# Intro to Size Reduction



SchutteBuffalo

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# How Does a Hammer Mill Work?

## Crush, grind, pulverize, shred…size reduction is amazing!

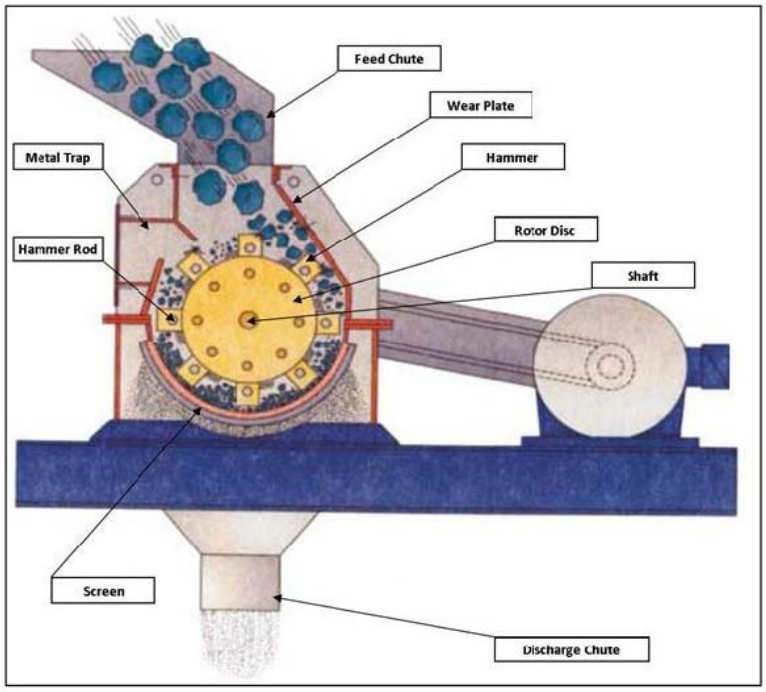
There are many terms that fall under this umbrella: crush, grind, pulverize, shred, de-lump, de-fiberize, just to name a few. Likewise, there is a whole host of machinery styles that accomplish these goals: hammer mills, grinders, shredders, lumpbreakers, impactors, jaw crushers and more.

The core process is the common denominator:

LARGE MATERIAL ⇨ smaller material

### But how does it work?

The simplest way to describe the concept of size reduction is to look at the industrial hammer mill model:



Hammer mills operate on the basic principle that most materials will crush, shatter or pulverize upon impact. This is accomplished by a simple four step process:

1. Material is fed into the mill, typically by gravity.
2. Inside the grinding chamber, the material is repeatedly struck by flailing ganged hammers which are attached to a shaft that rotates at a specified speed. The material is crushed by a combination of hammer blows, collision with the walls of the grinding chamber and particle on particle impacts.
3. Perforated metal screens or bar grates cover the discharge opening of the mill retain the coarse material for further processing while allowing properly sized material to pass through.
4. Hard, heavy material such as stone, glass or metal can exit the mill via gravity. Lighter or low density materials such as wood and paper may require pneumatic suction for effective discharge.

