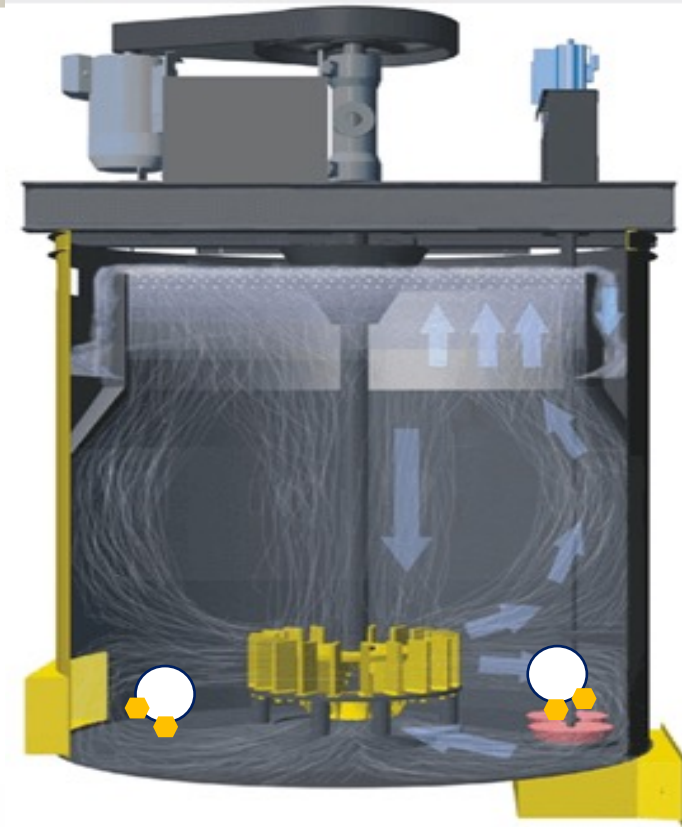
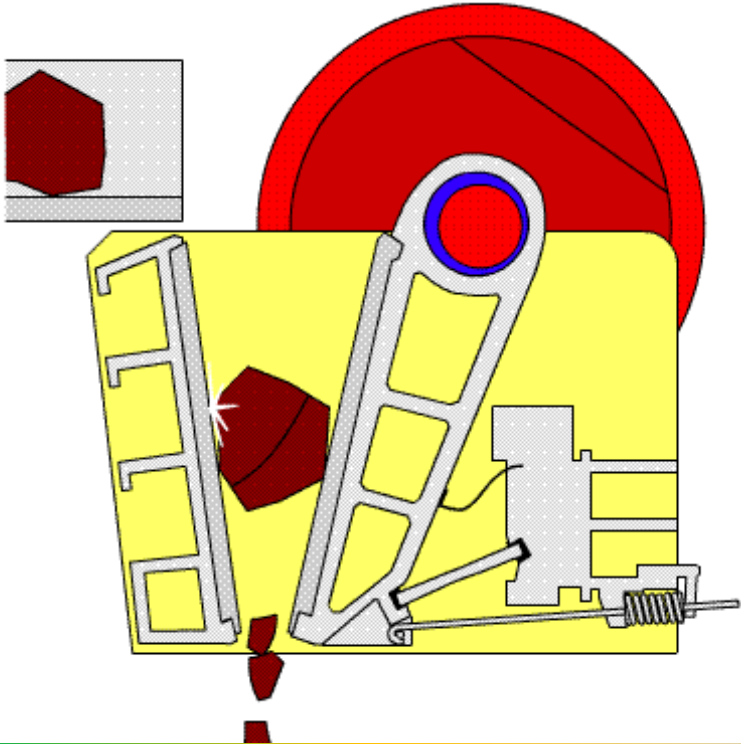


# MET 3145: Mineral Processing



By

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# *Lecture 2*

## *Screening of particles*

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By the end of the lecture students are expected to:-

1. Understand purpose of particle size screening.
2. Understand the efficiency of screening
3. Understand capacity of screens and industrial screens

## **2.0. Introduction**

## **2.1. Screening**

## **2.2. Efficiency of screening**

## **2.3. Near-mesh particles**

## **2.4. Screen surfaces**

## **2.5. Capacity of screens**

## **2.6. Industrial screens**

## **2.0. Introduction**

2.1. Screening

2.2. Efficiency of screening

2.3. Near-mesh particles

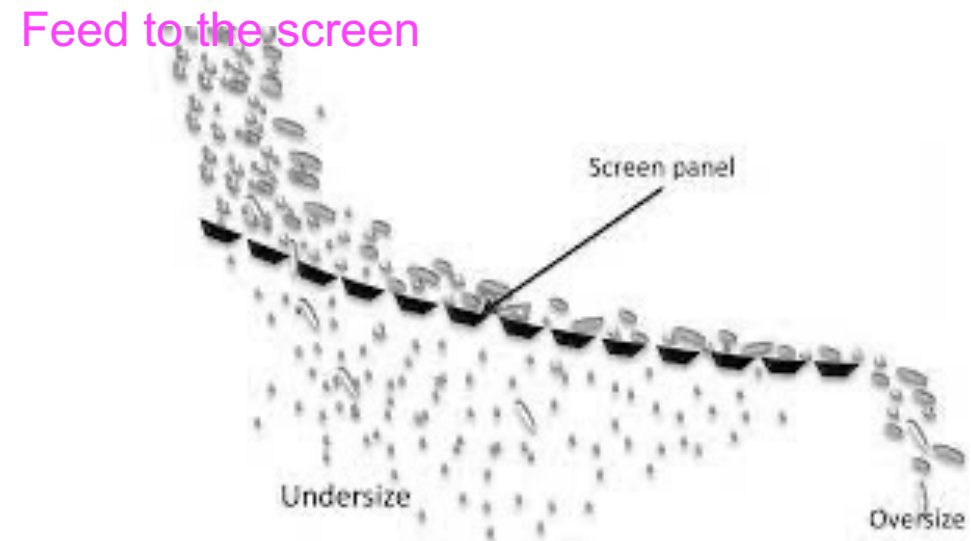
2.4. Screen surfaces

2.5. Capacity of screens

2.6. Industrial screens

## 2.0. Introduction

- Screening/or industrial sizing of the ground material is classification/or grading of particles into different size fractions.
- The sizing is done and particles are classified according to the minimum cross-section of the apertures of the screen “cloth” during the passage of the material over the screen.
- Particles that pass through a screen are termed “undersize” while particles that fail to pass are termed “oversize”.



