# Points to be covered

- Size reduction Equipment
- Crushers – Jaw and Gyratory crushers
- Crushing rolls
- Grinders
- Hammer mills

# The various types of size reduction machines are:

**A Crushers (coarse and fine)**

1. Jaw crushers
2. Gyratory crushers
3. Crushing rolls

**B Grinding (intermediate and fine)**

1. Hammer mills; impactors
2. Rolling-compression mills
    a. Bowl mills
    b. Roller mills
3. Attrition mills
4. Revolving mills
    a. Rod mills
    b. Ball mills; pebble mills
    c. Tube mills; compartment mills

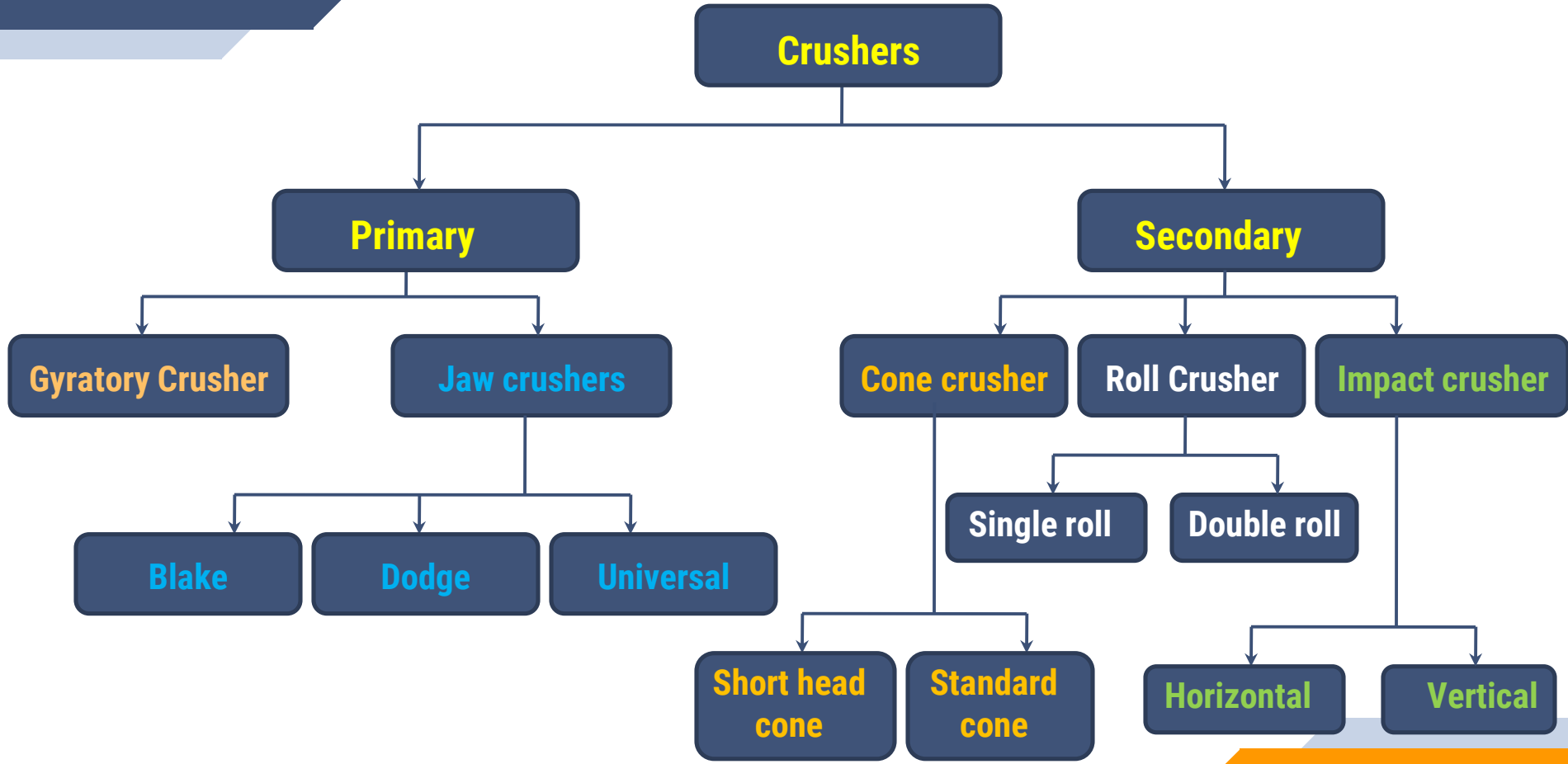
**C Ultrafine grinders**

1. Hammer mills with internal classification
2. Fluid-energy mills
3. Agitated mills

**D Cutting machines**

1. Knife cutter; dicers; slitters

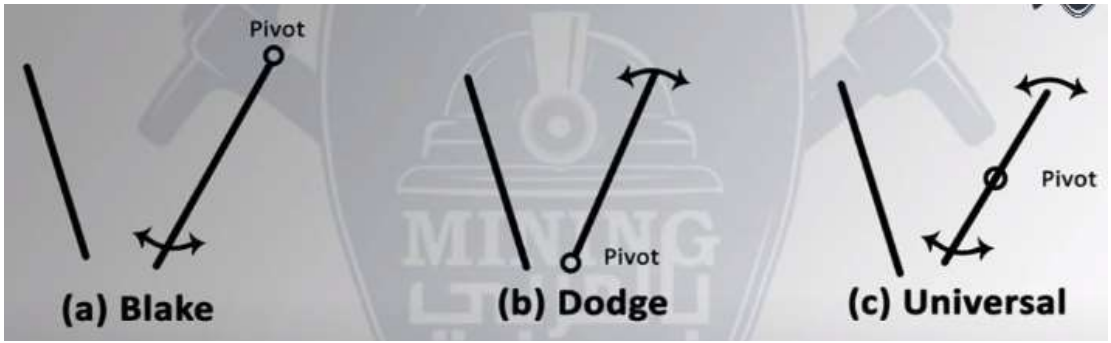
- ✓ Crushers works on the principle of slow compression action
- ✓ Grinders employ impact and attrition, sometimes combined with compression.
- ✓ Ultrafine grinders, it operate mainly by attrition.
- ✓ A cutting action is the characteristic of cutters, dicers, and slitters.

