Design of Rehabilitating Submerged Mines Economically, Speedily and the Relative Factors

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ABSTRACT

Coal mine were often submerged in mining.In this paper,the main methods of rehabilitating submerged mines,the affecting factors and the applicable conditions for the methods are discussed according to the many years' experience in China.We divide the rehabilitating methods into three kinds,these are the methods of drainage after blocking and blocking after drainage and absolute drainage.The affecting factors are water intrusion point conditions,hydrogeological condition,technological equipment and power supply conditions and the hydraulic contact condition between intrusion water resource and the near water supply fields. At the last,the economic benefit should be considered.

Because of the complexity of mine hydrogeological condition in China and the limitation of technique and knowledge,it is impossible to put mines to be submerged to an end completely.Therefore,it is impossible to make use of the past experiences.It is necessary to block up water intrusion points speedily and rehabilitate mine production as soon as possible by drainage in case mine is submerged.

The work of blocking up water intrusion point should be developped in short time,little grouting holes,little grouting materials,reliable quality of blocking and little investment in order to reduce to amount of drainage,rehabilitate mine production speedily and protect ecological balance and water resources.

It is important to determine the location of water intrusion point in order to block up it quickly.After the determination of water intrusion location,the choice of grouting point and the arrangement of grouting holes is the crux of blocking up water intrusion.Generally,it is effective to block up the water passageway which links the intrusion point and the pit.In order to make grouting effective,we should choose appropriate grouting method and materials according to that the water is motionless or flowing.When the water intrusion point is blocked up,appropriate drainage method should be chosen to drain off the water in pit.The installation of drainage equipment may be going on with the blocking process so as to shorten the time of mine recovering.

Blocking up water intrusion point and drainage work must be in a completed design of

rehabilitating,the technological,economical and practical design is a vital factor for the success of blocking and drainage.Therefore,making a good design is important and the design maybe needs to be continuously modified in the process so as to get the goal more effectively.

On the basis of the mine hydrogeological condition,the amount of the motionless water or the discharge of the flowing water and the condition of technique and equipment,the rehabilitation of submerged mine must use the methods of drainage or blocking.We divide the methods into three kinds,**that are blocking after drainage and drainage after blocking and absolute drainage.**The examples of the submerged mine rehabilitation are seen in the following table.

The method of drainage for rehabilitating submerged mines is active when the economical and technological conditions are admitted.It drains off the water in mine firstly and continuous drainag reduce the water pressure and makes the pressure in safety. So, the mine rehabilitated becomes also safe.But,when the discharge is on a very large scale,the drainage needs energetic equipment,long time and large investment and sometimes is limited by inadequate power supply and small tunnel section conditions and the difficulty of large equipment installation.

Draining off the water in mines by the method of blocking after drainage also needs energetic drainage equipment and also is limited by power supply,equipment and tunnel section conditions.Sincethe drainage does not continue after blocking up the water intrusion point,the water head in the aquifer can rehabilitate and there also is a potential water intrusion in mining. Ordovician limestone layer water and some eighth limestone layer and the second limestone layer water intrusions in some coal mines in North China and Maokou limestone water intrusion in South China are the examples.

Generally,the method of drainage after blocking is comparatively economical.Because it only needs draining off the water in mine in order to rehabilitate the production after blocking up the water intrusion,it greatly reduces the drainage investment.Some mines can only use the above method according to the technique and equipment condition at now. But, using this method also does not continue drainage after blocking up the water intrusion,the water head can rehabilitate and there is also a potential possibility of water inrush and five times mines submerged in four years in Hanwang coal mine is an example.In one word,the rehabilitation design plays a vital role for the rehabilitation speed,investment and safe production.

It was indicated by many mines rehabilitations that the design is determined after the comparation of different designs in technique and economic on the basis of hydrogeological conditions,technological equipment,installation,power supply conditions and the influences for near mines.The following factors should be considered in the determination.

1 THE KNOWLEDGE OF GEOLOGICAL CONDITION OF THE SUBMERGED MINE AND ITS WATER INTRUSION POINT CONDITION

(1) Generally,the method of blocking after drainage should be used when there are a little faults and the faults have no hydraulic contact with each other well,the transmissivities and storativities of the faults are weak,the aquiclude layers are stable and thick and the water intrusion point and geological condition are clear.For example,there was a water intrusion in Fengfeng Mine 1 when the 1532th working face was near to F1 fault,because the geological condition in the intrusion point area was clear,the method of drainage after blocking was used and made a success.Another example is in Zibo Xiajialin

The Examples of Rehabilitation Methods Used in Submerged or Partialy Submerged Mines