## 2.0. Introduction (cont.)

- The reasons for carrying out screening/ or sizing of broken rock/ore may be to:
  - ✓ prevent oversize material from entering equipment unsuitable to deal with it;
  - ✓ remove undersize prior to a comminution stage, which is set to reduce material to that size, thereby reducing the required energy for comminution;
  - ✓ present a correctly sized feed to a concentration process;
  - ✓ grade crushed rock into specified sizes as the final products;
  - ✓ remove undesirable material (wood, mill rejects, etc.) at any stage in the operating sequence.

2.0. Introduction

**2.1. Screening**

2.2. Efficiency of screening

2.3. Near-mesh particles

2.4. Screen surfaces

2.5. Capacity of screens

2.6. Industrial screens

## 2.1. Screening

- Those particles in the feed to a screen, that have their sizes smaller than the screen aperture (screen opening) are usually termed “true undersize” and these particles can, theoretically, pass through the screen.
- In practice, not all true undersize particles report to the screen undersize; some report to the oversize.
- The efficiency of the screening action is determined by the mass of the true undersize that reports to the oversize fraction.
- The less of the true undersize reports to the oversize fraction, the higher the efficiency of the screen.

## 2.1. Screening (cont.)

- The objective of screening is to pass the true undersize and those finer than true undersize particles through the given aperture of the screen and reject the oversize.
- However, the above objective is not easily met due to the following challenges
  - ✓ If there is a high amount of the materials to be screened on the screen there is a high possibility of particles interfering with one another hence affecting the screening efficiency;
  - ✓ The speed at which particles pass through the surface of the screen affects the screening efficiency;
  - ✓ Most of the screen openings are square or rectangular hence their edges offer an obstruction;
  - ✓ If the most significant dimensions of the particles are parallel to the surface.

2.0. Introduction

2.1. Screening

**2.2. Efficiency of screening**

2.3. Near-mesh particles

2.4. Screen surfaces

2.5. Capacity of screens

2.6. Industrial screens

## 2.2. Efficiency of screening

- There is no uniformly established expression for the efficiency of a screening process.
- The most logical method, which is also the most widely used method, is based upon the recovery of undersize.
- Here the efficiency is expressed as the weight of the undersize actually obtained, as a percentage of the weight of the true undersize actually in the feed:

$$E = \frac{u (f - o)}{f (u - o)} \times 100\%$$

here  $f$  = percentage of true undersize in the feed,  $u$  = percentage of true undersize in the undersize, and  $o$  = percentage of true undersize in the oversize  
Note: the above equation is the two-product formula, commonly used in the calculation of recoveries in flotation. We will later use it.

## 2.2. Efficiency of screening (cont.)

- If we may assume that all the material in the undersize fraction is true undersize material, then  $u = 100\%$  and the equation reduces to:

$$E = \frac{100(f - o)}{f(100 - o)} \times 100\%$$

- The efficiency of screening generally increases with:
  - ✓ Increase the percentage of openings in the screen area;
  - ✓ The smoothness of the screen surface;
  - ✓ Time taken in transit (greater length of screen, lower velocity over the screen);
  - ✓ Suitability of the shape of apertures to the shape of particles;
  - ✓ Decrease the percentage of undersize in the feed;
  - ✓ To a lesser extent increase with lower temperature (for dry and fine material).

## 2.2. Efficiency of screening (cont.)

- The efficiency generally decreases with:
  - ✓ Slackness of the screen cloth;
  - ✓ The increased feed rate to the screen;
  - ✓ Increase in thickness of the layer on the screen;
  - ✓ Too steep a slope of the screen;
  - ✓ Excessive movement;
  - ✓ Unfavourable shapes of particles (slabs, fibres);
  - ✓ The moisture content of the feed ( as long as it is not a true pulp);
  - ✓ Increased proportion of “near-mesh” particles in the feed.

2.0. Introduction

2.1. Screening

2.2. Efficiency of screening

**2.3. Near-mesh particles**

2.4. Screen surfaces

2.5. Capacity of screens

2.6. Industrial screens

## 2.3. Near-mesh particles

- Small particles compared to the screen apertures will easily fall through.
- In other words, particles that are coarse (large) compared to the screen apertures will be rejected easily and leave ample room for the passage of the smaller particles.
- The difficult particles are those of, say 1 to 1.5 times the size of the screen apertures and are referred to as “near-mesh”.
- Such particles will tend to blind the screen cloth because they get wedged into openings, which are just a little smaller than the particles.
- The near-mesh particles tend to build up in an excessive circulating load if the screen is in a closed circuit with a crusher, because most of the near-mesh particles will be rejected into the oversize, and they will undergo very little size-reduction when they are re-circulated, which has a discharge gap setting equal to, or almost equal to the screen apertures.

2.0. Introduction

2.1. Screening

2.2. Efficiency of screening

2.3. Near-mesh particles

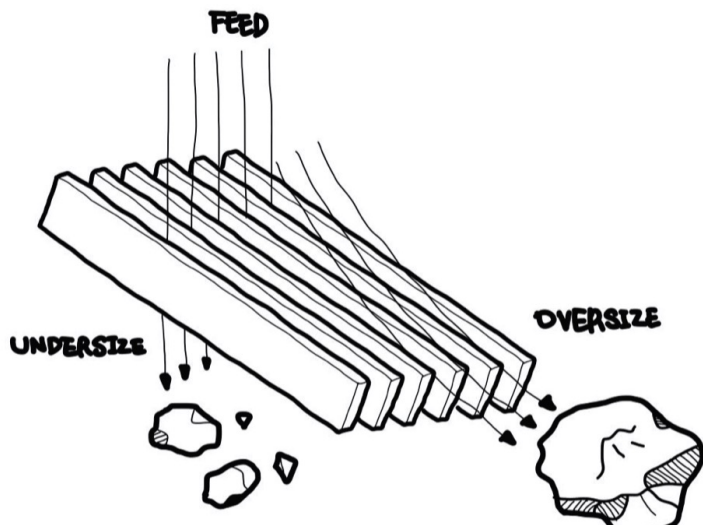
**2.4. Screen surfaces**

2.5. Capacity of screens

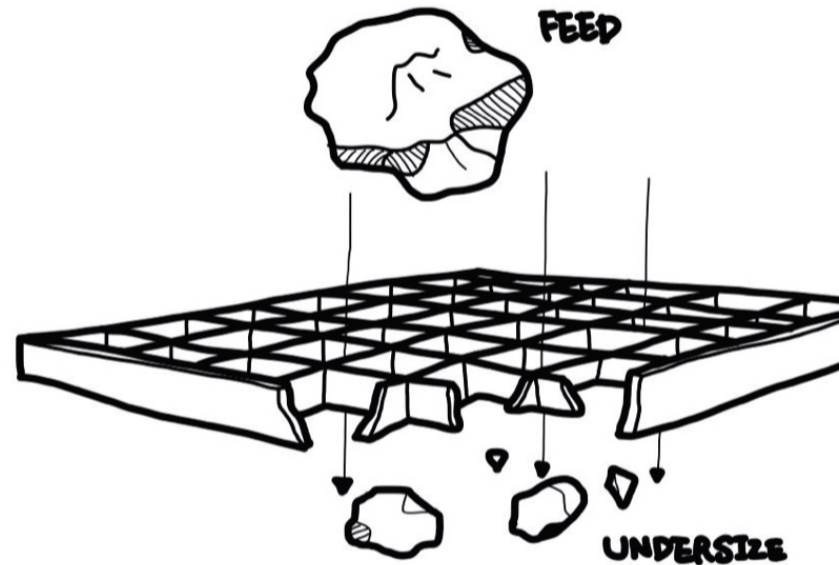
2.6. Industrial screens

## 2.4. Screening surfaces

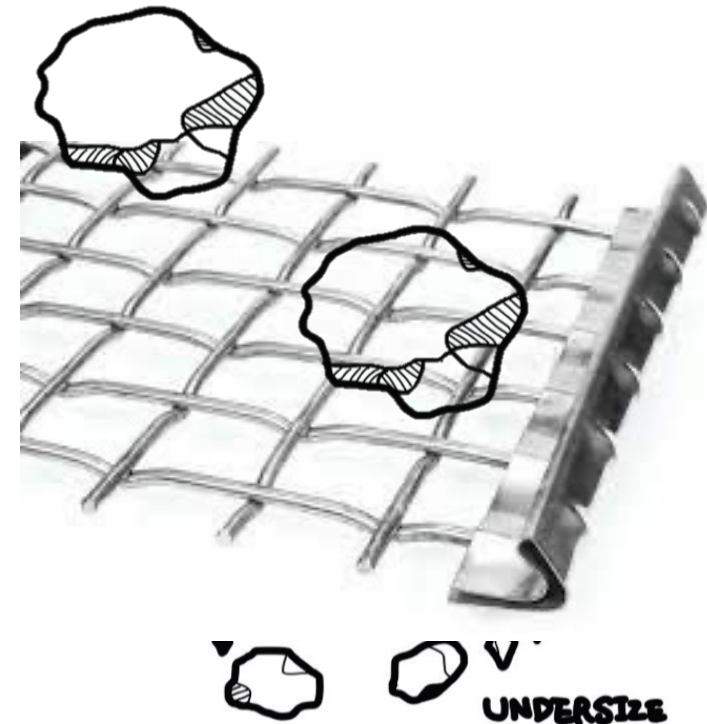
- The screening surface can be made of parallel bars/or rods or made of punched plate or woven-wire cloth.



Rod/or bar



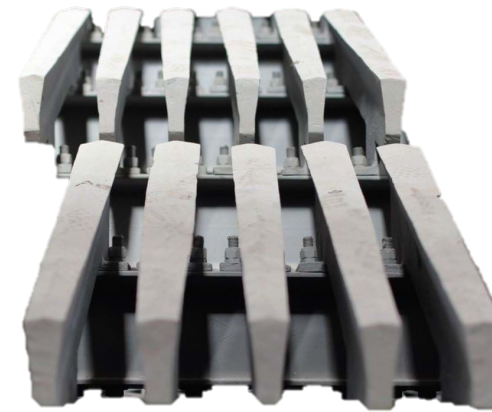
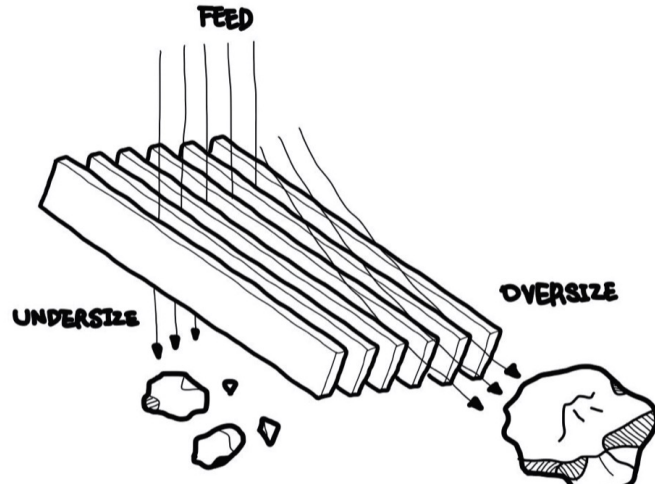
Punched plate



Woven-wire cloth

## 2.4. Screening surfaces (cont.)

- Bars are used for very coarse screening (grizzly screens)
- The bars used for screening should preferably have a wedge-shaped profile to minimise blinding, not an I-profile.

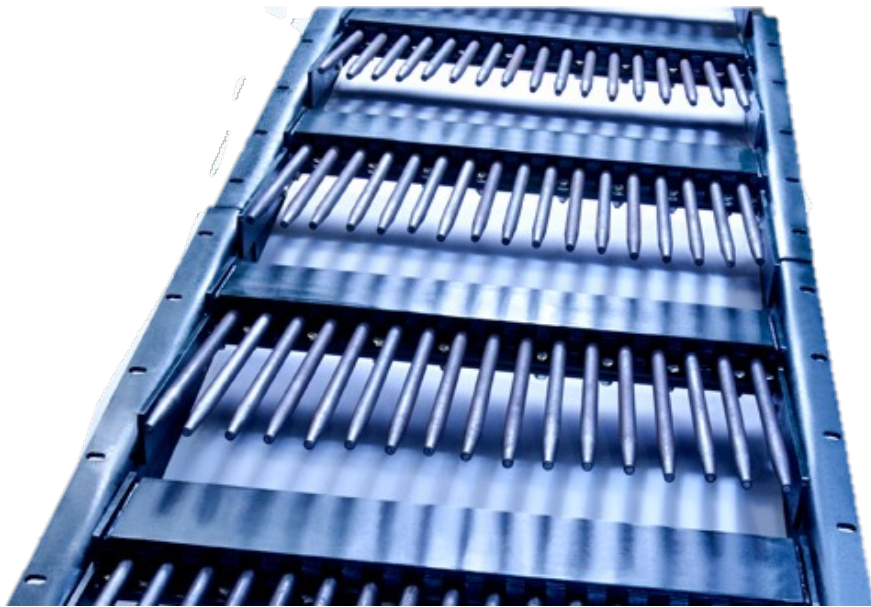


**Wedge-shaped profile**

- Stationary grizzlies bars are normally positioned parallel to the direction of feeding, to assist flow and to minimise blinding. The angle of incline is usually 25-50°

## 2.4. Screening surfaces (cont.)

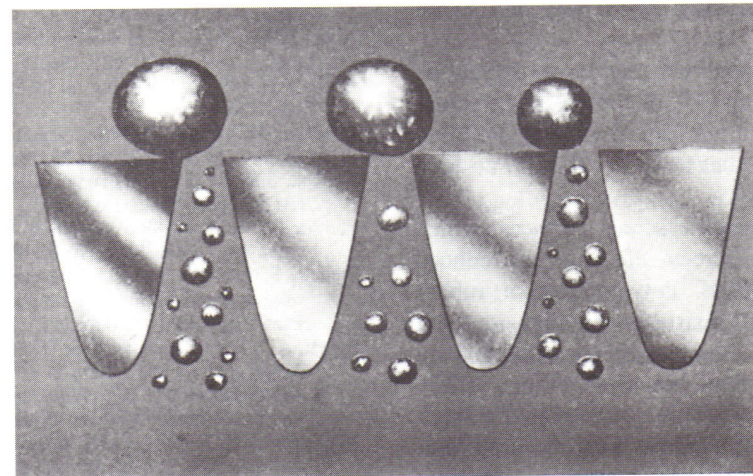
- Rod-deck screens are used for intermediate screening (3-25 mm). The rods are held in the deck by moulded rubber spacers and can be replaced individually so that in the case of slight damage only one or several rods and not the entire deck have to be replaced.



**Rod-deck screen profile**

## 2.4. Screening surfaces (cont.)

- Wedge wires are used in fine screening devices, as sieve bends. Such screens are strong and have relatively large areas.
- The wedge profile minimises particle blinding.



**Wedge wire screen**

## 2.4. Screening surfaces (cont.)

- Punched plate is used in screening coarse and intermediate material.