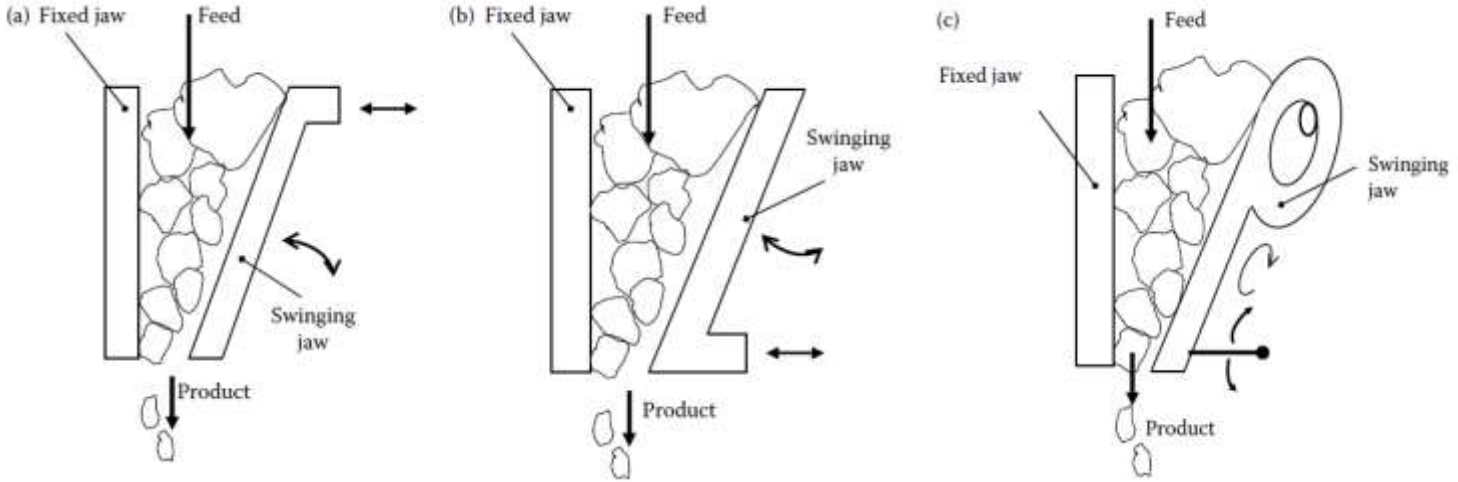

Crushers
Primary
Secondary
Gyratory Crusher
Jaw crushers
Cone crusher
Roll Crusher
Impact crusher
Blake
Dodge
Universal
Single roll
Double roll
Short head cone
Standard cone
Horizontal
Vertical

# Crushers

- Crushers are slow-speed units used for coarse reduction of large volumes of solids into pieces.
- The main types of crushers in use are
  - Jaw crushers
  - Gyratory crushers, and
  - Roll crushers - smooth- as well as toothed-roll designs.
- Apart from toothed roll crusher other crushing machines operate by compression and can break large lumps of extremely hard materials
- Toothed-roll crushers perform a dual function of tearing and crushing the feed, and are used for softer materials

- The crushing elements are two very strong plates called jaws
- One is vertical and is fixed to the machine frame
- Second is articulated to the equipment so that it can present a sway movement over the fixed one
- The three possible forms of articulation constitute the three most popular models known as Dodge, Blake, and universal or Denver crushers

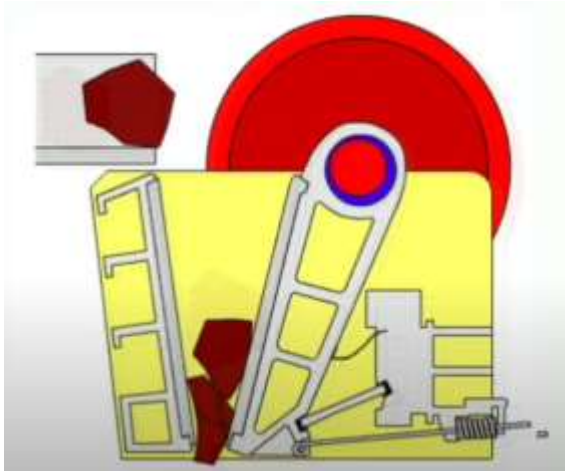





- In all of the models, the active faces of the jaws are flat or slightly bulged and provided with shallow grooves.
- All jaw crushers are large size units with large capacities and upper openings of up to 3 $m^2$ of section.
- They are able to produce up to 600 ton/h of crushed materials.

# Jaw crusher

- **Principle:** Compression, it reduces size by compression force results cubical products with minimum fines
- **Construction:** The jaws are set to form a ‘V’ open at the top
- The swinging or movable jaw which reciprocate in a horizontal plane usually make an angle of 20° to 30° with the fixed jaw (which is nearly vertical)
- The jaws are usually made of manganese steel or some other material that will withstand abrasion
- The faces of the crushing jaws are usually corrugated for concentrating the pressure on relatively small areas



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- Eccentric causes the pitman to oscillate in a vertical direction and this vertical movement is communicated horizontally (reciprocating motion) to the movable jaw by the toggles
- The speed of the operation should not be high or otherwise a large quantity of fines are produced as the material cannot escape quickly and gets repeatedly crushed
- Since the crushing action is intermittent the loading on the machine is uneven and due to this the crusher incorporates a heavy flywheel
- Since the maximum movement of the jaw is at the bottom (discharge), there will be little tendency for the crusher to choke

