APPLICATION OF TAILING SAND AND WATER AS BACKFILL MATERIAL IN METAL MINES

By
Sun Henghu1 Han Jianmin2 Li Shuqin3

ABSTRACT

This paper analyses problems associated with cement based technique in metal mines, and provides a new mining technique of packing the tailing sand and water into solidified material. In the new technique, the cementing agent is a solidifying material containing a high percentage of water and tailing sand. The sand and water solidify into the packed body at the same time. The slurry of the packed body varies widely in concentration and suitability for different mining conditions. It consists of two liquid materials, each composed of a cementing agent, tailing sand and water. The thick liquids are transported to the packing place at the same time. Their pumping property is good; they do not solidify or block up the pipe during transportation. At the packing place, the two liquids are evenly mixed. The mixed liquid flows out well and its solidifying speed is so fast that it solidifies into a packed body within a very short period of time. The compressed strength of the packed body can reach 1.2-5.2MPa in one day, which satisfies the requirements of different mining conditions. By using the new mining technique, all the tailing sand can be used again in the packed body and it is low in cost and investment. The mechanisation is easy and thus the working efficiency is increased and the use of labour decreased. Contamination problems caused by excess water drainage under the ground are resolved.

INTRODUCTION

In the non-ferrous and precious metal mining process, the packing technology is well established and has been widely accepted in China. A new packing technology, introduced in this paper, is called the Tailings-all Packing Technique. It uses chemical agents to cement and solidify all tailings including water, into solid material that is strong enough to be used in packing and compares well with conventional methods. This technique will solve the problems of sourcing the inert solid fill materials, and also saves dealing with the tailing on the ground. As a result, costs will be reduced, land use reduced and environmental contamination due to tailings prevented. Cement is usually used as a principal adhesive material in the conventional cement-tailing-sand packing techniques, but from this arise problems such as the dissipation of packing slurry underground, preparation of the tailings, and production and transportation of the high density packing material.

In China, the traditional cement tailing-sand packing technique is to prepare slurry of 60%-70% in weight on the ground, then deliver it to the site to be used through drill-holes or pipelines. This technique is simple in operation and reliable in quality. But the surplus water in the slurry must be drained away. In order to make the slurry dewater easily, fine sands in the tailings, i.e. those below -37μ, must be sorted and taken away. Only coarse sands, greater than +37μ, can be used. In summary, this technique requires tailing screening equipment on the ground and facilities underground dewatering the tailings slurry. Thus, this technique is complex and costly. In addition, in the dewatering process, cement and fine tailing sands will

1. Dr & Prof. Beijing Graduate School, China University of Mining Science and Technology, Beijing, China
2. Northern Jiaotong University, Beijing, China
3. Beijing Graduate School, China University of Mining Science and Technology

11th International Conference on Ground Control in Mining, The University of Wollongong, N.S.W., July 1992.
easily flow away with the water. This results in greater cement addition than necessary, a lower rate of cement utility and poorer strength of packing body. The escaped material will contaminate the working environment underground. The lengthy dewatering and very slow process of solidification means that a long period of packbody maintenance is needed, thus the operational cycle of packing and mining is affected. For mines producing insufficient tailings, a sand grinding system can be built, otherwise river sands may be purchased to make up the shortage. However, it is difficult to build and maintain the dam to store the sorted fine tailings.

The high-density tailings-all packing technique is in the process of research and development. This technique compensates for some deficiencies in conventional cement-tailing sand packing techniques. However, the problems of low production capability, difficult transportation and the need for dewatering still remain unsolved.

The pump packing technique, using tailing sand, has been used in various foreign mines. The density of the packing material is high, normally more than 80% in weight. It requires no dewatering. All tailing sands can be used as solid packing materials, so the tailing sand utility is high. However, the construction of a slurry preparation and transportation is expensive. China imported this technique but trial use shows that it is not suitable for China, as it is very expensive and pipeline blocking often occurs.

To remedy this, a packing technique was invented to cement and solidify the tailing sands and water from the washery plant. In this new technique, the density range of the packing slurry is wide and its pumpability is good. It can be transported several kilometers by pumps without pump and pipelines being blocked during transportation. The outstanding features of this new technique are that the tailing sand need not be dewatered and screened - all the tailing sands and water from the washery plant can be solidified into a packing body. Thus, the packing ability and the utility of the tailings are great, the packing cost is low, and there is no contamination under, or on, the ground. After being packed into the working face, the slurry solidifies at a controlled rate that ranges from several minutes to several hours. Because the maintenance time of the packing body is shorter, mining and packing efficiency will be higher. The strength of the packing body is even higher - over 2 MPa, fully meeting the safety and technical requirements of the packing mining method. In addition, this new packing technique involves less investment, is simple in construction and easy in operation.

PACKING SYSTEM

In the new packing technique, all the tailing sands and water from the washing plant are piped equally into two agitators, and two kinds of solidifying materials, A and B, are added into the agitators respectively with water. The agitators are then disturbed to make the materials reach the state of suspension. Both slurries can be kept in liquid form for 24 hours, or for several days, without solidification and they will still be pumpable. They can be delivered several kilometers away by pump without blocking the pump and pipeline during transportation. Before being packed, the two slurries are pumped into a mixer at the packing site simultaneously from two sets of transporting systems, after which the evenly mixed slurry is delivered into the packing place. Once the two slurries are mixed, some reaction takes place for some time. Because a large part of the water in the mixed slurry can be solidified, the mixed slurry with sand and water, quickly solidifies to a packing body containing a large amount of solid water. The packing system is shown as in figure 1.

This packing system is simple in structure, flexible and convenient in construction, easy to control and its equipment is inexpensive. The packing slurry can be transported at low or high density, so the technical difficulty of packing is small. As all the tailing sands in this system need not be dewatered and screened, the packing slurry is easy to produce and the packing ability is great.

FEATURE OF PACKING MATERIAL

The packing material used in this paper is compounded by adding some solidifying material directly into tailing sand from the washing plant which is not dewatered or screened. The density of the tailing sand from the washery plant may range from 15% to 70%. In...
In other words, both the tailing sand and the packing slurry have a wide density range, making it suitable for various conditions. Before being packed, the packing slurry is prepared in two parts: part A and part B. These two slurries are all floating liquids that are composed of the tailing sands, water, and solidifying materials A or B respectively. The pumping and transporting properties of the two slurries are good. They can be in a liquid state for more than 24 hours and pumped for several kilometers. These two slurries are transported in parallel to the packing location by two separate pipes and are evenly mixed in a 1:1 ratio through a mixer to form the packing slurry. The mixed slurry is cast into the packing place and is, for some time, in a liquid state which means it can flow smoothly into the packing place. After this, the mixed slurry solidifies to a solid packing body in from 5 to 10 minutes to several hours if properly adjusted.

In addition, some other materials such as cement, coal ash and quartz sand can also be added into the slurries before or after mixing.

Solidifying materials A and B have been invented by the authors especially for packing in metal mines and for support in coal mines.

From the point of view of the packing and productivity, the strength of the packing body must be high enough to maintain normal working of the mining equipment on the packing body and to ensure that the safety requirements of mines are met when used as supporting materials.

Table 1 shows the test results of packing body strength from various metal mines in China.

Compared with packing body strength required, and used, in handbooks and relevant documents in China and other countries, the test data of each recorded time shown in Table 1 are in accordance with all standards of packing and mining production. If the packing body is required to be of such a low strength that is just in a solid

<table>
<thead>
<tr>
<th>Mines</th>
<th>Tailing Sand Density %</th>
<th>Tailing Sand ratio in slurry</th>
<th>Packing Body weight kg/m³</th>
<th>Single axis compressive strength MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6 h</td>
</tr>
<tr>
<td>Zhaoyuan Gold Mines</td>
<td>25</td>
<td>16:18</td>
<td>1300</td>
<td>1.10</td>
</tr>
<tr>
<td>JinChuan Cooper Mines</td>
<td>45</td>
<td>14:16</td>
<td>1550</td>
<td>1.40</td>
</tr>
<tr>
<td>Fankou Lead and Zinc Mines</td>
<td>35</td>
<td>12:14</td>
<td>1600</td>
<td>1.15</td>
</tr>
<tr>
<td>AnQin Cooper Mines</td>
<td>20</td>
<td>14:18</td>
<td>1280</td>
<td>1.40</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>10:14</td>
<td>1410</td>
<td>1.60</td>
</tr>
</tbody>
</table>

11th International Conference on Ground Control in Mining, The University of Wollongong, N.S.W., July 1992.
state, solidifying materials A and B can be added which will greatly reduce the cost of the packing body.

