot flow efficiently into the grinding chambers.

The screens in a vertical rotor hammermill are full circle, and so do not have the ability to keep products from rotating within the grinding chamber. The bottom of the screen must be completely enclosed, normally with 2mm perforated material. Screen and hammer changes are relatively quick, with the grinding chamber being lowered pneumatically to give access to the grinding chamber. The grinding chamber is often advertised as being able to withstand an explosion.

As the material enters the grinding chamber it first contact the side of the “top” hammers, and is gradually accelerated as it passes through the grinding chamber. This reduces the effectiveness of the multiple inlets somewhat, as most efficient grinding in a hammermill occurs when the difference in velocity between the hammers and the products is greatest. To offset the affects of irregular wear on the hammers, there may be two or three different hammer types used in an AVRHM with some hammers being longer, thicker, or with additional hardfacing on the sides and body of the hammers.

“Air Swept Pulverizers” are called so as they utilize high volumes of aspiration air to help convey products through the grinding chamber, and in many cases this same aspiration air functions as a built in classifier. By fine tuning the air flow, fairly precise control over the finished particle size can be maintained. Different machines use different grinding mechanisms, but all rely on high velocity rotors that impact the material being ground.

Some machines use an internal screen, while others are “screenless” and employ specially designed internal grinding plates to affect the particle size reduction within the machine.

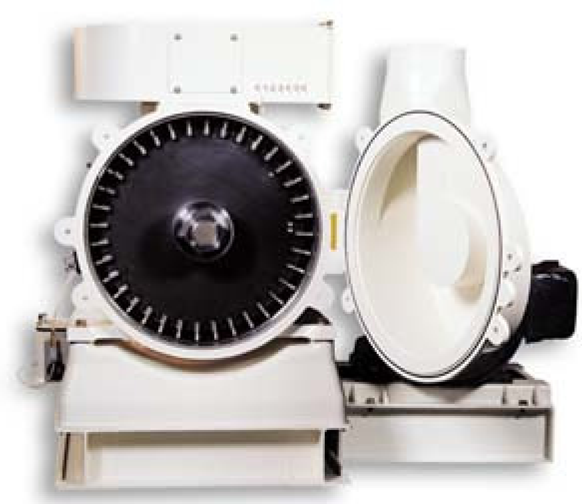


As shown in this illustration, coarse material is drawing into the pulverizer through the inlet (1), and is impacted by the internal fan assembly and rotor tips (2 and 3). The material also contact the wear liner or grinding plates (4) and the lighter (i.e. finer) fractions are exhausted by the discharge fan (7). Heavier (i.e. coarser) particles are recirculated back to the inlet for further processing (8).

The primary advantages of air swept pulverizers is their ability to product a very fine finished product under almost all operating conditions. Additionally, air swept pulverizers may be able to process materials with higher moisture or fat content due to the absence of any internal screens, and the high air flow rates that tend to scour the internal components of the machine while in operation.

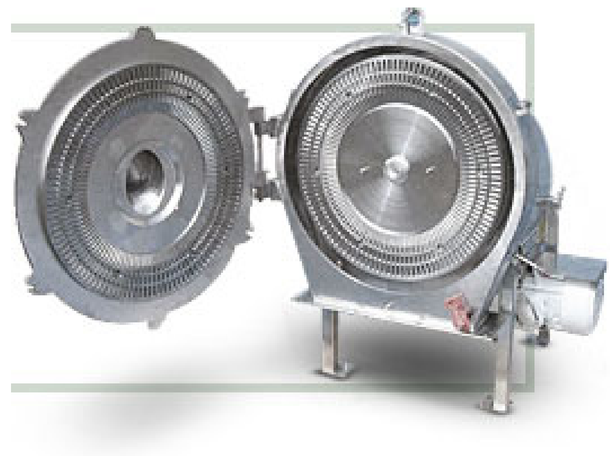
The disadvantages of the air swept pulverizers include limited applications (useful only for fine grinding), high aspiration air flows, and high operating costs.

Because the air swept pulverizers operate at very high speeds, they are only suitable for producing very finely ground finished materials and so will only be appropriate for rations that require very fine finished particle sizing. If a feed production facility must produce a variety of finished particle sizes for different product requirements, it will be necessary to have multiple grinding machines of different types in the facility. Additionally, since they rotate at very high speeds air swept pulverizers tend to generate very high noise levels and may require a separate enclosed grinding room to meet basic environmental requirements.