The mine or place of intrusion	Intrusion time (Year,Month,Day)	Intrusion elevation(m)	Water table (m)	Water pressure (MPa) or (Kgf / cm^2)	Max. discharge (m^3 / min)
Jingxing Mine 3	1942,6,2	147.8	217.9	0.686(7)	8
Jiaozuo Lifeng Mine	1956,2,8	−115	80.0	1.91(19.5)	5.4
Yanmazhuang mine 101 working face	1960,10,31	−0.47	96.0	0.868(9.65)	15
Lihe Mine	1937	−6	92.14	1.176(12.0)	16.9
Zibo shuangshan Mine	1958,8	-145.3	197.0	3.528(36)	7
Zibo Xiajialin Mine	1934,9		69.0	2.45(25)	23.6
Zibo Beidajing	1935,5,13			2.156(22)	443.0
Dafeng 9204 working face	1969,6,29	−49.6			27.13
Bianhe Mine	1975,1,2				85.0
Anyang Tongyie Mine	1965,8,25	−6			23.3
Lifeng Mine E18 working face	1967	−105			120.0
Fengfeng Mine 1532 working face	1960,6,4	−102	130.68	2.28(23.27)	150.0
Xingmilianggou Shaft 3	1962,6,26	+51			23.3
Huaibei Xiangcheng Mine	1973,5,24	−250		2.66(27.2)	12.13

The Examples of Rehabilitation Methods Used in Submerged or Partially Submerged Mines

Table (continued)

Mine or place of intrusion	Water resource	Submerged condition	Rehabi. method	Grouting place
Jingxing Mine 3	from O fault	whole submerged	AD	blocking intrusion point
Jiaozuo Lifeng Mine	from L8	tunnel submerged	AD	
Yanmazhuang Mine 101 working face	from L8	working face submerged	AD	
Lihe Mine	from O	whole submerged	AD	
Zibo shuangshan Mine	from O		AD (failure)	success in DAB
Zibo Xiajialin Mine	from O	whole submerged	DAB	blocking fault
Zibo Beidajing	from O fault	whole submerged	DAB	blocking fault
Dafeng 9204 working face	from O and L8	whole submerged	DAB	blocking fault and aquifer
Bianhe Mine	from O	whole submerged	DAB	blocking fault
Anyang Tongyie Mine	from O palco–collapse	whole submerged	DAB	blocking collapse
Lifeng Mine E18 working face	from O palco–collapse	partially submerged	DAB	blocking collapse
Fengfeng Mine 1532 working face	from O	whole submerged	DAB	blocking bottom
Xingmilianggou Shaft 3	from O	whole submerged		blocking bottom
Huaibei Xiangcheng Mine	from Taiyuan L			blocking tunnel

Annotation: O——Ordovician Limestone
L8——The Eighth Limestone
AD——Absolute Drainage
DAB——Drainage After Blocking

Mine,there was an ordovician limestone water intrusion when the working face was near a fault only 5 meters, the maximum discharge was 80–90M^3 / Min,the method of drainage after blocking was also used,the water in mine has been drained off for 40 days after blocking.

If the water intrusion point and geological conditions are not clear,the method of blocking after drainage can be used when enough energetic drainage equipment which is used for draining off motionless water and recharging water can be received.For example,the blocking of the water intrusion in Jingxing Mine 3 failed by using the method of drainage after blocking because the water intrusion point and geological conditions were not clear,using the method of blocking after drainage made a success.

(2)From the view of removing the hidden danger of water intrusion in coal mines,there is no good effect either using the method of drainage after blocking or the method of blocking after drainage when a lot of faults and their transmissivities and storativities are strong,the discharge of the aquifer is large and the aquiclude layer is tattered or thin.The method of absolute drainage is reliable when economic and technique are admitted.

(3)It is very difficult to block and more detail work is needed when the water intrusion points are very deep from the earth surface and distribute in a big area and the grouting holes do not easily locate in the points.

2 THE ABUNDANCE EXTENT OF THE INTRUSION WATER RESOURCES

The absolute drainage method can be used for rehabilitating submerged coal mines when the water intrude from the thin limestone layers in the Permo–Carboniferous coal mines in North China and the thin limestone layers have no hydraulic or have weak hydraulic contact with the Ordovician water.Evenif the initial discharge is large,the water will be reduced as the drainage going on. The water intrusion in Lifeng Coal Mine in Jiaozuo is an example.The thin limestone layer whih the intrusion water is from has a well hydraulic contact with the Ordovician limestonewater,sometimesthe Ordovician limestone water intrudes directly even in some coal mines,and thewaterpressure increases as the mining is deeper and deeper in some of coal mines,in all these conditions,the water intrusion discharge is always large.

The eighth limestone water intrusion in some coal mines in Jiaozuo and Ordovician limestone water intrusion in Jingxing,Fengfeng and so on are the examples.When Jingxing Mine 3 was submerged in 1942,Japanese who used the method of blocking after drainage with six 200–hp pumps draining and one 4M^3box draining could not reduce the water level after one year draining.The rehabilitation was not realized even draining with the 40M^3 / Min capacity pumps before the liberation.From the above,we can see the water in such aquifers is not easy to be drained off and the bigger capacity pumps and long time draining are needed to rehabilitate.In this case,if the blocking method is used and the water passageway is blocked,the water can be drained off gradually even it is in such amount.As for which method should be used either drainage after blocking or blocking after drainage is determined by knowing various factors such as the water intrusion point,the geological and hygrogeological conditions,power supply,equipment condition and so on.

