Carbon and Comminution

Against the backdrop of COP27, and amidst growing stakeholder pressure to reduce emissions, the context of energy in mining, particularly in countries utilizing coal fired energy, requires serious review. Not only is the mining industry a big contributor to CO2 emissions, but it is also the first source of emissions in most product value chains. On the other hand, the mining industry plays a critical role in the modern global economy, providing the key components to support decarbonisation and climate adaptation infrastructure. The importance and sheer scale of the mining industry makes the industry critical to the climate change solution as a small percentage of incremental improvements in energy efficiency across the whole industry could result in massive greenhouse gas emissions reductions.

Rethinking Energy

Mineral resource bases are less than crustal abundances due to the mineralogical barrier, which is the minimum grade after which mining is not economical, this mineralogical barrier is essentially an energy barrier.

An often-overlooked challenge to the industry achieving net zero goals is the deterioration of ore grades over time as higher-grade reserves are being depleted. Generally speaking, the overall trend of grade will always be a function of time as the highest grade and least complex deposits are mined, leaving evermore geologically and metallurgically complex deposits behind. These deposits require increased amounts of energy in order to liberate and concentrate the economic minerals. Furthermore, the tonnage required from ore to concentrate is a hyperbolic function of grade meaning that lower grades result in the need to extract greater tonnages which require increased levels of hauling and, consequently increased carbon emissions.

The general deterioration of ore grades is exacerbated by an accompanied, however less acute, decline in the grain sizes of economic minerals.

This is because the amount of grinding required to liberate the minerals of economic interest increases as the size of the minerals decreases.

In a typical mine, comminution accounts for close to 40% of the total energy requirements however the need to import grinding media like steel balls adds to the carbon footprint of comminution. The effect of ore grade and grind size depends on the economic mineral and the mineralogy of the host rock.

There will also be a difference in emissions depending on the mining methods which are dictated by the in-situ geological conditions. The depth of the deposit broadly determines the mining method, particularly whether underground or opencast. Underground mines generally operate at higher grades and process less materials allowing them to be more energy efficient, however underground mines do have more indirect emissions related to their overall operations such as infrastructural development and ventilation.

A Way Forward

The ESG imperative in mining is to improve the efficiency of resource utilization whilst still reducing the waste and emissions generated from operations. However, assessing the holistic impact of metal production is difficult due to complex value chains and numerous inputs and outputs. Furthermore, energy in a mining operation is a “shared commodity” distributed across the entire operations which means it has shared responsibility and therefore suffers accordingly, in a “tragedy of the commons”.

While miners don’t have to be energy experts, they increasingly need to think about energy more strategically and remain open to innovation and questioning the current conventional thinking.

A mining company could derive value through an energy management portfolio to optimize energy by adjusting the operations and energy related activities to reshape demand. According to Deloittes, mining companies could reduce energy consumption by 20% through effective energy management.

Solutions to reduce the embodied energy and carbon emissions from metal production could include direct and indirect strategies such as;

- Improving the efficiency of fossil fuel electricity generation
- Renewable energy, energy storage and alternative fuels
- Energy efficient processing equipment such as compressed air, high-pressure rolls, stirred mills and pumped hydrological solutions
- Capture and sequestration of carbon dioxide emissions within industrial stacks
- Direct smelting of ore instead of grinding, such as is done for sponge iron
- The use of emerging technologies such as big data and artificial intelligence to optimize processing
- Improved resource geology and mine design optimization
- Incorporation of blasting into the comminution strategy (There are some radical, out of the box hypotheses around harnessing energy from extreme combustion leveraging the power of explosives used during blasting).

There is also a role for offsets and carbon credits in alleviating the economic constraints and incentivizing mining to explore these energy efficient solutions.

The bottom line however is that the mining industry will have to invest in innovation amidst very challenging physical constraints in order to maintain a broad and collective industry license to operate and fulfil its full potential as the global differentiator in the battle for a net zero society.

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