Utilizing Paste Diverter Valves to Optimize Paste Backfill Operations

Scott Sargent and Michael Prince
Victaulic

ABSTRACT

Underground mines use intricate piping networks, known as paste backfill systems to fill stopes after extracting materials for processing. These piping networks require extensive manual labor to operate and maintain a functional system, as these systems operate under extremely rigorous conditions. Diverting paste fill from one stope to another requires removal and reinstallation of the pipe to redirect the flow of the line. This process is laborious, time consuming, and requires extensive planning to ensure safer operations. New innovations and products are now making these manual processes a thing of the past, resulting in increased backfill reticulation, job site efficiency, and safety. This paper evaluates a new system that uses a diverter valve, as opposed to manual changeover, to reduce downtime, eliminate safety hazards, and increase processing throughput.

INTRODUCTION

Deeper depths increase the expense and risk profile of a mining operation. In order for a mine to expand underground operations, it must determine that the ground already mined has been solidified enough to create a stable platform for work and create ground support for the walls of the stopes. The process used to fill old stopes to maintain safe underground conditions and operations in the mining industry is referred to as “backfill.”

Backfill is essential for a safe and economic underground mining operation. The process ensures stable ground conditions and reduces the costs of waste disposal. There are three major types of backfill operations that are used in the industry today, cemented paste (CPB), hydraulic, and dry tailings. The costs associated with backfill mining typically represent 20% of the total cost of a mine operation (Belem and Benzaazoua 2004) and, in today’s market, the economic survival of many mining operations hinges on the implementation of innovative, cost-effective technologies that improve productivity and efficiencies across the mining life cycle.

Due to ever-changing conditions and continual growth, backfill systems are composed of an expansive piping network. These pipelines are subject to an abrasive slurry comprised of rock, sand, ore and other chemicals that make up the backfill paste. On top of the slurry, these piping systems are also subject to high pressures, generally exceeding 725 psi (5 MPa), as well as abrupt changes in the direction of the flow (Belem and Benzaazoua 2004). As a result, the pipelines and valves that make up these systems require constant maintenance and repair.

Efficient backfill distribution is necessary to ensure overall mine safety, and the current standard operating procedures for backfill mining are labor intensive, inefficient, and can expose miners to high risk environments. Improving the efficiency of backfill operations and reducing associated lost time have a direct impact on productivity and profitability of a mine.

BACKGROUND

Conventional backfill utilizes the tailings waste produced from mineral processing, a component of the mining operation. The tailings waste is then moved to a paste factory, where the tailings are mixed with additives such as Portland cement, lime, pulverized fly ash, and smelter slag. The binding agents develop cohesion within the CPB so that exposed fill faces in the stopes will be self-supporting when the adjacent slopes are extracted (Belem and Benzaazoua 2004). From the paste factory, the CPB is then either gravity fed or pumped into a network of pipelines that transports the backfill into the previously mined stopes. This piping network generally consists of a main pipeline dropping vertically 200 meters or more below the surface, where it levels out horizontally and the flow can be split into two different pipelines (Figure 1 and 2). This piping structure repeats this process at each level of the mine, depending on the project.

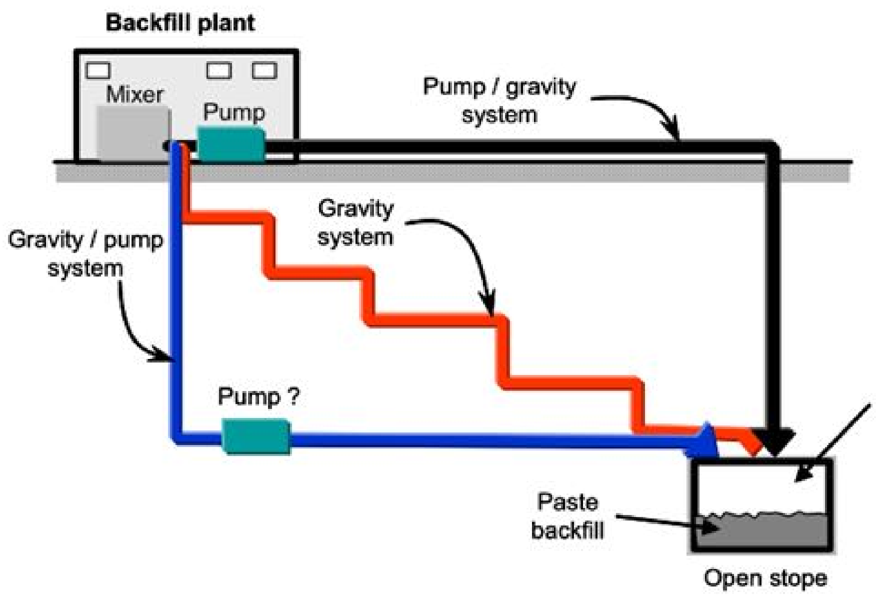

Figure 1. Basic configurations for paste backfill distribution systems (adapted from Thomas 1979)

Figure 2. Paste fill pipeline diversion

The process of filling a stope requires a multi-step process to ensure the CPB mixture matches design criteria set forth by the mine so the backfill has sufficient strength to handle the stresses incurred during adjacent stope excavation. The first step in the process is to flush the pipeline with water to verify the pipeline is clear. The size of the water slug must be accurately measured, as water content drastically affects the cure time and ultimate strength of the cement. After the slug flushes to the correct stope, paste is then pumped into the pipeline. Following the filling of the stope, the line is flushed again with another slug of water to ensure there is no paste left in the line, which would lead to a clogged piping system. At this point, the system is ready for changeover to the other leg of the piping network.

In most backfill operations, the location where the two pipelines split consists of multiple high-pressure pipes or ductile iron pipes with welded linings and couplings, so these pipelines can be manually welded or coupled to re-route the paste to other sections of the mine. This process requires the manual removal and reinstallation of the piping for every change in backfill reticulation. In order to reticulate the paste flow to another section of the mine, teams of two or three miners are required to go to the diversion location and manually arrange pipeline pieces to re-route the pipeline. Depending on the project, this process might be repeated at every level of the mine. Reticulation rates of mines vary depending upon site conditions and mine standards, but in most mines this process takes place frequently. Each reticulation may require workers to change just one paste diversion line, but depending on the size of the underground network size, it could require upwards of four to five diversions.

MINERALS BACKFILL PROJECT

In 2014, a minerals company was in need of a safe and efficient solution for diverting their underground tailings/paste backfill flows into new areas. The 6”/150mm main feedline that ran along the ceiling was shut down and flushed with water as was needed to remove any tailings and paste backfill that built up during the filling process. This process would typically take more than an hour, during which time a pipe jack and trailer would be brought to the area of the mine to help with movement of the schedule 120 pipe. The line was uncoupled, the main pipe was rolled into position with the pipe jack, and the uncoupled section of pipe was joined with the next pipe section used to divert the backfill to the next stope to be filled. The line was then restarted and tailings and paste backfill was sent down the line. In timed studies, this process has shown to take a minimum of three hours per transition.

Working with Victaulic, the customer presented this issue shortly after a near miss safety event during one of these changeovers. The solution was a revolutionary design that sets a new standard for backfill paste system diversion.

After installing the Victaulic Series 725 diverter valve, the main line was flushed with water and the valve was actuated with the use of an air compressor. The valve was then able to divert the tailings in just 90 seconds, saving the company from having to send two or three men down to the area for more than an hour to manually divert the flow. Using the diverter valve also negated the safety concerns associated with handling the schedule 120 pipe due to its weight. Since the manual process was undertaken almost every other day, the company saves over 65 man hours every month.

Figure 3. Victaulic Series 725 Diverter Valve installation

The Victaulic diverter valve was hung from the ceiling of the mine in line with the current piping system, as in Figure 3. Only minimal plumbing adjustments were needed for the installation procedure. The pipeline system has a throughput of approximately 865 thousand gallons per day. This pipeline runs at approximately 30 percent solids content, and has run a total of 2.6 million tons of backfill through the valve without incident since installation.

THE SOLUTION

In 2013, Victaulic introduced the industry's first grooved-end valve designed specifically for paste backfill systems. From installation to backfill completion, the Series 725 Diverter Valve is easy to install, simple to maintain, and cost efficient. Providing 180-degree service, the valve reduces the need for crews to manually redeploy backfill piping systems to other areas of the mine, reducing safety risks, saving time and reducing costs.

Designed with durability in mind, the diverter valve is built to withstand the high pressures experienced in backfill reticulation (the valve is rated to 1,000 psi/6.9 MPa). The valve utilizes specially designed flow path characteristics to reduce wear due to abrasive slurry and high flow conditions. Additionally, the valve is offered with numerous options for actuation, depending on site-specific needs and availability.

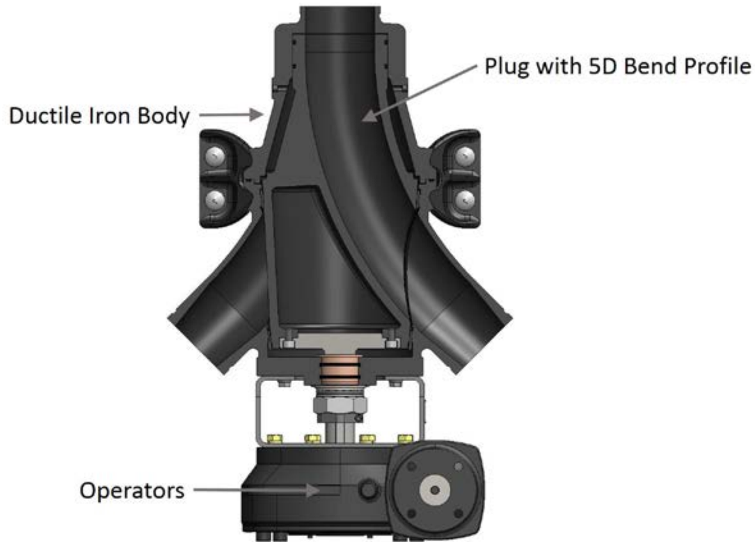

Figure 4. Victaulic Series 725 Diverter Valve

Ease of Installation

By eliminating the need for constant manual rerouting of paste backfill flows, the reticulation operation of backfill pipeline systems is made fast and simple. One or several diverter valves installed at every level of the mine can manage backfill reticulation without wasting time on deploying manpower. Diverter valve installation is made simple with the grooved piping system that ensures that the plug aligns properly with the pipeline to improve performance and reduce wear. The grooved connection allows for this valve to be installed using just three couplings attached to the piping network.

Durability

The paste backfill mixture is unique to each mine site and can be composed of a variety of corrosive and abrasive materials including sand, concrete, and tailings. These materials cause pipe ruptures over short time periods in these applications. Pipe ruptures lead to filling unplanned sections of the mine with paste backfill, which inevitably leads to costly maintenance and repairs. The diverter valve's PPS coated ductile iron body and plug are able to resist the corrosion and abrasion caused by heavy paste. The plug of the diverter valve was designed to handle the high wear and pressures by incorporating a 5-D bend curvature.

Using 5-D bend profile, the valve ensures a smooth transitional flow of backfill. Smooth flow of paste backfill is essential to reducing the wear effects that are standard for these operations. Figures 5 and 6 show the flow characteristics between different bend profiles, as well as the profile used for the diverter valve. Additionally, the smooth profile eliminates the need to continuously flush pipelines as the valve is not prone to clogging that occurs due to abrupt change in direction at the slit locations throughout the backfill system.

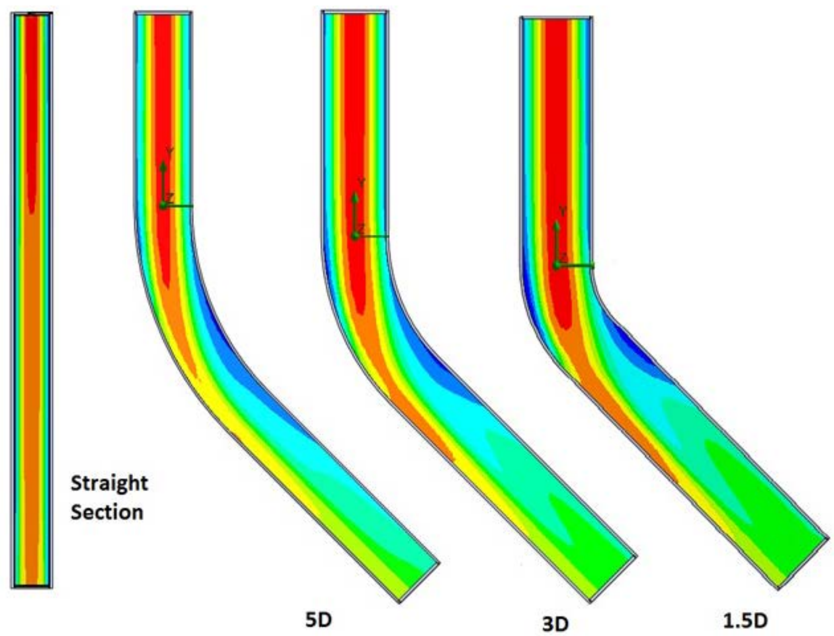

Figure 5. Bend radius effects on flow characteristics

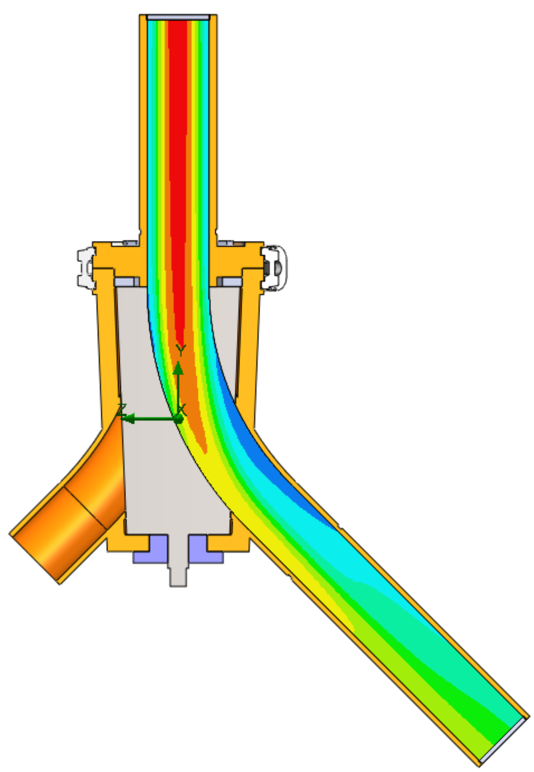

Figure 6. 5-D bend valve characterization

Remote Operation

The valve offers three different standard actuation options: manual gear operator, pneumatic operator, and a multi-turn electric motor operator. Mine sites that require someone be present for the line transition can utilize the manual operator, which includes internal gear limit stops to assure orientation of the plug is precise to prevent premature wearing of the valve. This reduces operator error, as does the large position indication arrow attached to the top of the manual operator, making it easy to know the exact operation location of the valve, especially considering this work is often performed in poor lighting conditions.

Remote operation of the valve is a key feature that allows operators to change the flow of paste from the safety of the control room. The valve is available with an electric actuator (Figure 7) or a pneumatic air motor for remote switching of flow diversion. This allows the mine site to set up a complete PID system where they can use timers, sensors, and Victaulic valves to detect the exact conditions of the piping system and dictate flow diversion at the precise moment all without touching a tool. Remote control of the valve not only improves on-site safety for crews but also allows for quicker paste backfill re-routing and streamlined backfill operation.

Figure 7. Electric actuator application install

CONCLUSIONS

The Victaulic Series 725 diverter valve has surpassed expectations in operational use for paste backfill flow control. With ease of installation and operation, the diverter valve allows mine operators to backfill more efficiently and safely in order to advance operations more quickly, generating considerable cost savings through the reduction of labor and maintenance downtime while improving operational efficiency and overall productivity of the mining operation.

With more than three years of operational experience since the diverter valve's launch and more than 70 installed valves processing nearly 30 million tons of paste, considerable data has been collected on the valve's capabilities and performance. Figure 8 below shows some current data from various sites:

Mine Site – Fill Material	Tonnage (US Tons)	Installation time/ No. of Reticulations
Site A (GRLC) – Paste	650,000	18 Months / 152 Reticulations
Site B (GCC) – Paste	250,000	12 Months / 175 Reticulations
Site C (GSB) – Sand	1,250,000	12 Months / 135 Reticulations
Site D (SW) – Paste	2,600,000	2 Years / 330 reticulations

Figure 8. Current data

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