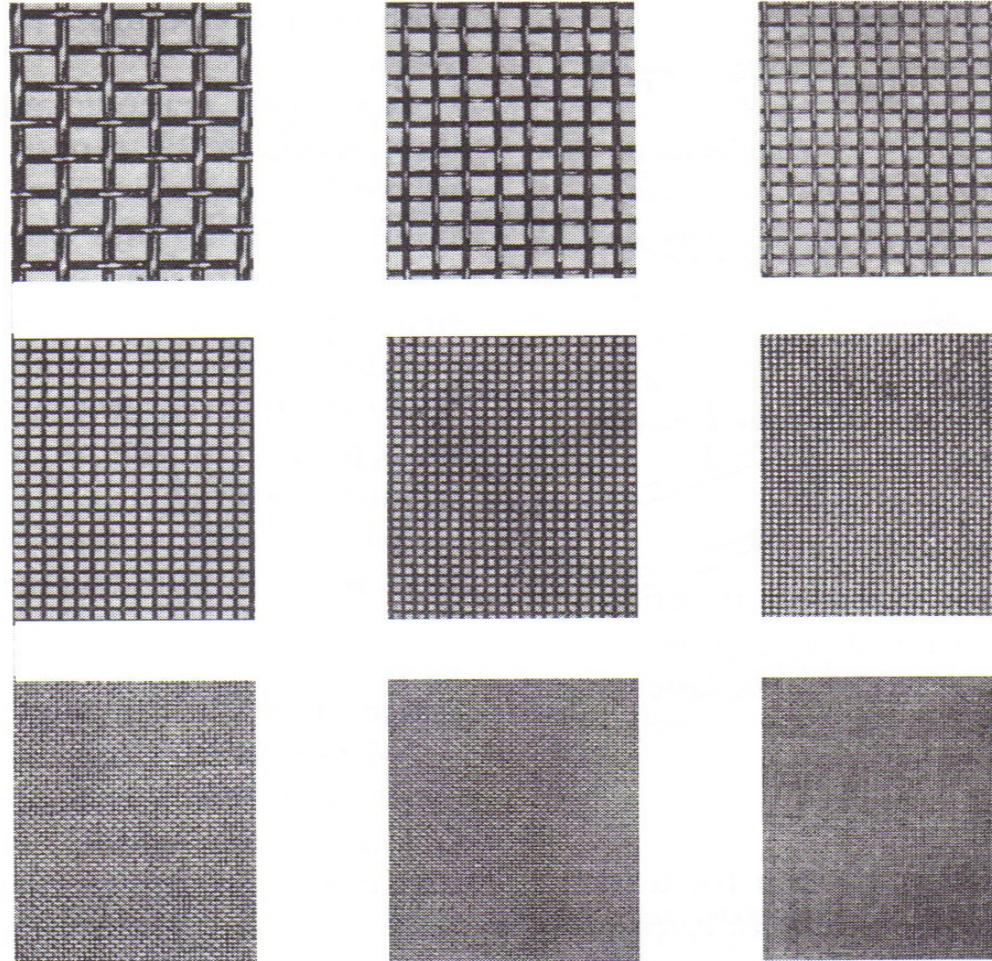
- The openings can be made in any variety of shapes, which is considered to be suitable.

## 2.4. Screening surfaces (cont.)

- Round openings are recommended for coarse screening because the relatively low percentage of openings leaves the screen cloth (the perforated plate) stronger than in the case of rectangular (slotted) openings.
- Slotted openings give a higher percentage of openings and are preferred for finer screening and for acicular (needle-like) particles.
- In comparison to woven-wire screens and bars, punched screens have a relatively smooth surface. This has the following advantages:
  - ✓ more evenly distributed wear, hence a longer life;
  - ✓ less slope required, hence less headroom required;
  - ✓ less interference with stratification.

## 2.4. Screening surfaces (cont.)

- Woven-wire screens are available from 10 cm aperture down to 37  $\mu\text{m}$  (400 mesh).
- However, for the coarser applications (10 – 2 cm) punched plate is usually recommended.



## 2.4. Screening surfaces (cont.)

- The finer size range of particles (i.e., below 1 mm = 16  $\mu\text{m}$ ) sieve bends hence classifiers are more satisfactory because of their much larger capacity in this range and very fine woven-wire cloth is very expensive and easily damaged.
- Woven-wire cloth has a higher percentage of openings than the corresponding punched plate but is less strong and the surface is less smooth.
- Woven-wire cloths, usually constructed from steel, stainless steel, copper, or bronze, are by far the most widely used screening surfaces, especially in the range encountered in crushing circuits.
- Fine screens can have the same or greater open areas than coarse screens, but the wires used must be thinner and hence more fragile.

2.0. Introduction

2.1. Screening

2.2. Efficiency of screening

2.3. Near-mesh particles

2.4. Screen surfaces

**2.5. Capacity of screens**

2.6. Industrial screens

## 2.5. Capacity of screens

- It is difficult to come up with a well-defined expression for the capacity of a screen.
- For many pieces of equipment the capacity can be said to be the maximum possible throughput (feed rate).
- In the case of screens, this would not be a useful expression, since very high throughputs might be possible (very high velocity over the screen, very thick layer on the screen), but at unacceptably low efficiencies.
- The usual expression for the capacity of a screen is:
  - “The capacity of a screen is the maximum feed rate at which the screen will still perform satisfactorily”.