## One size does not fit all

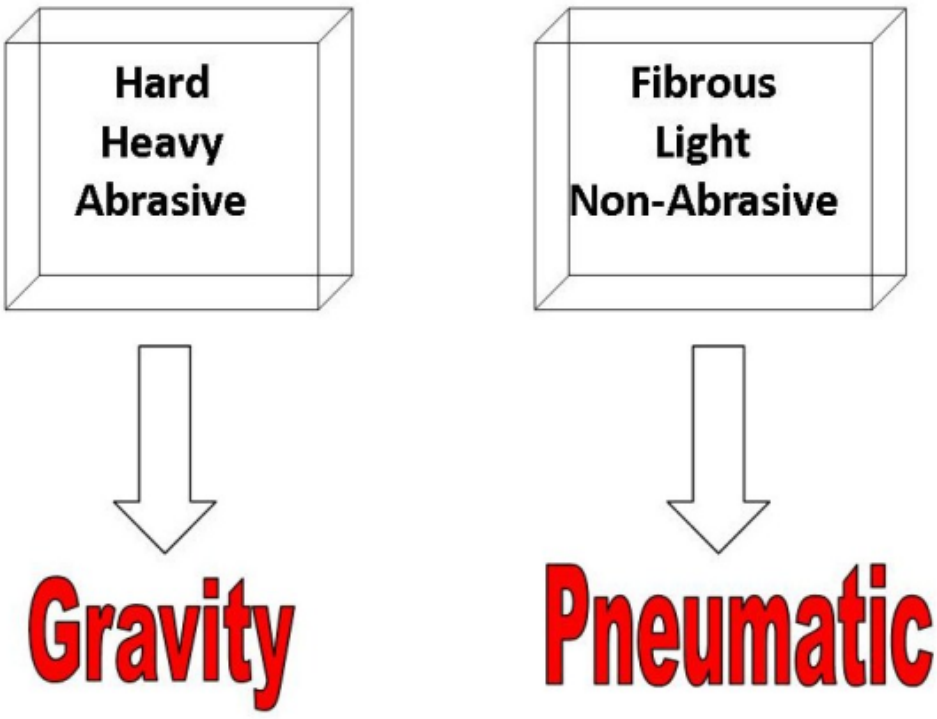
Finished particle size is determined by a combination of the following: screen (or bar grate) size, shaft speed, hammer size, and hammer configuration.

For example, a fast shaft speed, small screen and large number of hammers typically produces a fine end product. Conversely, a larger screen, fewer hammers and slower shaft speed will result in a coarse product.

Each of the key components: screen size, shaft speed, hammer size, and hammer configuration can be changed individually or in combination to achieve the precise finished particle size at the desired production rate.

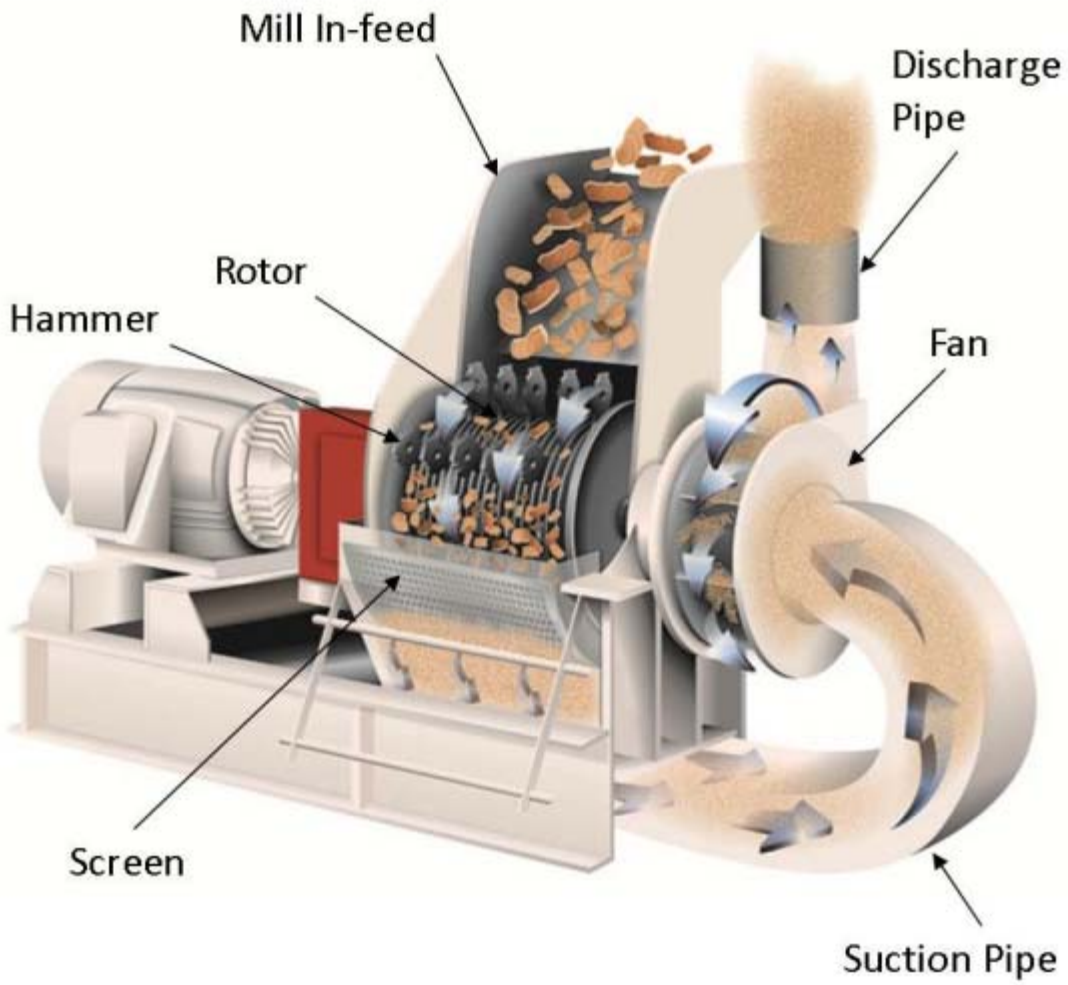
## Evacuation options

Once the material is reduced to the desired finished particle size and passed through the screen, there are two options for how it exits the mill. The method is determined by the material's characteristics. If the material is:



# How Does Pneumatic Discharge Work?

It's all about the fan. Air swept mills are used primarily when grinding light, relatively non-abrasive materials to a mid range to fine particle size because lighter particles require suction to overcome the rotor airflow. The fan pulls the material from the mill in-feed through the grinding chamber. In addition, it pulls the finished product through the suction pipe, into the fan itself, and then blows the material out of the discharge pipe either to storage or next stage of processing.



## Why choose pneumatic?

There are three key benefits:

1. A properly designed pneumatic discharge system can increase production as much as 300-400% over gravity discharge mills when grinding light materials to a fine particle size.
2. Without air, dusty material will take the path of least resistance, typically out the feed chute. In a pneumatic system, dust is controlled and contained because all material is pulled in a common direction.
3. The fan also aids in material transport to storage or next stage processing.

## Bonus advantage:

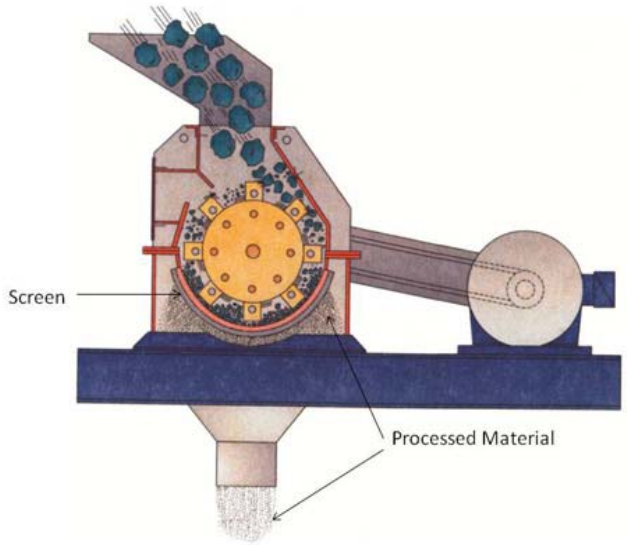
The ability of the fan to pull the material through the screen allows for processing of materials with slightly higher moisture content than can be effectively processed via gravity discharge.

# How is Finished Particle Size Determined?

In any given size reduction application, the specific properties of the material being processed play a key role in how the desired finished particle size is achieved. Hardness, brittleness, moisture content, oil content, etc. are all considered when determining not only the appropriate style of size reduction equipment, but also the configuration of the equipment's internal components.

## 70% control

In the majority of hammer mill applications the key factor determining finished particle size is the screen. Any material that enters the grinding chamber must be reduced to a size small enough to pass through the screen that covers the mill's discharge opening. Because of this the screen size generally provides 70% or more of the control over the finished particle size.

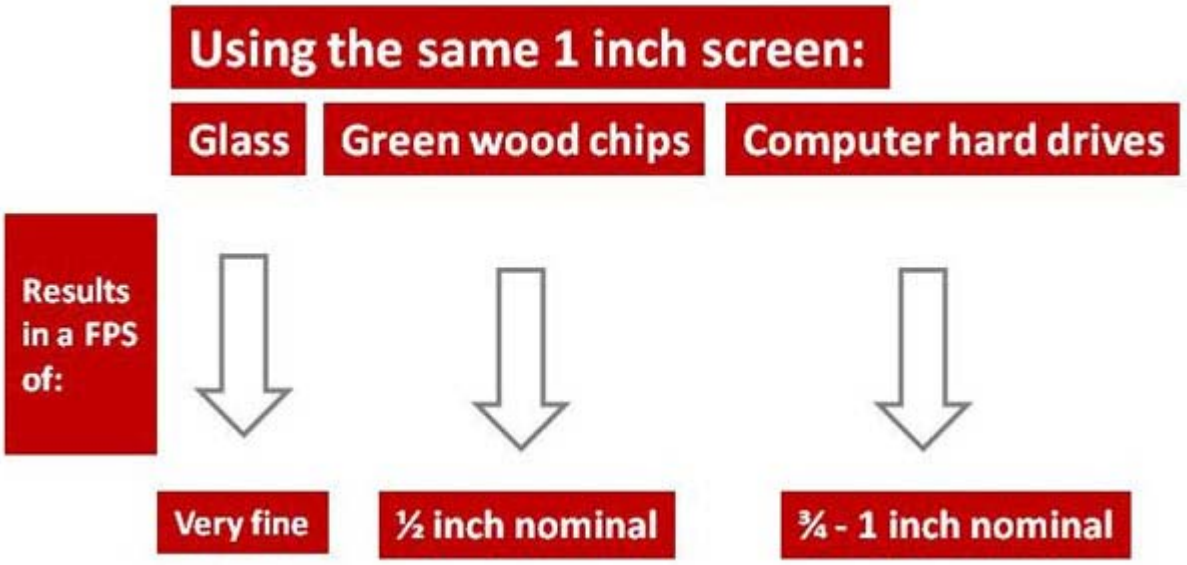


## Sizing up screens

Screens and bar grates are constructed from steel and are available with perforations (screens) or spaces (bar grates) in a broad range of sizes. Screen size is determined by the size of the openings in the screen, and is described in the following units of measure: inches, millimeters, microns (one millionth of a meter), and US mesh (the number of wires running east/west and north/south in one square inch of screen).

The appropriate screen size is determined by the desired finished particle size, and the properties of the material being processed. That is, characteristics such as friability and moisture content have an effect of the manner in which a material will break down. As a result, using the same screen to process materials of different properties will result in a range of different finished particle sizes.

For example:




This variation is called *particle size distribution*, and it is based on the individual properties of the materials being processed.

In this example: Glass is very friable, and will shatter very easily upon impact. In comparison, green wood chips are a fibrous material with a moisture content of up to 60%, which both effect the ease with which they are reduced. Finally, computer hard drives are very hard and comprised mostly of metals, making them comparatively hard to process and will break down to a size just slightly smaller than the screen or bar grate used.

## The force factor

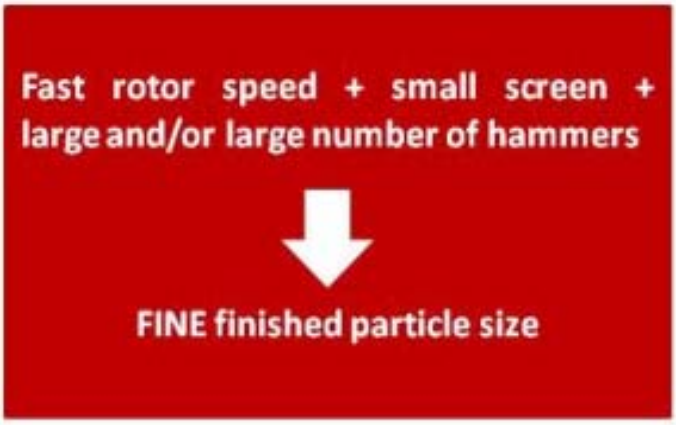
But screen size only accounts for only about 70% of what determines the finished particle size. The remaining 30% is attributed to the force of the impact on the material being processing. In the case of hammer mills, force is determined by rotor speed, and the size and number of hammers.