When the cemented tailing sand slurry is used, problems always exist such as sedimentation and segregation, isolation, leaking out and environmental contamination. This makes the packing body strength uneven and lower than the designed value. The packing slurry discussed in this paper has a wide density range and its solid particle size is in a suspension state. All the slurry mixes evenly into a solid packing body since there is no extra water and no other materials coming from the packing body when the slurry solidifies; thus there are no problems such as mentioned above. The strength of the packing body is even and close to its designed value.

The tailing pack technique described in this paper is economically viable and technically advantageous. In applying this new technique, it has been shown that the amount of solidifying materials A and B is about 100 to 200 kg per cubic meter of packing body. It is economical compared with the cement tailing sand packing technique. Also, there is no need to prepare ground sand or to buy sands in the case of those mines producing insufficient tailing sands, and because there is no dewatering, screening and water draining from the slurry underground, the cost of the auxiliary work and transportation of the tailing sand are saved. Also, the working environment underground is greatly improved, and there are many technical and economical benefits for the mine.

APPLICATION

Every mine has its own conditions and even in the same mine, different areas may have different conditions; the packing and mining technique should be determined accordingly. The packing technique reported in this paper can be modified or combined with other packing techniques to meet various requirements of mining production.

1. In mines with a high output of tailing sands, all, or part of, the tailing sands will be used without screening, thus the number of sand reservoirs is reduced, their service life prolonged and the difficulty of building the fine tailing sand dam overcome. In the mines with a low output of tailing sands, there is still no need to grind the sand or to buy river sand for packing because water can be used as a substitute for the solid packing material in slurry.

2. In the upward layer-by-layer packing and mining technique, the surface strength of the packing body must be suitable for the mining equipment to move and work on it. The thickness of this higher strength surface is about 0.3 to 0.5m. The high strength layers are produced by the addition of high-water-fast-setting packing material. In this system, solidifying materials A and B are added into the water with little or no addition of tailing sand. The working surface of the packed body is smooth and its surface strength grows quickly, because the packing slurry of the high-water-fast-solidifying material is low in density, flows well and is fast to solidify. By introducing the above method, there will be some time saving in pack construction by as much as 24 hours, thus mining productivity can be greatly increased in comparison with the traditional packing method. In addition, there is no loose top contact problem in the traditional packing and mining technique because of the low density and easy flowing properties of the high water slurry.

3. For the mines that have long been using the after-screening tailing-sand packing technique, the discarded coarse tailing sand may also be used for packing while the previous fine tailing sand waste can now be used to make the packing slurry by the method introduced in this paper. This not only solves the problems of environmental contamination and tailing dam construction, but also overcomes the shortage of sand supply and hence the wasted and harmful material becomes a useful product.

CONCLUSION

The new packing technique addressed in this paper can be used alone or in conjunction with others, one compensating the other, so as to produce comprehensive economic benefits. From the authors’ research, the following conclusions can be drawn:

1. The packing system reported in this paper is simple in structure, inexpensive in equipment, convenient in construction and easy in implementation.

2. The tailing sands and solidifying materials A or B used to form the packing slurry have a wide density range from 15% to 75% by weight. The production, transportation and packing abilities of the packing slurries
are so great that the mining and packing work can be done simultaneously. In addition, the packing slurry need not be sorted. All the tailing sands and water from the washery plant solidify into the packing body, which reduces environmental contamination and simplifies the construction process.

3. The flowing property of the packing slurry is good, so the levelling and top compaction of the packing body can be realized. The solidifying speed of the packing slurry and the rapid strength forming properties of the packing body reduce the interruption between mining and packing, thus increasing the mining efficiency. The strength of the packing body fully meets the mining requirements of coal mines.

4. Solidifying materials A and B are rich in raw resources, easy in production technology and have no side-effects.