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A Review of Underground Mine Backfilling Techniques with a Paste Backfill Process

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***Abstract*— The mining industry is a rigorous area for human progress. The depletion of profitable minerals at the surface has necessitated deeper underground mining. Safety and environmental considerations have prompted mining corporations to contemplate the backfilling of mine waste to prevent mine collapse during subsequent extraction stages, ground subsidence upon mine abandonment, and environmental contamination. This study reviews the primary ways of backfilling underground mines, with a focus on the cemented paste backfill method. The selection of the backfilling process should be determined by subsequent objectives, available equipment and materials, and economic considerations. Cemented paste backfill technology is an emerging technique that enhances safety in underground mining situations and serves as an effective preventative measure for environmental contamination by disposing of dangerous waste minerals beneath.**

***Index Terms—Backfill Process, Underground mine,* Backfilling Techniques, waste, Cemented paste backfill.**

I. INTRODUCTION

Underground extraction of valuable minerals generates voids in many configurations, including stope, cave, chamber, goaf, and gob forms. These subterranean cavities provide instability risks for the extraction of neighbouring pillars containing valuable minerals, as well as subsidence concerns for surface infrastructure.

during operations or after to the abandonment of mines. Consequently, during the historical evolution of mining technology, many techniques for refilling or backfilling gaps have been devised. The prevalent backfilling techniques used depending on economic considerations and objectives, such as mine development or closure, include rock backfill, hydraulic backfill, cemented paste backfill, and silica-alumina-based backfill methods.

II.THE PASTE BACKFILL PROCESS

A.Materials and mix design

The paste combination consists of three primary components, with quantities tailored to operating needs, tailings characteristics, and ground conditions.

B. Aggregates

Mine tailings, the finely pulverized rock remnants resulting from mineral extraction, are the principal solid component. In contrast to traditional hydraulic fills that only use coarse particles, paste backfill may include the whole tailings stream, hence minimizing surface waste. Additional solid wastes, including coal gangue, fly ash, and metallurgical slags, may also be included.

C. *Binders*

Cementitious ingredients are included to initiate hydration processes that enhance the strength of the paste. Although ordinary Portland cement (OPC) is prevalent, research investigates more cost-effective and sustainable alternatives such as ground granulated blast furnace slag (GGBFS) and fly ash. Binders are the primary contribution to backfill charges, representing up to 75% of overall costs.

D *Water and additives*

Water serves to facilitate mixing and to begin the hydration process of the binder. Chemical additives, including water reducers, plasticizers, and accelerators, are often used to enhance the fluidity and mechanical characteristics of the paste.

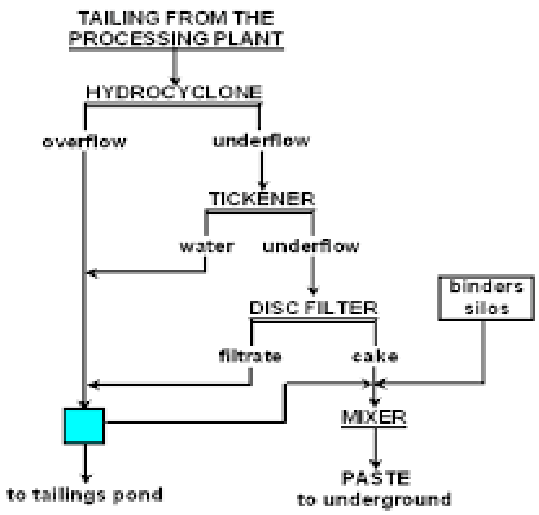

Fig : Flowchart of backfilling Process

III PREPARATION AND MIXING

(A)Thickening:

The tailings slurry from the mineral processing facility undergoes dewatering in a high-capacity paste thickener to attain a solids concentration of 70–85%.

(B)Filtration:

Vacuum disc filters may be used to enhance the solids concentration of thickened tailings, resulting in a filter cake.

(C)Mixing:

The filter cake, binder, and water are constantly blended in a spiral or screw mixer to create a homogenous, high-density paste devoid of segregation.

IV. TRANSPORTATION AND PLACEMENT

The prepared paste is transported underground via a pipeline reticulation system:

A. Pumping or gravity:

The paste is delivered to the mine voids (stopes) using gravity flow for deeper sections or high-pressure positive displacement pumps for shallow or long-distance applications.

B. Placement:

The paste is positioned in the stope behind a barrier. Its high-concentration, non-segregating characteristics need minimum water drainage, hence considerably accelerating the filling cycle relative to traditional hydraulic fills.

V. KEY BENEFITS AND APPLICATIONS

A. Environmental protection

Backfilling reduces the amount of surface disposal by offering a secure and efficient method of burying mine tailings and other industrial wastes. In addition to lowering the danger of dam collapses and acid mine drainage-related environmental contamination, this also reduces the footprint and responsibility of tailings storage facilities.

C. Mine safety and stability:

Regional ground and pillar support is provided by the cemented paste, which hardens into a robust, self-supporting mass. This makes the mine more stable overall and gives workers and equipment a safe place to work.

D. Increased resource recovery:

Backfill greatly increases the total extraction rate by stabilizing the mine and enabling the recovery of nearby ore pillars that would otherwise be left behind.

E Increased productivity:

Compared to traditional fills, mining may restart in nearby regions considerably sooner because paste backfill's quick drying period reduces the stope cycle time.

F Surface subsidence control:

Backfilling stops ground subsidence in mines under populous areas, enabling mining to continue without affecting surface infrastructure such as roads, railroads, and houses.

VI CHALLENGES AND FUTURE TRENDS

A. Challenges:

- High capital cost:

Paste factories and pipeline networks may need a substantial upfront infrastructure expenditure.

- Operational complexity:

For certain constant feed material, appropriate binder management, and equipment dependability, paste backfill operations need strong process control.

- Performance variability:

Changes in water chemistry, material interaction, and tailings particle size may all have an impact on backfill strength.

- Cost of binders:

One of the biggest operational obstacles is still the high cost of binders.

B. Future trends

- Sustainable and low-carbon binders:

Using solid waste such as metallurgical slag, chemical slag, and waste heat to create cost-effective, low-carbon, and highly active composite binders is the main goal of research.

- Intelligent systems:

Smart backfilling systems are emerging as a result of the combination of sensors, cloud platforms, and artificial intelligence. Intelligent fill parameter prediction, real-time monitoring, and automated control are made possible by these technologies.

- Process optimization:

In order to lower expenses, increase productivity, and improve environmental performance, research is still being done to optimize the paste backfill process. This entails advancing barrier construction, transportation strategies, and mixing technology.

VII CONCLUSION

The paste backfilling technique, which combines economic, safety, and environmental goals, is a crucial and more popular tactic in contemporary underground mining, according to a wealth of studies. Businesses may fill mined-out spaces and reap a number of advantages by turning mine tailings and other industrial waste into a high-density, non-segregating paste.

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