3 THE INFLUENCE ON NEAR MINES AND WATER SUPPLY FIELDS

(1)The drainage for rehabilitation can reduce the discharge of near mines so as to raise the economic benefit when the water in submerged mine has a hydraulic contact with the near mines.For example,when Zhongmacun Coal Mine in Jiaozuo was submerged,

the drainage from the main and auxiliary shaft made the water level in submerged little mine reduced,drainage from little mine also found the water level in submerged Zhongmacun Mine reduced,which showed that the two coal mines have a good hydraulic contact with each other.A good effect was made by joint draining from the two coal mines.

(2)How to rehabilitate mines will be more complicated when the intrusion water resource has a hydraulic contact with the near water supply fields.For example,one of the reasons by using the method of drainage afte blocking for rehabilitating, the submerged Zibo Xiajialin Mine is for preventing the bad influence result from the drainage. But using the drainage method is possible when the water drained from the mine can be used for water supply.

4 POWER SUPPLY,TECHNOLOGICAL EQUIPMENT AND INSTALLATION CONDITIONS

(1)Power supply and technological equipment(such as the pump type,pump capacity,pump pipe and so on)play a restrictive role in rehabilitation plan.Many mines can not drain off water because of the lack of power supply.

(2)The possibility of the equipment installation in the tunnels should also be considered.It holds up the choice of drainage plan that the small tunnel section in which the pumps can not be installated in design and the over load the head–frame will bear because of the installation of many hanging pumps in pit shaft.Certainly,the head–frame can be reinforced for the installation,but the economic benefit should be considered.

(3)Drainage of using submerged pump has a good advantage in rehabilitation.The aided facilities can be reduced and the amound of pumps which must be installed can be increased since the submerged pump and its pipe take a little room.Centrifuged pump showed a absolute advantage in the rehabilitation of submerged Yanmazhuang and Kailuan Coal Mines.

5 THE WATER INTRUSION POINT AND GROUNDWATER FEATURES

When the measuring data and drawing of the mine are not correct and there is a big different location between the tunnel and its poin in the drawing,it is difficult to determine where the water intrusion point is,therefore,the grouting can not be successful.

When the lower mining level is submerged,the drainage must be taken to keep continuous mining in upper mining level.When the water is flowing, the technological problems of "grouting in flowing water" should be considered.The groundwater erosion capacity should be evaluated before grouting no matter which blocking method you take.

6 REASONABLE INVESTMENT

When the rehabilitation method is chosen according to the above conditions,the economic benefit is needed to compare for the choice of the reasonable plan if some method all can be used.Making the comparation of different plans,the consideration for future should be kept in mind.Although using the method of drainage after blocking rehabilitated submerged mines temporarily in some coal fields with little investment and short time,many rehabilitations for many submergences in the future actually wasted a lot of money and had a bad influence on production.Therefore,the comprehensive analysis of the various factors is important,the determination only based on one of the factors will produce side effects and economic loss even.

The main conditions in which the different rehabilitation methods should be used are concluded in below according to the typical rehabilitation examples which are listed in above table.

—The condition of using the method of drainage after blocking

(1) There are few faults,the faults have no hydraulic contact with each other and their transmissivities and storativities are weak.The aquiclude layers are thick and locate stably.The rocks in the layers have a good strength.

(2) Large intrusion discharge

(3) Power supply and technological equipment are not enough

(4) The tunnel section is small

(5) The intrusion water resource has a hydraulic contact with the near water supply fields

(6) The drainage time and investment are much more than the blocking

—The conditions of using the method of blocking after drainage

(1) There are little faults,the faults have no hydraulic contact with each other and their transmissivities and storativities are weak.The aquiclude layers are thick and locate stably.The rocks in the layers have a good strenth.

(2) The intrusion discharge is small or the drainage equipment is enough although it is large.

(3) Power supply,technological equipment and the tunnel section can satisfy the need of the drainage and installation.

(4) There are a lot of water intrusion points which distribute widely and steeply.

(5) The measuring data of the mine are not correct,the water intrusion points can not be determined.

—The conditions of using absolute drainage method

(1) There are a lot of faults which have hydraulic contact with each other and their transmissivities and storativities are strong.The aquiclude layers are tattered and locate unsteadily.

(2) The intrusion discharge is small and can be easily drained off or the water level must be reduced for the safety production.

(3) The joint drainage should be used when the intrusion water in the submerged mine has hydraulic contact with the water in another submerged mine or the near mines.

(4) Power supply,technological equipment and the tunnel section can satisfy thneeds of drainage.

(5) Reasonable in economic.