## 2.5. Capacity of screens (cont.)

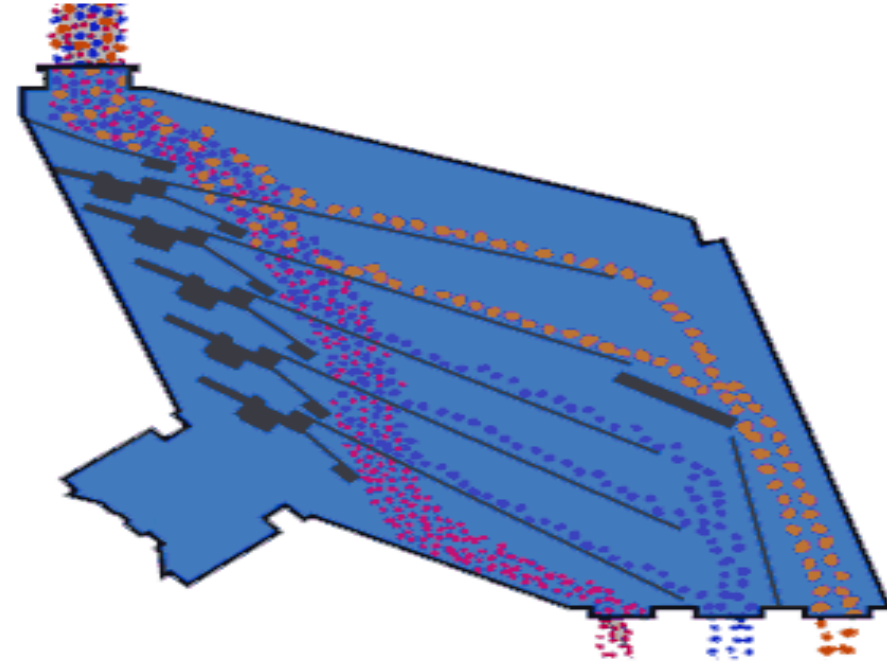
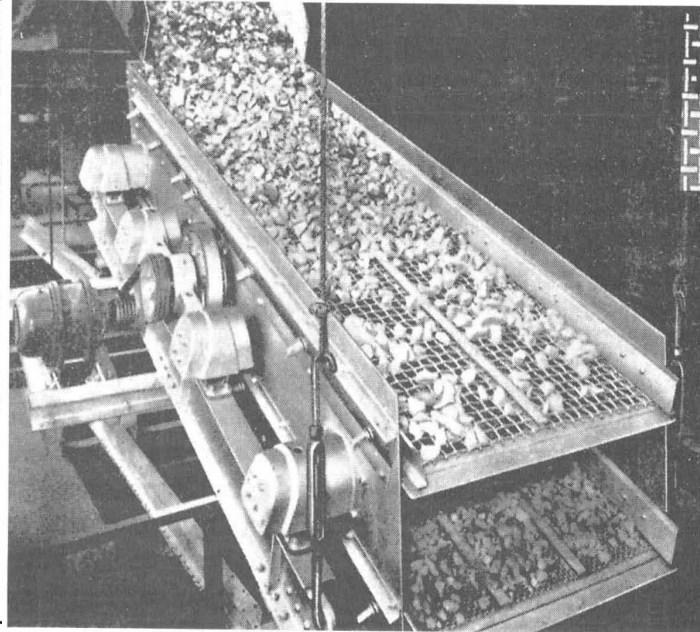
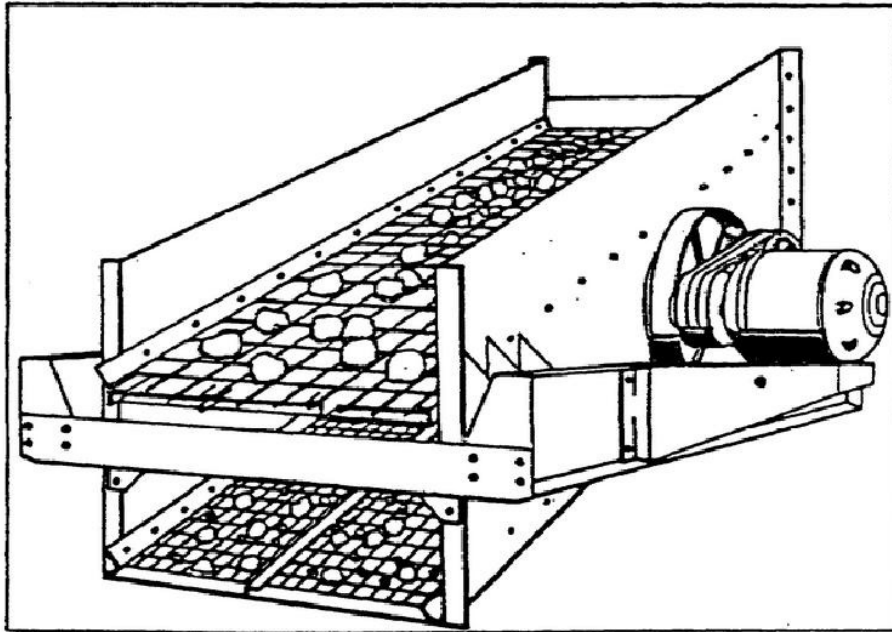
- “Satisfactorily” is of course, highly subjective. This is usually taken to mean a screening efficiency of 80-90 % for coarser screening (above 5-6 mm) and 70-80 % for finer screening, though at fine screening below 1-2 mm, efficiencies of 65-70 % are accepted.
- There is no uniformly established notation for screen capacities. Screen ratings are usually given in mass (metric tonnes or short tons) per unit of screen surface ( $\text{m}^2$  or  $\text{foot}^2$ ) per mm screen aperture per unit of time (hour or 24 hour day), e.g.:

Tonne /  $\text{m}^2$  / mm / 24 hours

- Note that this notation for the capacity of a screen uses the screen “throughput” (the feed rate to the screen) and not the rate of production of undersize.

## 2.5. Capacity of screens (cont.)

- Multiple-deck screens (double or triple-deck screens, very rarely quadruple-deck) have a coarse screen on top with one or two progressively finer screens underneath.



- The aperture size of the lowest screen is the limiting size (separating size) for the unit. The oversize from all screens are combined.

## 2.5. Capacity of screens (cont.)

- The coarse upper screen serves the double purpose of reducing the amount of material, presented to the lower screen(s), and at the same time protecting the lower screen(s) from the impact of heavy, coarse rock, so that the lower screen(s) can have a higher percentage of opening and thus a higher efficiency.
- The efficiency of the lower screen(s) is also improved because a significant proportion of the total load has been taken off by the upper screens. Consequently, the feed rate to the system can be high, without loss of efficiency.

2.0. Introduction

2.1. Screening

2.2. Efficiency of screening

2.3. Near-mesh particles

2.4. Screen surfaces

2.5. Capacity of screens

**2.6. Industrial screens**

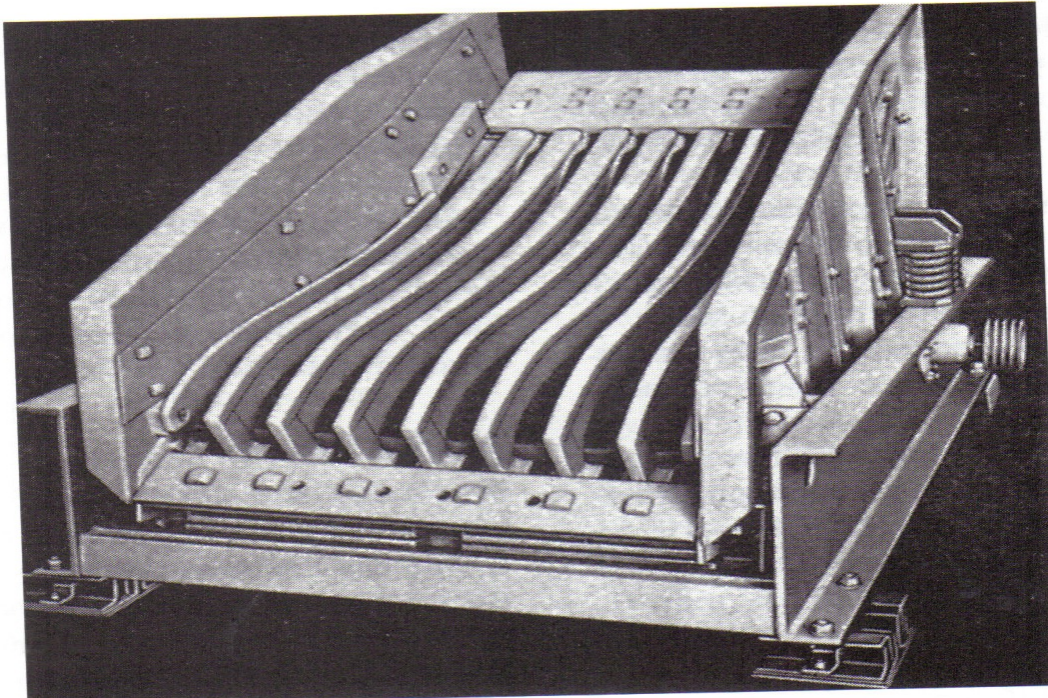
## 2.6. Industrial screens

- The screens used for size-separation (course and intermediate particle size separation) can be roughly classified as follows:

Coarse (> 4 cm)	<ul style="list-style-type: none"> <li>✓ Grizzlies (fixed or vibrating or with rotating rolls)</li> </ul>	Bars (rails or rods)
Intermediate (from 100 mm down to 1-2 mm)	<ul style="list-style-type: none"> <li>✓ Fixed screens</li> <li>✓ Revolving screens</li> <li>✓ (trommel screens)</li> <li>✓ rod-deck screens</li> <li>✓ shaking screens</li> <li>✓ vibrating screens</li> </ul>	Punched or slotted plates, rods or Woven-wire screen cloths

### Grizzlies

- Grizzlies consist basically of a series of heavy, parallel bars, usually mounted in a frame. Their purpose is mainly to prevent oversize material from entering equipment (bins, chutes, rail cars, crushers) unsuitable to deal with it.



- They can also be used to remove undersize prior to primary crushing (scalping).

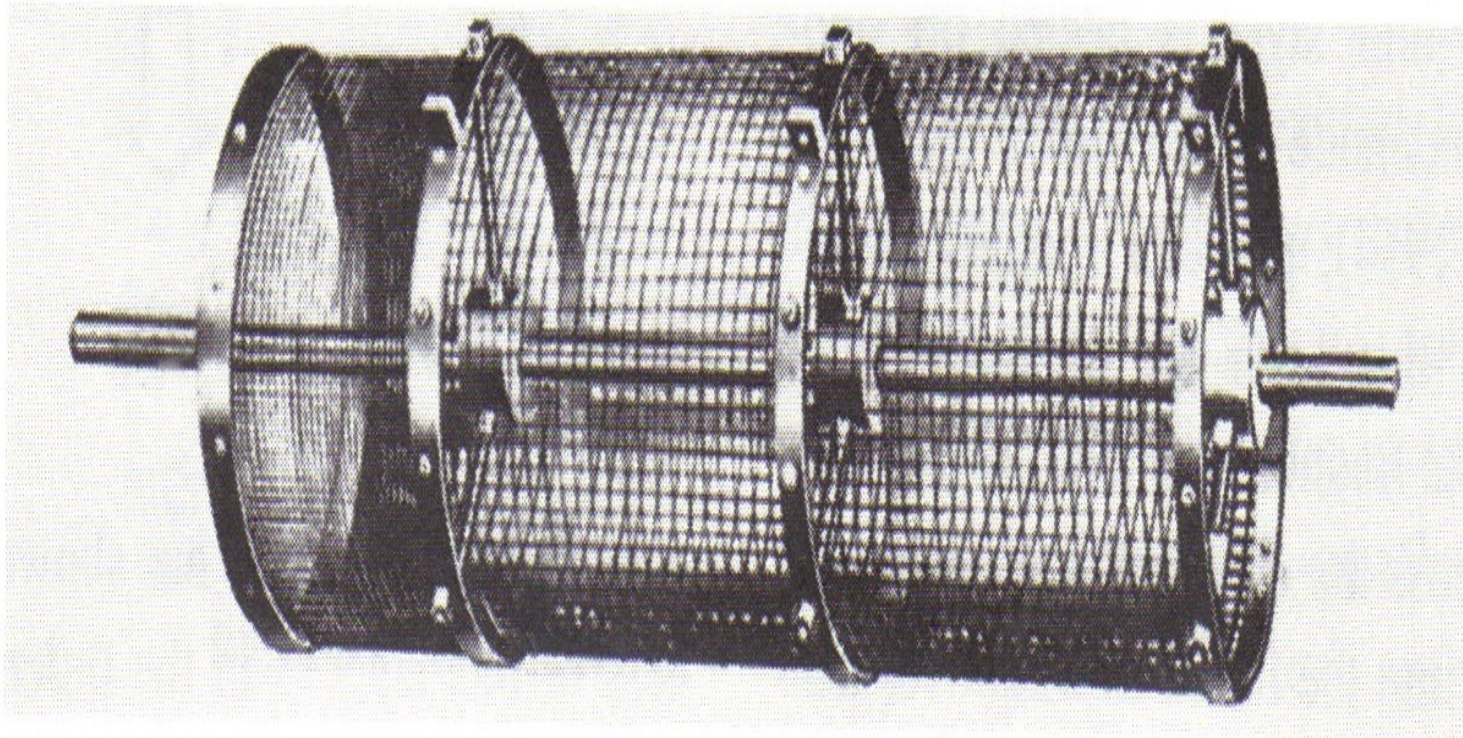
### Grizzlies (cont.)