# Protection of machine

- The machine is usually protected so that it is not damaged if accidental peace of iron such as hammer heads, stray bolts ect., enter into the crusher by making one of the toggles in the driving mechanism relatively weak.
- That is one particular toggle is made into two pieces which are held together with bolts that are purposely made the weakest part in the crusher, so that it stresses are set up these bolts shear first
- Thus the failure is made at a point that can be easily and quickly repaired, instead of breaking some vital part of the machine

# Working

- The material to be crushed is admitted between two jaws from the top
- The material caught between the upper part of the jaws is crushed to a smaller size during forward motion by compression
- The crushed material then drops/ falls into the narrower space below during the backward motion and is recrushed as the jaws close next time
- After sufficient reduction, the crushed material drops out the bottom of the machine
- The jaws usually open and close 250 – 400 times per minute.

# Capacity of Jaw Crushers

- The theoretical capacity of a jaw crusher is

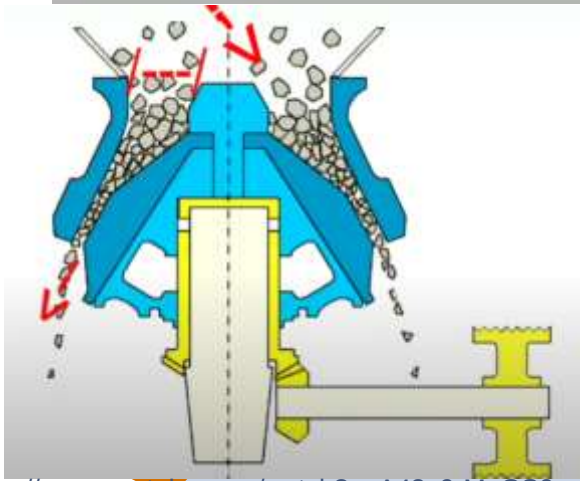
$$Q = \frac{\rho_p A w_j N_j (1-\varepsilon)}{60} kg/h$$

Where,

- $\rho_p$ - Density of the material
- $A$ – Area of swing, $m^2$
- $w_j$ – jaw width, m
- $N_j$ – Number of swings per minute, $min^{-1}$
- $\varepsilon$ - porosity of particles

# Gyratory crusher

- **Principle:** it works on the principle of compression
- **Construction and working:**
- It consists of two vertical conical shells, the outer shell having its apex in downward direction while the inner cone is positioned with its apex upward
- The inner shell acts as the crushing head, which is the form of truncated cone and is mounted on an oscillating shaft
- The upper end of this cone is held in a flexible bearing while the lower end is connected to an eccentric

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- The eccentricity causes the conical crushing head to oscillate between open side setting and closed side setting (OSS and CSS) discharge openings.
- Hence, the crushing action takes place around the whole of the cone and is continuous
- The eccentricity also determines the capacity of gyratory crushers.
- The material to be crushed is fed from the top and is crushed between the stationary outer shell and the crushing head
- They are crushed several times before being discharged from the bottom
- An additional crushing effect occurs between the compressed particles resulting in less wear of the crusher materials, this is known as interparticular crushing

- The material to be crushed is charged from the top the conical head gyrates inside the casing
- At any point on the periphery of the casing, the bottom of the crushing head moves towards and thus away from the stationary wall
- The solids caught in the ‘V’ shaped space between the head and the casing are broken and rebroken until they dropout from the bottom of the machine
- The speed of the crushing head usually lies between 125 -425 gyrations per minute.

# Features of the gyratory crushers

- 1. Continuous in action
- 2. Fluctuations in stresses are smaller
- 3. Load on the motor is nearly uniform
- 4. Power consumption per ton of material crushed is smaller
- 5. Requires less maintenance than jaw crusher
- Since the capital cost is high it is suitable only where large quantities of materials are to be handled

# Comparison between Jaw and gyratory crushers

## Jaw crusher

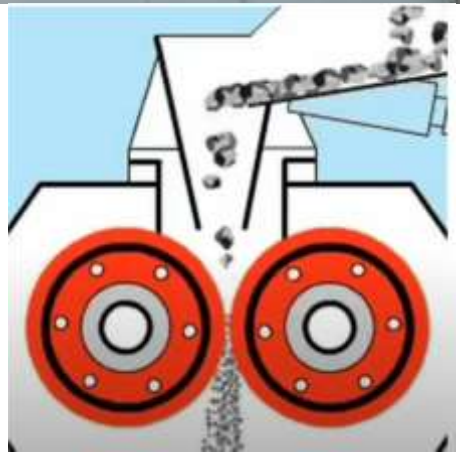
- Reciprocating motion
- Discharge is discontinuous
- Primary crusher (Large size feed)
- The load on the motor is not uniform
- More maintenance required
- Power consumption per ton of material crushed is more
- Low capital cost
- It has smaller capacity when used to produce a small size reduction

## Gyratory crusher

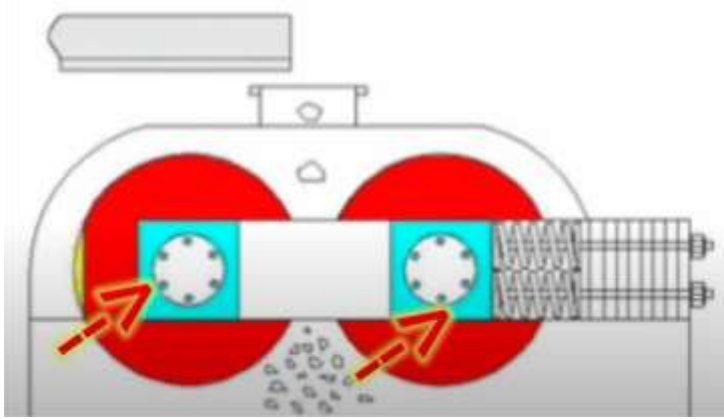
- Gyratory motion
- Discharge is continuous
- Secondary crusher ( Smaller size feed)
- Load on the motor is uniform nearly
- Less maintenance is required
- Power consumption is low
- High capital cost
- Large capacity

# Roll Crushers

- **Principle:** Size reduction is achieved by compression
- **Construction:**
- Smooth roll crushers consists of two heavy metal rolls of the same dimension (diameter) placed side by side each other on the horizontal position
- The rolls mounted on the shafts are rotated toward each other at the same speed
- One of the shafts moves in the fixed bearings while other moves in the movable bearings
- The clearance between the rolls can be adjusted according to the size of feed and the size of product required
- One of the rolls is driven directly and the other by friction with the solids being crushed



- The rolls have relatively narrow faces and are large in diameter, therefore they can nip moderately large lumps
- The material fed to the machine is reduced in size by compression and discharged from the bottom
- The machine is protected by spring loading (i.e. by mounting the bearings of one of the roll shafts against coiled springs) against damage due to tramp and very hard material
- When used as crushers, roller mills have diameters of up to 2 m with lengths of up to 1 m and speed of rolls varies from 50 to 300 rev/ min
- Reduction in the order of 3 or 4:1, that the feed reduces its average size a fourth of its original size.



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# Working

- The material to be crushed is fed from the top
- As the rolls rotate the material gets caught between them and gets reduced in size by compression and discharge from the bottom

**Industrial applications:**

- Used in situations in which fines are to be minimized
- They are employed for crushing of oil seeds, coal, phosphate rocks, abrasive materials petroleum and explosive materials in gun powder industries.

# Selection of crushing rolls

While selecting the rolls for a certain purpose, it is necessary to know

- 1. The size of feed
- 2. The size of product
- 3. The amount of material to be handled
- 4. The coefficient of friction between the roll surface and the material to be crushed ( incorporated with a relation b/n the size of the feed and the size of the product fixes the diameter of rolls and also determines whether a particle will be drawn into rolls and gets crushed or not)

# Capacity of crushing rolls

- The theoretical capacity of a crushing roll 'Q' in kg/h is given by

$$Q = 60\,\pi\, D_1\, D_3\, b\, N\, \rho$$

- Where,

  $b$ – breadth of roll face, m

  $N$ – Number of revolutions per minute, rpm

  $\rho$ - Density of the material to be crushed, kg/m$^3$

- The volumetric capacity is affected by speed, nip, diameter and breadth of roll face
- Actual capacity is usually b/n 10 – 30 % of the theoretical one

# Grinders

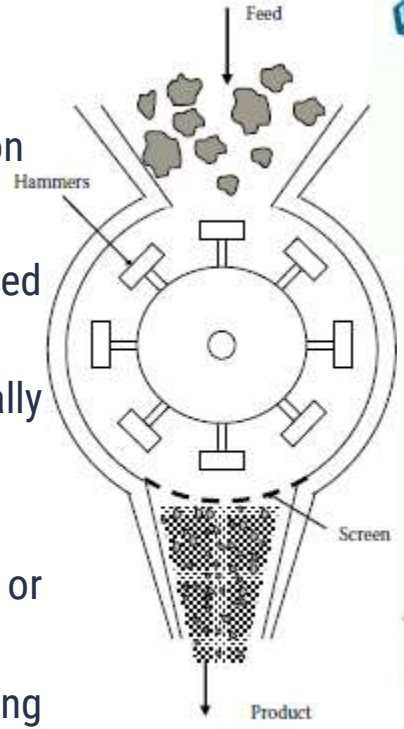
- Subdividing the solids to a finer product than crushing
- The size reduction machine employed for an intermediate duty
- A grinder is often charged with the product from a crusher which it reduce to powder

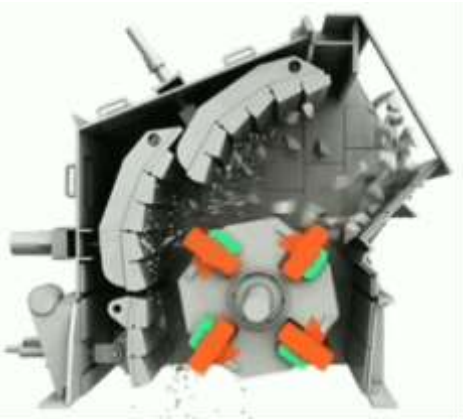
# Hammer Mill

**Principle:** Size reduction is achieved by impact and attrition

**Construction:**

- The hammer mill consists essentially of a high speed rotor turning inside a cylindrical casing
- The rotor is mounted on a shaft which is usually horizontal
- The sing hammers are pinned to a rotor disk
- The hammer are rectangular bars of metal with plain or enlarged ends
- The particles are broken by the set of swinging hammer



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- The product falls through a gate or screen
- Several rotor disks each carrying four to eight swing hammers are often mounted on a single shaft
- The rotor disk diameter ranges from 150 mm to 250 mm
- As the hammers are hinged, the presence of any hard material does not cause damage to the equipment
- The hammers can be readily replaced when they worn out

# Working

- The material to be crushed is fed from the top of casing, the shaft is rotated at a high speed and centrifugal force causes the hammers to swing out radially.
- The material is beaten by the hammers around inside of the casing and by impact against the breaker plates (located on inside of the casing) or the screen is crushed until it is small enough to fall through the screen
- The hammer mill is a very versatile piece of equipment, which gives high reduction ratios and may handle a wide variety of materials from hard and abrasive to fibrous and sticky.
- Hammer mills are employed to grind tough fibrous solids like bark, sticky clay, etc.,

- Hammer mills provide good performance, high capacity, and need little space, apart from attaining the highest reduction relations for single comminution units.
- Their disadvantages are the elevated noise and vibration they cause and the accelerated wearing of their hammers and hardened walls.

Any questions?

# THANK YOU