Lecture 1 - Welcome
Lecture 2 – Ore Preparation – Crushing

Prepare ore:
- Optimise process conditions
- Processes thrive on consistent conditions

Composition of deposit varies:
- Climate and geological period it formed
- Weathering and geological events
- Can be reduced by on site blending and good mine planning

As mined/ Run of mine: Material after mining that has undergone no processes except for basic crushing and screening of waste.

Size reduction:
- Increase surface area. Energy intensive process

Crushing:
- Large lumps (>>150mm) reduced to smaller lumps (less than 50mm)
- Done to improve material handling and pre-blending

Grinding:
- Reduction to a fine powder (everying <<250 microns)

Crushing methods:
- Two solid surfaces
- Shearing
- Crushing in a particle bed
- Impact at one solid surface
- Impact between two particles
- Shear action of surrounding medium

Crusher system choice depends on:
- Hard or soft
- Wet or dry
- Largest particle/lump size
- Sticky or dry
- Downstream processes (subsequent size reduction/processing)

Crusher types:
- Jaw crusher – can accept large lump size. Moderate size reduction of hard or soft rock. Placed below hopper without feeder.
- Cone crusher – moderate size rocks only (~100mm). Good for secondary crushing. Requires feeder.
• Hammer crusher – moderate input size handling. High size reduction. Higher wear rates. Good for soft ore
• Roll crusher – Handles sticky materials. Good for soft ore.

Blocking and hold-ups in hoppers and transfer chutes can be major issues. Open conveyers and transport systems can cause environmental issues.

Conveyers:
• Belt conveyers – most common. Can transport over several km. More efficient than some but still consumes power. Many blockages and spillages at transfer points. Can be open or closed – closed usually in environmentally friendly areas.
• Bucket elevators – steep incline or vertical conveying
• Drag chains – hot material
• Screw conveyers
• Pneumatic conveyers – small sized ore

Lecture 3 – Stockpiling and Pre Blending

Stockpile and pre-blend ore:
• Need a buffer stock to cover short mine stoppages.
• Natural raw materials are variables.
• Consistency

Simple stockpiles:
• Useful for consistent ore (iron)
• Small plants with small capital investment

Blended stockpiles:
• Good for variability
• Large complex processing plants with high capital investment

Mining strategies:
• Selective mining – require good knowledge of deposit. Drilling to core almost always necessary.
• Variability of run of mine should be reduced by effective mine planning and strategy- maximise downstream outputs and enhance profitability.

Effectiveness depends on:
• Initial deviation from mean
• Timescale chosen
• Downstream mixing effectiveness
• Process residence time

Effective pre-blending:
• Product quality is optimised
• Grinding mill output optimised
• Mill power consumption reduced
• Plant capacity maximised
• Downstream blending units can be smaller
• Waste minimised
• Profitability enhanced.

Ore consistency is determined by sampling

\[ \sigma = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2} \]

Pre-blending done in the stockpile:
• Piles are layered
• Can be done in open or undercover (more expensive)
Method depends on:
• Variability, physical nature, homogenising required

Homogenising effect:
• Reduction in variability
• Homogenising effect, \( H = \frac{\text{SigmaIn}}{\text{SigmaOut}} \)
• \( H \) is approximately proportional to the number of layers of the stockpile, i.e. \( H \sim \sqrt{N} \)
• Large number of thin layers for optimal homogenisation
• \( N \) is typically 400 layers

Different pre-blending stockpiles:
• Materials laid down in layers or across the face
• All layers reclaimed together during reclaiming

Pre-blending investments are repaid many times over in the downstream process which are even larger investments

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Lecture 4 – Comminution Laws and Machinery
Why grind ore:

• Increase surface area
• Facilitates separation of ore from gangue
  - Improve chemical reaction rate
  - Required for most flotation processes

Don’t need to grind in moving bed related processing – i.e. blast furnaces

Usually multistage – crushing, coarse grinding and fine grinding

Choice of system affects:

• Product quality
• Initial capital cost
• Ongoing energy usage and maintenance costs

Tensile stress responsible for breakages and fracture
Applied stresses include compression or shear – converted to tensile stress through internal forces

Basic grinding techniques:

• Impact by cascading media – usually suitable for most materials, including very abrasive and hard materials. Lifting and dropping action has high energy costs. Common form is a ball mill
• Impact by rolling media – also suitable like above. Typified by rod mills – particles don’t cascade, they roll over one another. Looks very similar to cascading mill.
• Autogenous action: no grinding media. Larger particles fall on smaller particles. High energy consumption. Critical size particles accumulate
• Semi autogenous grinding (SAG) – Uses minimum ball charge along with general autogenous action.
• Crushing beneath rollers – suitable for most materials, very abrasive. Energy efficient and high capacity
• Attrition – particles are impacted by hammers or pegs attached to a rotating shaft. Intense stirring action

Grinding efficiencies generally very low. Theoretical energy requirements are low, however there are significant losses:

• Friction – machine, material loss, machine wear
• Tumbling action of balls
• Unsuccessful particle breakage
• Kinetic losses

Grinding laws:

• Grindability: measure the rate of grinding in a mill
• Work index: energy required to reduce a particle from infinite size to 80% within passing 100 microns
• Abrasion: kWh per kg or lb of metal lost – used to determine mill rates.

Grindability: