INJECTION OF LIMESTONE INTO UNDERGROUND MINES FOR AMD CONTROL

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ABSTRACT

A pneumatic stowing device developed by Burnett Engineering, Inc. was used in West Virginia to seal a mine portal. The purpose of this project was threefold. First, it demonstrated an improved underground mine filling system and made the technology known to those who work to correct mine subsidence problems. Second, it sealed a hazardous mine from public access. Third, limestone filling of underground mines with acid mine drainage (AMD) is an effective method of reducing or eliminating acid run-off. The mine portal was pneumatically backfilled with 120 short tons of ASHTO number 57 limestone using the Burnett Pneumatic Pipefeeder for a distance of 70 ft and sealed. The portal was successfully sealed in less than four hours. The flow rate of water draining from the mine at the portal varied between 2 and 80 gpm. This flow rate remained unchanged during the first eight months after sealing and improved the water quality from a pH of 2.8 before the mine was sealed to a pH between 3.8 to 7.0. Acidity concentrations decreased from around 550 mg/L to net alkaline water during this same time period. Since January 1996, much higher flows caused much of the water to flow across the top of the limestone minimizing treatment.

INTRODUCTION

Mine subsidence and acid mine drainage (AMD) are two important problems impacting the coal fields of Appalachia. Decades of surface and underground mining with few regulations governing coal extraction and reclamation have left hundreds of square miles of land susceptible to subsidence and thousands of miles of streams contaminated by AMD. With the passage of the Surface Mining Control and Reclamation Act (SMCRA) in 1977, an abandoned mine land reclamation fund was established, and money for this fund is generated by a tax on extracted coal by current coal operations. The fund is used to rectify subsidence problems, land slides, and other hazards from abandoned mines. AMD is also addressed when these abandoned areas are reclaimed.

Mine subsidence is a particularly difficult problem because an area may subside so quickly that it endangers human life and property. Once the subsidence occurs, filling the void with gravel, fly ash, or grouts of concrete and limestone is usually accomplished by the use of expensive drilling/injection equipment. Sometimes access to the subsided area is limited which restricts the degree and quality of the subsidence filling project. Cost effective methods to cast or propel mine-filling materials into mine voids are needed to enhance subsidence reclamation. Part of the solution requires that equipment used for propelling these materials must be portable and durable with minimum breakdown and repair.

This project demonstrated the filling of deep mine voids with rock by a Pneumatic Pipefeeder at an abandoned mine site (Burnett 1990). The Pipefeeder was developed by Burnett Engineering, Inc. and was originally tested at the U.S. Bureau of Mines, Subsidence Abatement Investigation Laboratory in 1989. The Pipefeeder was set up at the abandoned Sovern Run deep mine in Preston County, West Virginia, and used to seal a portal with 120 short tons (st) of 1/4-in size limestone. An additional benefit from stowing the portal with limestone is that AMD discharging from the portal may be treated by its contact with the limestone.

PNEUMATIC PIPEFEEDER

A drawing of the Pneumatic Pipefeeder is shown in Figure 1. The Pneumatic Pipefeeder is a simple and inexpensive pneumatic stowing tool with no moving parts. Fill material is metered into the hopper of the Pneumatic Pipefeeder at a controlled rate. The material to be stowed can be metered into the hopper by a belt conveyor or other material handling device. The material fed to the Pneumatic Pipefeeder hopper falls through the Pneumatic Pipefeeder and is intercepted by the flow of a high velocity jet of air. Air is supplied to the Pneumatic Pipefeeder at 100 pounds per square inch (psi) and expands to pipeline pressure which is 4 psi or less (a function of total air flow, solids flow, pipe diameter and pipe length). During this expansion the air velocity is accelerated to 1,600 ft/sec and, after mixing with the solids and air velocity, is reduced to the pipeline velocity of 120 to 150 ft/sec. The average material velocity after it has been accelerated is about one-half the air velocity. Figure 2 shows the distance material can be transported for various pipe lengths and air and material flow rates.

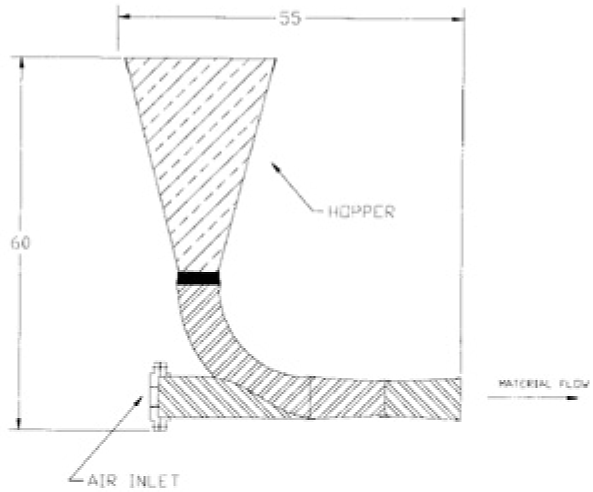


Figure 1. Diagram of pipefeeder assembly.

The material velocity is 60 to 120 ft/sec in a 6-in diameter pipe when 100-psi air is supplied at 1,500 ft^3/min to 2,000 ft^3/min. The material exits the pipe, which can be up to 300 ft long, and is cast up to 70 ft from the pipe end, depending on the angle of the pipe end to the ground, Typical material flow rates range from 25 st/hr to 50 st/hr depending on the air flow available and the pipeline length. Figure 3 shows the relationship between throw distance and mine height. The pipe outlet must be angled upward to maximize the distance thrown. The optimum angle of the pipe at the exit varies with different mine heights. Higher mine entries or room heights result in longer material throw distances.

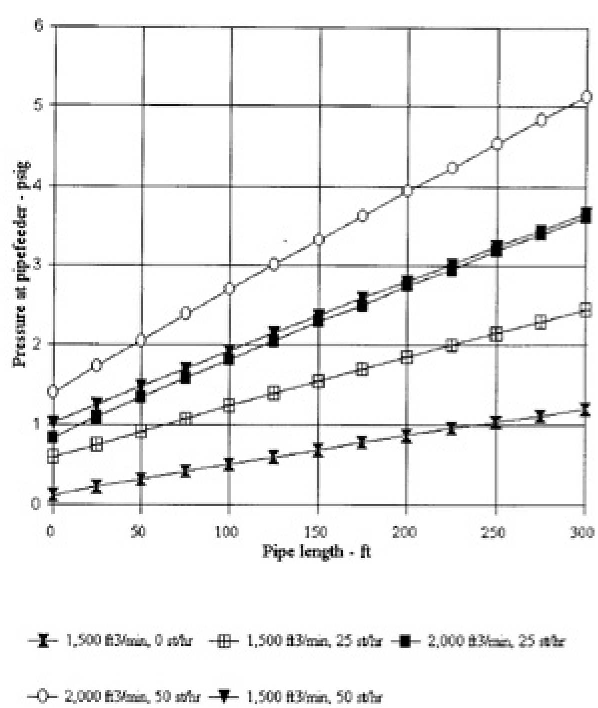
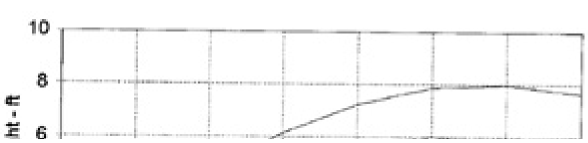


Figure 2. Pressure developed at Pneumatic Pipefeeder for various



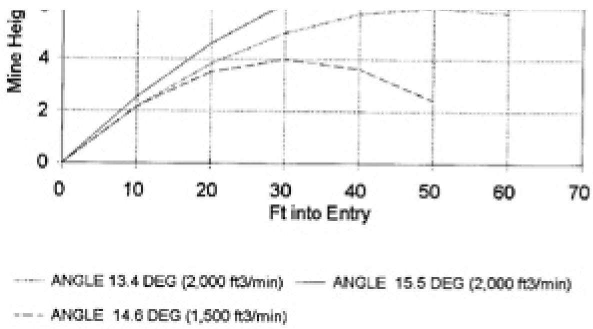


Figure 3. Material throw distance from the end of the pipe as a function of pipe angle, air flow and mine height.

air flow and material flow rates for 6-in diameter pipeline lengths to 300 ft.

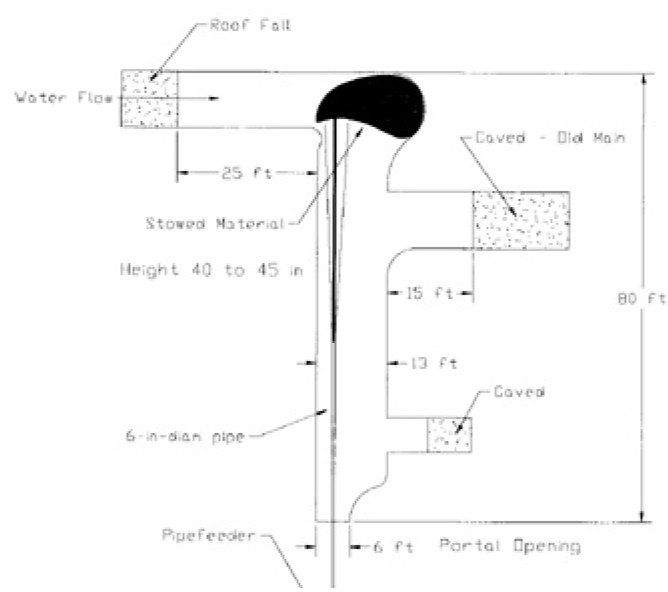
DEMONSTRATION SITE

The Sovern Run portal is located at the northwestern boundary of Preston County near Valley Point, WV, about 15 miles southeast of Morgantown, WV. A mine map of the Sovern Run Mine is shown in Figure 4. The mine and surface is owned by John Peasley who lives on the property. The mine portal was easily accessible and had evidence of roof falls. The roof had caved at the opening causing the bottom of the opening to be at the original level of the roof. Beyond the opening, the floor dropped about 3 ft to the original floor. The fall at the opening had backed up water in the mine to a depth of 3 ft. Due to the slope of the entry, the water depth at 40 ft inside the entry decreased to less than a foot deep. Water quality exiting the portal had been monitored for two years and had a pH of 2.8 and acidity values of 500 mg/L. The mine therefore was not only a danger to the public since it was open at the face, but it was also draining highly acidic water.

PNEUMATIC PIPEFEEDER DEMONSTRATION

The Pneumatic Pipefeeder was located near the portal with a 6-in diameter pipe extending 30 ft into the portal. Figure 4 is a plan view of the portal and the pipefeeder setup. A conveyor belt fed the gravel to the hopper of the Pneumatic Pipefeeder at a steady rate which was controllable from the conveyor. A front-end loader kept the conveyor hopper filled from stock piles of ASHTO number 57 limestone. Two 825 ft^3/min, 120 psi air compressors in parallel were used to power the Pneumatic Pipefeeder.

The plan called for ASHTO number 57 limestone to be stowed into the portal to seal the opening. Based on entry into the mine, the pipe was pushed as far as possible into the entry from the outside to about 30 ft. The pipe was shortened as necessary as the portal was filled with limestone by removing pipe sections until the gravel face reached the face of the portal.



The Pneumatic Pipefeeder and 50 ft of pipe were installed at the entrance of the mine by two people in approximately 15 min. The conveyor rented for the project took 2 hr to set-up. The conveyor was a 50-ft long belt conveyor, larger than necessary for the task, but was the only one available at the time. The compressors were parked on the road above the portal with a hose dropped down through the brush to the Pneumatic Pipefeeder. A small crawler tractor with a front-end loader was used to feed material into the conveyor hopper. The equipment setup was completed by 5:00 PM on Monday, 15 May 1995. Stowing was started and 60 st of ASHTO number 57 limestone gravel were stowed in the mine by 6:45 PM. With half of the gravel placed on the first day, the system was not operated again until a demonstration of the equipment took place for interested parties on 17 May 1995. The stowing was restarted upon arrival of the visitors. During the demonstration, the portal was filled out to the opening and completely sealed in about 1 3/4 hr. A total of approximately 120 st of limestone was stowed in the mine void.

Figure 4. Sovern Run Mine plan view of the Pneumatic Pipefeeder demonstration site in Preston County, West Virginia.

WATER QUALITY BEFORE MINE SEALING

During 1992 and 1993, the quality of water draining from the Sovern Run Mine varied between pH 2.7 to 3.1 and acidity concentrations ranged from 376 to 570 mg/L. Iron concentrations were between 22 to 60 mg/L, while aluminum concentrations varied between 38 to 58 mg/L. Flows ranged from 5 gpm to >80 gpm (Table 1).

After stowing 120 tons of limestone in the portal, water quality improvements were seen. Water pH increased from 2.8 to 5.3 immediately after backstowing, then stayed pH 6.0 for the ensuing five months. Acidity concentrations were decreased from an average of 458 mg/L to 42 mg/L, and alkalinity increased from 0 mg/L to an average of 57 mg/L. During the eight months after sealing, there appears to be a trend of decreasing alkalinity generation by the limestone.

Starting in January 1996, very high flows caused the water to short circuit and the water flowed out at the top of the limestone. As evidenced by the water quality, very little of the water contacted the limestone for treatment, and it has largely returned to its pre-stowing quality. It is not clear why the water is not flowing through the limestone. Small amounts of floc and thin coatings of iron hydroxides can be found in the water and on the limestone, but it does not appear that enough floc has precipitated to plug the limestone pores restricting water movement. Further sampling of the water during 1996 will give an indication of the longevity of the limestone in treating AMD from the portal, particularly when normal flows resume.

CONCLUSIONS

This project demonstrated to those agencies and companies who design and install mine closures that pneumatic stowing is a very effective method of sealing a mine portal. The seal constructed at the Sovern Run Mine was very tightly packed with gravel, making it nearly impossible to dig out without mechanical equipment. While providing a tight seal, the stowed material allowed water to drain from the mine initially, but high flows during a particularly wet winter has resulted in the water flowing over the top of the limestone. The portal was filled with 120 st of material in 4 hr which included all pipe moves. An additional benefit to constructing the seal at the Sovern Run Mine is the water draining from the mine increased from a pH of 2.8 to a pH of 6.0 during May to December 1995. Since January 1996, much higher flows have resulted in the water flowing across the top of the limestone minimizing treatment.

Historically, agencies that specify mine closures are often not specific on the methods used to seal the mine. Too often mine closures are allowed to be constructed by simply pushing rock and debris into an opening with very little material filling the mine void more than 10 ft from the portal face. History has shown that this type of closure can subside and the openings can reappear over time, creating a dangerous condition that invites people to enter a mine that is thought to be closed.

The development of this pneumatic tool was undertaken by the U.S. Bureau of Mines Abandoned Mines Program to provide state and federal agencies with the means to effectively backfill mine entries and mine voids. It is now up to these agencies to take advantage of this work and the work of other contractors by creating mine closure specifications that ensure that the improved methods are applied. Proper closure of mines can greatly improve the probability that no person is injured or killed by entering a mine that was closed in a poorly engineered manner.

Table 1. Water quality measurements at Sovern Run Mine.

Date	pH	EC S/m	mV volts	flow gpm	acid mg/l	alkal mg/l	Fe mg/l	Al mg/l	Mn mg/l	Mg mg/l	Ca mg/l	SO_4 mg/l
Before												
2/19/92	2.8	1.35	-	30	550	0	47	55	8	-	78	845
4/2/92	2.7	1.35	-	40	570	0	60	58	8	-	66	942
6/26/92	2.9	1.45	-	15	466	0	28	51	11	-	84	893
9/3/92	2.8	1.35	-	5	399	0	24	40	8	-	69	753
1/26/93	2.9	1.34	-	35	447	0	31	38	7	-	73	788
2/23/93	2.9	1.35	-	80	424	0	26	42	8	-	71	771
4/30/93	2.9	1.45	-	40	445	0	36	49	8	-	69	868
5/26/93	2.9	1.56	-	50	544	0	31	46	8	-	82	926
6/30/93	2.9	1.59	-	20	535	0	26	53	9	-	87	948
7/14/93	3.0	1.53	-	15	245	0	24	53	9	-	90	917
10/8/93	3.0	1.48	-	20	498	0	31	51	8	-	89	925
11/15/93	3.1	1.17	-	50	376	0	22	40	6	-	66	667
After												
5/23/95	5.3	0.65	244	15	78	0	0.3	2.0	6.3	26	224	225
6/28/95	5.7	1.27	190	25	60	108	0.3	0.6	7.4	42	190	198
8/1/95	5.9	1.57	170	2	35	80	1.4	0.4	7.2	58	161	160
8/30/95	5.8	1.44	214	10	34	76	2.1	0.5	6.8	64	226	204
10/4/95	5.8	0.77	142	40	43	34	7.0	0.7	4.5	39	134	320
11/9/95	6.8	0.23	220	50	2	42	-	-	-	-	-	-
12/10/95	7.0	0.31	245	1	0	48	0.9	0.4	1.0	-	-	-
1/26/96	3.2	1.84	---	126	748	0	81	104	11.1	115	146	1580
2/23/96	2.9	2.02	456	77	993	0	95	121	10.0	95	123	-

ACKNOWLEDGMENTS

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