Air swept pulverizers by design utilize high aspiration air flow rates. High air flow combined with the temperatures generated in the grinding operation can lead to high moisture losses. This can produce a shrinkage of the raw materials, and can lead to problems with condensation in the associated duct work as well as bridging and poor flow characteristics of the finished ground meal.

Due to the high power consumption and large fans used in association with air swept pulverizers, the energy cost per ton is normally quite high. It is quite normal for an air swept pulverizer to achieve a capacity of 1 MTH for 100 HP (75 kW) connected. Based on an energy cost of $0.07/kWh, this amounts to more than $5.00 per ton, adding a 75 HP (55 kW) fan the total electrical cost per ton can easily exceed $9.00 per ton. In addition the high speed of the rotor assembly can result in high wear rates of the working parts, often exceeding $0.50/ton.



Current “Disc Mills” are modern developments of older attrition mills or burr mills that have been used in various milling industries for centuries. The original disc mills were the now famous stone mills used in the early mechanized production of flour from wheat and other small grains. Modern disc mills have the plates mounted on a horizontal axis or with some angle to the horizon to facilitate material feeding into the machine. The basic mill consists of one fixed plate, and one turning plate, with the ability to adjust the spacing between the plates. Larger disc mills, such as used in the corn wet milling industry are often “double running” with both disc turning, but in opposite directions. The material is fed through an opening in the center of one disc, and is abraded between the plates. Finished particle sizing is controlled by the speed of the disc(s), the spacing between the discs, and the type of finish or pattern on the face of the disc.

For the feed industry, commercial machines are generally smaller (up to 75 HP / 55 kW) and so limited to a maximum throughput of around 10-12 TPH. In operation, the finished products are rather like a compromise between the uniform product of a roller mill, and the fine ground product of a hammermill. For fibrous products like barley and oats, the finished ground material will contain a higher percentage of coarse husk fraction than would be obtained through a hammermill and in fact rather similar to products produced through roller mill processing but with a higher level of fines content. The initial cost of disc mills is roughly the same as a hammermill, and since no air assist is used the installed cost for a disc mill system would be lower. The replacement parts tend to be highly specialized and available only from the original equipment manufacturer. Disc mills have not found widespread popular use in commercial feed milling.

Chinese “Vibrating Screen” hammermills have been introduced to the world, but very little is known about their actual performance. The machines have been promoted as being more efficient than conventional horizontal or vertical rotor hammermills, but the available data does not support those claims. The key operating principle proposed for the “vibrating screen” hammermill is introducing an oscillation or vibration of the screen where the distance between the screens and the hammers is rapidly changing while the machine is in operation. This action is said to incorporate a combination of screening (classification) with grinding in one operation. The vibrating screen is said to further improve grinding efficiency by “extruding” the material through the hammermill screens.

From the data presented (Feed Tech Volume 11 Number 3), it appears the only real difference is that the vibrating screen hammermill produces a much coarser finished product when other factors (hammermill screen size, motor load, through put) are held constant.

The “vibrating screen” hammermill is also said to produce less product heating, which should indeed occur if the materials are not being ground to a smaller finished particle size. Obviously more solid data must be made available if any of the claims of the “vibrating screen” hammermill are to be substantiated.

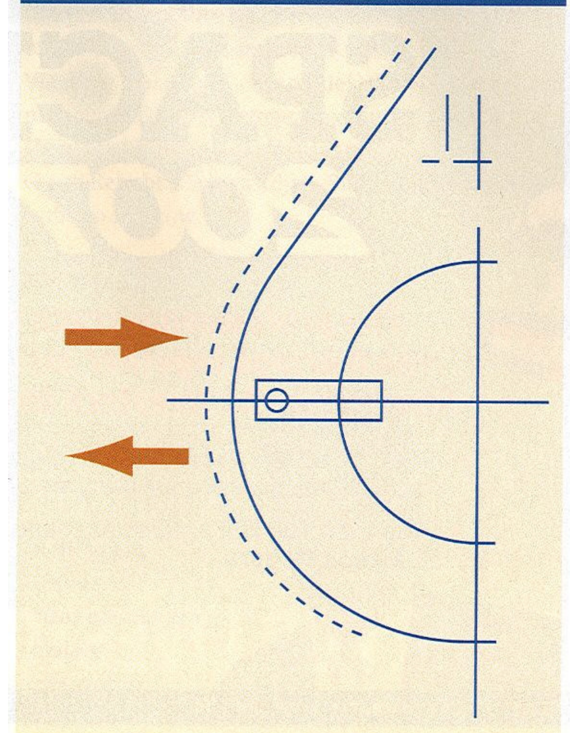


Figure 1 – Screen movement of vibrating screen in hammer mill