- Grizzlies are usually given a slope of 25-50°, dependent upon their application and the characteristics of the ore. The greater the angle, the greater the throughput, but the lower the efficiency.
- With stationary grizzlies, the bars are parallel to the slope and the feed is in the direction of the bars, to facilitate the flow. The bars should preferably be wedge-shaped to minimise clogging.

## 2.6. Industrial screens (cont.)

### Trommel screens

- In trommel screens, the screen surface rotates around a horizontal or slightly inclined cylinder axis.



## 2.6. Industrial screens (cont.)

### Trommel screens (cont.)

- The side of the trommel is the screening surface, which is connected to the main shaft by a number of “spiders”.
- The main shaft and hence the entire trommel revolves.
- The feed enters the trommel at one end and moves towards the other end.
- During this transit, the undersize is removed through the screen apertures and the oversize leaves the trommel at the discharge end.
- The revolving speed is slow (below “critical” speed), so the trommel screen does not work like a centrifuge.

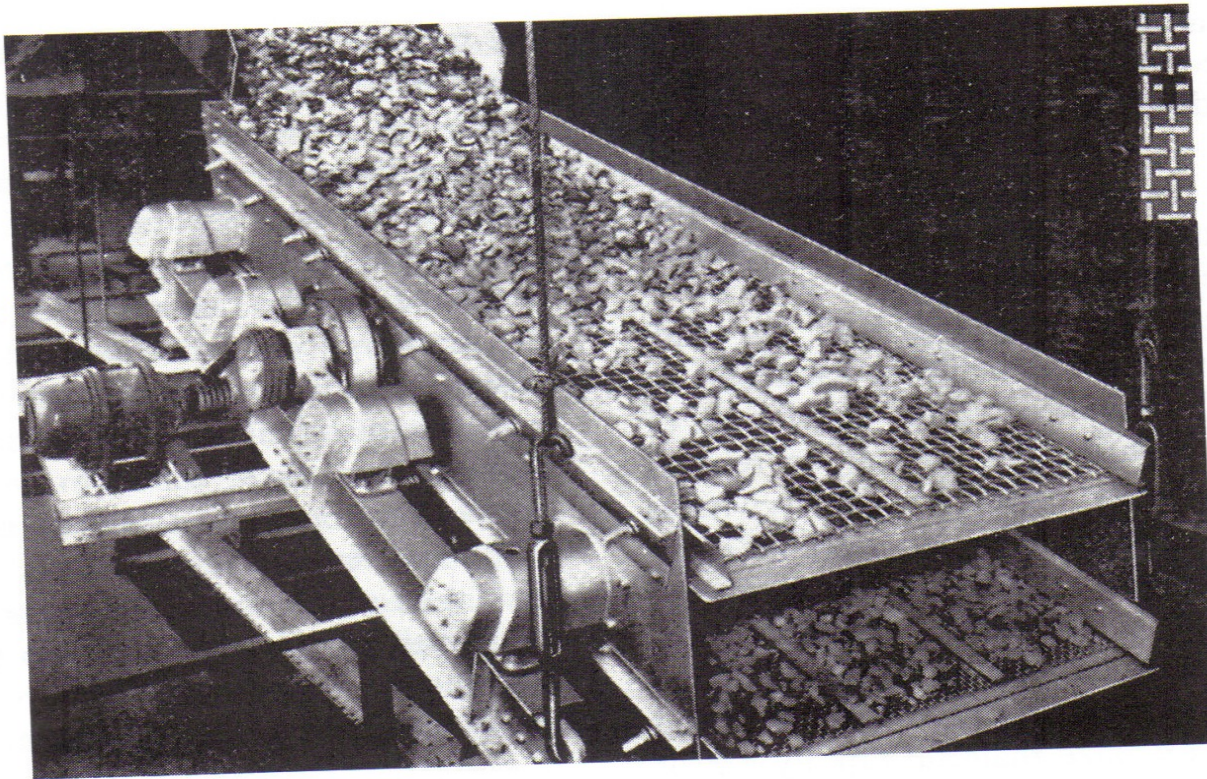
### Trommel screens (cont.)

- Trommel screens can be used either wet or dry. For a long time they were the most commonly used screens, but have now largely been replaced by vibrating screens, which have a much higher capacity and efficiency.
- The screening surface can be punched plate or woven-wire cloth.
- The slope of the trommel affects the rate of travel. To a certain limit an increase in slope increases both capacity and efficiency.

## 2.6. Industrial screens (cont.)

### Vibrating screens

- Vibrating screens are the most important screening machines for mineral processing applications.



- They handle material up to 25 cm in size down to 250  $\mu\text{m}$ .

## 2.6. Industrial screens (cont.)

### Vibrating screens (cont.)

- They handle material up to 25 cm in size down to 250  $\mu$ m.
- Their main application is in crushing circuits where they are required to handle material ranging, in general, from 25 cm to 5 mm in size.
- With vibrating screens, the frequency of vibration is much larger than with shaking screens (600-700 min<sup>-1</sup>), but the amplitude is much smaller (2-20 mm).

## 2.6. Industrial screens (cont.)

### Vibrating screens (cont.)

- Vibrating screens are now by far the most widely used screens in industrial practice, thanks to:
  - ✓ Large capacity per unit of screen area;
  - ✓ Low cost of operation;
  - ✓ Low cost of maintenance;
  - ✓ Flexibility and ease of operation;
  - ✓ Easy accessibility;
  - ✓ Good visual control little headroom required.

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*End of Lecture 2*

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