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Valorization of mining waste and tailings through paste backfilling solution, Imiter operation, Morocco

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ABSTRACT

Mine waste and process tailings storage is one of important challenge for which mining operations are increasingly confronted. Treatment discharges of plants and main part of waste rock development are generally stored on surface areas. The volume and chemical characteristics of these materials generate serious problem for required storage spaces and mainly environmental degradation. Paste backfill (PBF) is one of ingenious solutions to minimize the quantity of tailings to store. PBF is basically defined as a combination of mine processing tailings, binder, and water mixing. The purpose of this paper is to present backfilling components characterization and formula verification for a waste valorization solution through paste backfilling technology in Imiter operation. Obtained results and realized analysis demonstrate PBF conformity and adequacy with assigned underground functions. However the studied recipe can be more ameliorated to obtain an optimal mixture ensuring the required mechanical strength.

1. Introduction

More than 20 years ago, concentrator treatment discharges of mining plants were wholly stored on tailings parks on surface areas. The quantity and chemical characteristics of these tailings, often rich of sulfurs, generate serious problem for storage requiring spaces and mainly environmental degradation due to acid mine drainage.

Moroccan mining operations use different kinds of backfill depending on the extraction method. The most used backfills are mechanical backfill (only waste material) and hydraulic backfill (cemented backfill).

The environmental legislation, increasingly requiring, leads mining societies to minimize as possible, the volume of tailings stored on the surface. Morocco is one of countries which are going to make the environment preservation as the first preoccupation during and at the end of mining activities.

Cemented paste backfill has become increasingly widespread, mainly because it reduces by 50%–60% the quantity of sulphidic tailings deposited on surface, increases ore recovery, and minimizes stoping sequences [1]. It's a mixture of total mill tailings generated during mineral processing, Portland cement or blended cement with supplementary cementitious material (lime, pulverized fly ash, and ground granulated blast furnace slag), and water (tap water, lake water or recycled and/or treated mine process water) [2].

The purpose of this paper is to present testing results and analysis done to assess Imiter PBF mixture as a waste and tailings valorization solution against underground defined functions.

2. Paste backfill technology

2.1. PBF advantages

Since their introduction in 1990, PBF technology has demonstrated advantages regarding economics factors, environment, geo-mechanics and safety [3,4].

This success of PBF is explained first by the engineered character of the product which allows high quality in comparison with old backfill methods.

Actually, the economic and environment benefits of PBF have not to be approved. Costs due to tailings management in the storage areas and closing budget can significantly be reduced.

PBF technology is suitable for most mining methods because of its versatile characteristic which has allowed the increasing of resource extraction.

In term of safety, PBF is used as local and regional ground support and also help to reduce the number and exposure time of operators by fast filling rates. The fast filling increases, in addition, mine productivity with shorter stop cycle times.

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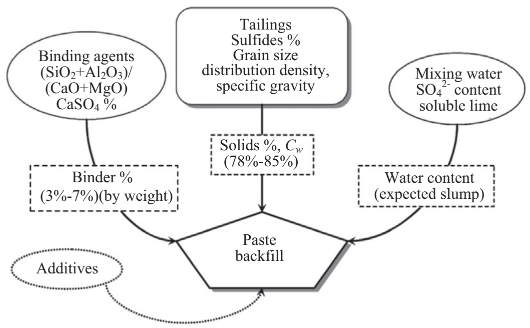

Fig. 1. Schematic diagram illustrating the different components of paste backfill [3].

2.2. Influencing parameters

As showed in Fig. 1, the percentage and characteristics of each PBF component (tailings, binder, and water) affect directly the mechanical strength of hardened backfill.

(1) Chemical composition of tailings

The sulfurs content is the most important parameter to verify the chemical composition of tailings because of its direct influence on increasing the tailings density. The pulp density is a critical determining factor in the strength of cemented backfill. Increase in its value significantly increases the backfill strength [5].

(2) Morphology of grain and size distribution

Generally a well-graded material can help to minimize the hardening time of PBF. The morphology of tailings particles can also affect the quality of the final product mainly with phyllo-silicate material.

(3) Binder and water chemistry

It's inefficient to choose paste backfill mixtures without testing first the binder and mixing-water chemistry. The binder chemistry combined with the mixing-water chemistry affects the formation of primary and secondary hydrates during paste backfill strengthening. The cohesion of the paste backfill matrix is directly dependent on the nature of the precipitated hydrates [6]. Presence of sulphide-rich compounds can causes deterioration in the hardened paste matrix due to sulfate attack [7].

Fig. 2 shows the composition impact of each component of mixture on the backfill strength expressed with uniaxial compressive strength (UCS).

2.3. PBF limit strength

The first step of PBF design is to calculate critical strength ensuring both stability of PBF and filled stope. The value of critical strength to reach depends on the function of the PBF in the mining method.

PBF can be used to support voids roof and then its design will be focused on rigidity and mechanical cohesion. In case where one side of PBF has to be exposed, the shear strength is the main parameter conditioning the backfill stability.

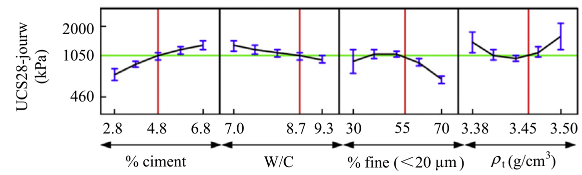

Fig. 2. Example of component impact simulation curves [8].

2.4. PBF mixture optimization

At this stage, each proportion of tailings, binder (one or several cementation agents) and mixing water has to be defined in an optimized recipe.

The backfilling cost represents 2%–20% from the total mining operation cost. Knowing that 75% of backfilling cost corresponds to binder acquisition, it's important to optimize recipes to product backfill with a minimum cost [9].

The recipe optimization takes into consideration the mechanical and delivery exigencies thought a pertinent selection of type and binder proportion.

2.5. Flow sheet production

Generally, the PBF plant is located on the surface nearby the processing plant to facilitate the recovery of tailings at the end of the processing line.

The following presents the classic procedure of PBF fabrication: thickening of tailings slurry to about $C_w = 55\%$ (solid weight percentage); filtration of tailings with disk filtersor pressfilters to C_w between 70% and 82%; binder addition with a proportion between 3% and 7% from the total mass of dry tailings; water addition (processing or fresh water) to generate an optimal slump comprised between 150 and 250 mm; recipe mixing in a screw mixer with high power during 45 s to 1 min; and underground implementation of PBF through delivery network [9].

2.6. Transportation

Several works focused on the problematic of backfill transportation since their introduction PBF product must be delivered from surface to underground via boreholes and pipes at the highest practical density (Fig. 3) [10–13]. Practically, it is not easy to have real proprieties of PBF rheology because of experimental dispositive complexity.

It makes difficult or even impossible determination or prediction of paste viscosity which depends on several factors [3].

Generally, the slump test and flow-loop test are used to evaluate the paste consistence and pressures drop along the transporting network.

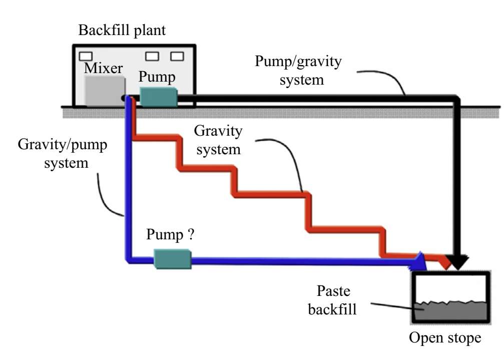

Fig. 3. Basic configurations for paste backfill distribution systems [14].