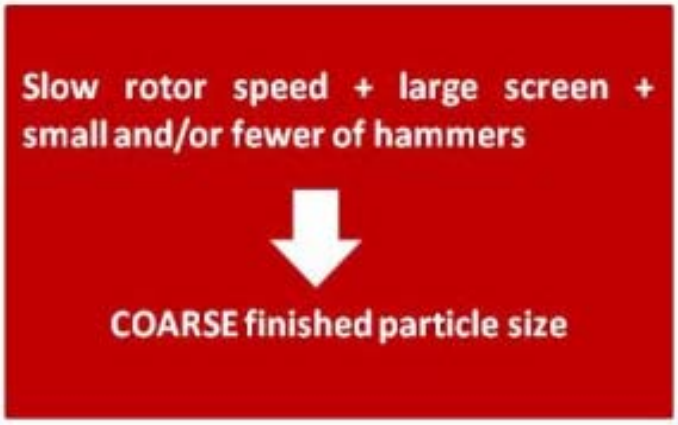
Let's take a closer look, this time using the example of a drinking glass:

**Rotor Speed:** Slowly tap the glass with a hammer and it will break into perhaps 3 to 4 large pieces. Conversely, if you hit it with the same hammer at a rapid speed, it will break into many more, much smaller pieces.

**Hammer Size:** Strike a water glass with a butter knife, and it will break into a few large pieces. Strike the same glass with a sledge hammer, and it will shatter into 1000+ pieces.

*In short:*



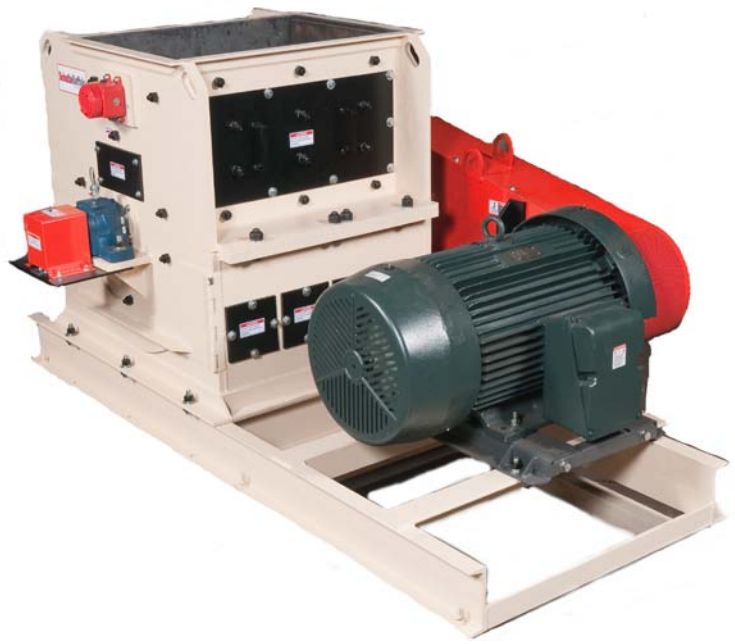



# Size Reduction Equipment: Five Key Styles

Hammer mills are just one type of machinery among the much larger category of size reduction equipment that also includes:  shredders, jaw crushers, ram fed grinders, roll mills, ball mills, and more. Looking a bit closer, even within hammer mills, there are several styles to choose from. Among those styles, the functionality of a hammer mill remains basically the same:

## Gravity Discharge

## Industrial Hammer Mills



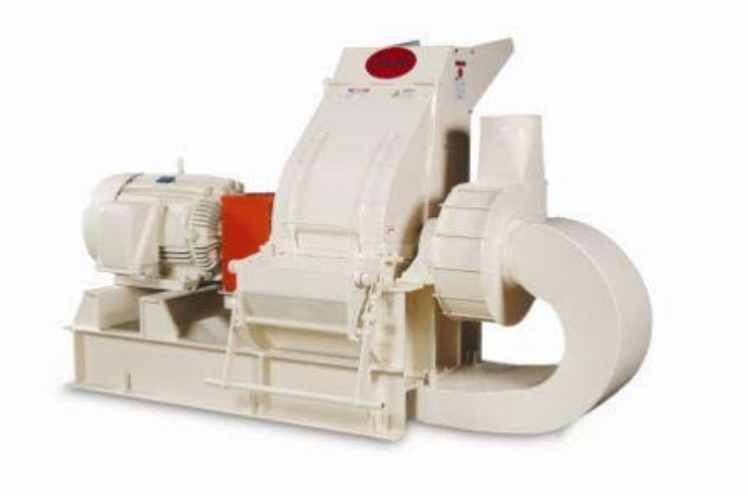
Industrial hammer mills have the simplest and most recognizable functionality. A rectangular steel chamber houses a shaft to which swinging hammers are attached. As the shaft rotates at high speed, the hammers flail out and impact the material. In addition to the hammers, size reduction occurs through particle on particle contact and through contact with the breaker plate inside the grinding chamber. Because of their simplicity, the industrial hammer mill is easily adaptable to different sizes and mill designs.

Important to know: Replaceable steel liner plates protect the mill's interior from wear caused by grinding abrasive materials.

Ideal Applications: glass, coal, coke, dry chemicals, metals, resin, porcelain, aggregates, asphalt, ceramics.

## Pneumatic Discharge Hammer Mills

The grinding mechanism of this group is quite similar to the gravity discharge hammer mills. However, the pneumatic mills typically use a thinner hammer and the interior wall of the grinding chamber features a ribbed liner plate. This plate has a washboard effect on the material, and works in unison with the hammers and particle on particle impact to reduce the material. The biggest difference of course is the group's the use of air assistance to evacuate material from the mill. Whether attached to the main mill shaft, or as a separate optional component in a high production model, the fan pulls the material through the mill, and conveys it to storage.



Important to know: Specially designed notched hammers are ideal for tearing and shredding. In addition to assisting the evacuation of light or low density materials, the pneumatic suction can increase throughput up to

400% over gravity discharge hammer mills.

Ideal Applications: hogged wood scrap, wood chips, bagasse, biomass, paper, carpet, meat and bone meal

## Full Circle Screen Hammer Mills

This next group also features the same grinding mechanism as the first two, and the same thin hammers as the pneumatic hammer mills. The amount of screen coverage is what sets them apart.

The nearly 300 degree coverage of the rotor translates to a greater surface area for the processed material to evacuate the grinding chamber. As a result, compared to the industrial mills, you get greater throughput per horsepower with full circle screen hammer mills.

Important to know: To achieve the circular, nearly full coverage of the rotor requires that the screen be somewhat pliable and therefore relatively thin. Because of this, the full circle screen mill is best suited for light, easy to grind materials to that do not require initial grinding against a breakerplate.

Ideal Applications: corn, grain, spices, grasses, planer shavings, sawdust

## Horizontal In-Feed Hammer Mills

The unique quality of the horizontal in feed mills is that material is fed into the side of the hammer mill, instead of the top. This design makes them ideal for long, linear or otherwise large, geometric materials to be processed without a pre-grind.

This group includes trim scrap grinders and pallet grinders. As with the prior styles, the horizontal mills use heavy duty screens covering the discharge area to determine finished particle size.

Important to know: the style and design of the hammers aggressively moves the material into the mill. Feed rolls are ideal to properly control the rate that material enters the grinding chamber.

Ideal Applications: trim scrap, truss plant scrap, 2x4s, whole pallets, pallet scrap

## Lumpbreakers

The Lumpbreaker is quite different from the prior categories in both design and functionality. Instead of swinging hammers attached to a shaft rotating at high speed, the lumpbreaker has stationary hammers attached to a slower moving shaft. As the shaft rotates, the hammers remain rigid,

and pass between combs attached to the wall of the grinding chamber.

Lumpbreakers do not use screens for sizing. Instead, the configuration of spacing between the hammers and combs, along with hammer size and RPM allows some control over the finished particle size.

Important to know: The open in feed, fixed hammers and slow shaft rotation give the lumpbreaker the ability to accept a certain amount of a headload, making it suitable for large blocky materials, de-agglomerating, de-lumping, and returning materials to a flowable consistency.

Ideal Applications: sugar, cement, dry chemicals, agglomerated powders

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