A DESIGN SCHEME ABOUT THE CONSTRUCTION OF PUMPEDHYDROELECTRIC STORAGE USING WASTED OPEN-PIT MINE

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Abstract

There are more than 300 large open-pit mines in China, and 130 of those large open-pit mines yield more than 1,000 $\times 10^4$ tons per year in output. As the exploitation of natural resources is drying up, many mines are about to be closed and abandoned. Waste mine pits bring heavy troubles to both local society and environment, such as the geological hazards, air and water pollution. How to cure the waste open-pit mine comprehensively is an urgent issue, meanwhile well utilization of it is also more important for the development of mine region. For well utilization of waste resources and sustainable development of mine region[1][2][3], a new idea was put forward that constructing a PHS using wasted large open-pit mine[4]. This report will introduce a design scheme of a pumped hydroelectric storage (PHS) in an open-pit mine.

1 Description of the site

1.1 Basic conditions

This open-pit mine, called Haizhou open-pit mine, is located in the northeast of China, it used to be the largest mechanized open-pit mine in China, and it will be the largest waste open-pit mine that will be closed due to resource exhaustion in recent years. This mine covers an area as large as 30km^2 in the south of Fuxin city, the pit is 4km long and 2km wide, the max depth is367m. In the south of the pit, there are barren hills distributed from east to west, their elevation ranges from +260~+285m. The waste dump is located to the south of the hills, makes up of the backfilling waste mining slag stones shape like terrace and east-west distributed, it is 4km long and 3km wide, 275-310m in elevation.

Figure1 satellite image of Haizhou open-pit mine

1.2 Topography of the mine pit

The elevation of the bottom of the basin is -192m, and the elevation of barren hills in the south region of the mine pit is more than +180m. The maximum fall from the bottom of the mine pit to the hills in the south is more than 480m, which makes it a proper site for PHS.

The slopes of the pit belong to high slope more than 367m. The south slope with current angles of 38° ~41° is a reverse slope. The north slope with current angles of 16° ~ 18° is a consequent slope (same as the strata inclination angle).

1.3 Geology conditions

The formation lithology is mainly Quaternary diluvium, Cretaceous stratum and Jurassic stratum. Cretaceous Shahai Formation (K1s) is mainly composed of sandstones. Jurassic Sunjiawan Formation (K_{2s}) is mainly composed of sandstones and Jurassic Fuxin Formation (K_{1f}) is coal-bearing formations.

There are 11 normal faults in the region, and two large faults through the entire mine area diagonally. There is not active fault or any other new tectonics. Earthquake intensity in the region is grade VI.

1.4 Rock Mass Quality

The sandstone strength is usually high, according to the rock tests, the mean compression strength of the argillaceous siltstone is up to 50MPa, its average elastic modulus is more than 30GPa, the internal fractional angle is 33.20,and the cohesion force is 4.13MPa. Accordingly the sandstone is a type of medium hard rocks. The coal-bearing rock stratum (as it is interbedded with coal seams, shales and sandstones) is the Ⅲ-2 grade rock masses, partially is IV grade rock masses. Thick-bedded sandstones are under the coal-bearing stratum, shales also are scattered around, which makes it the Ⅲ grade rock.

1.5 Environment Problems

This vast open-pit mine has some serious environment problems as the geological hazards, air and water pollution. Since the rock masses were damaged by blasting excavation, there have been many geological disasters of the slope slides and the collapses, for instance, 85 times of slope slides had occurred from 1953 to 2004 (1.7 times per year). , its total area of unstable slope is about 4.34 million m^2. There are nine weak layers under the coal seams in the north slope, those weak layers mainly are composed of clay shale or thin coal seams, so the ground fissures occurred due to the bedding sliding of the north slope. The remained coals in the south slope of the mine pit have been spontaneously combusting and create lots of air pollutants. Otherwise, the groundwater from aquifers around the pit has been polluted by the mining activities. Those impacts threaten the production and life of surrounding area[5].

2 The PHS design scheme

2.1 Description of the design scheme

The lower reservoir uses the low basin of mine pit by setting up impervious structures, its storage capacity is 12 million m^3 and the normal water level is -130m. The water recharge is groundwater inflow from aquifers around mine pit[4], at present, groundwater influx is about 2.4 10^4 m^3, which can meet the need of water supply[6]. Tow upper reservoirs are arranged at the south barren hills, the storage capacity is 5 million m^3 each, and the normal water level is +275m. The head difference is 405m from the upper reservoir to the lower reservoir.

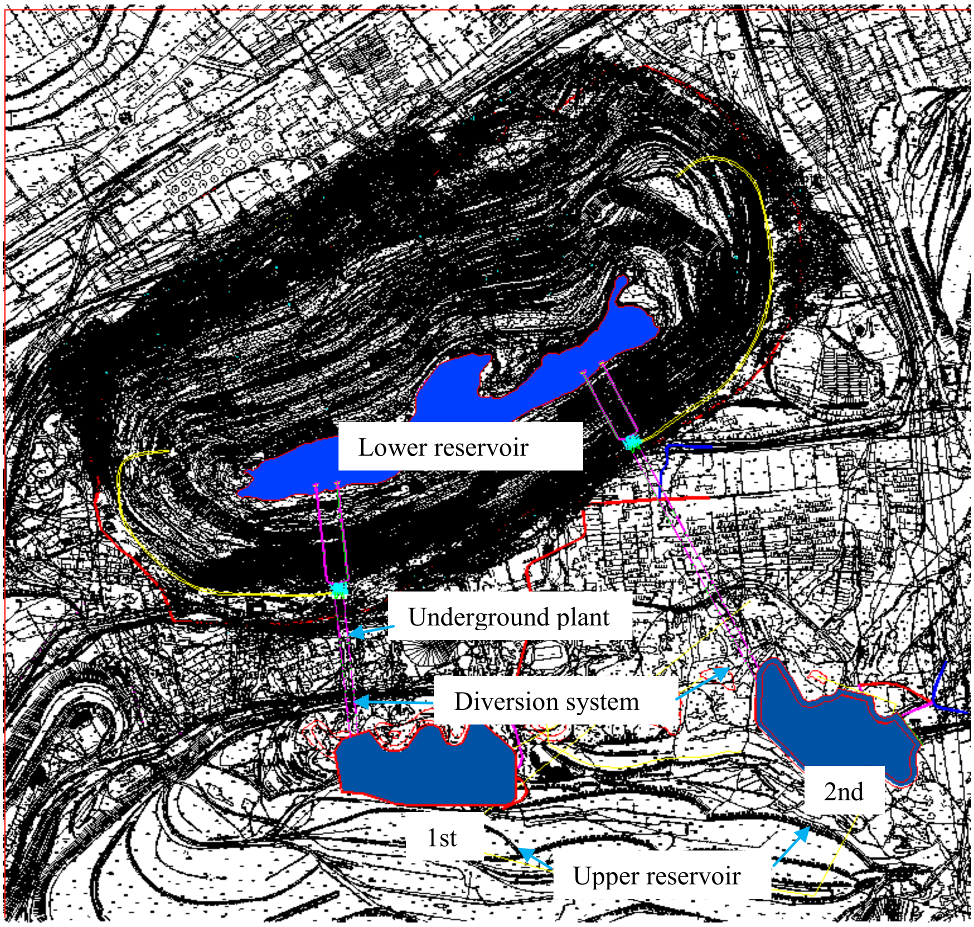

Figure2 Layout diagram of the PHS of Haizhou open-pit mine

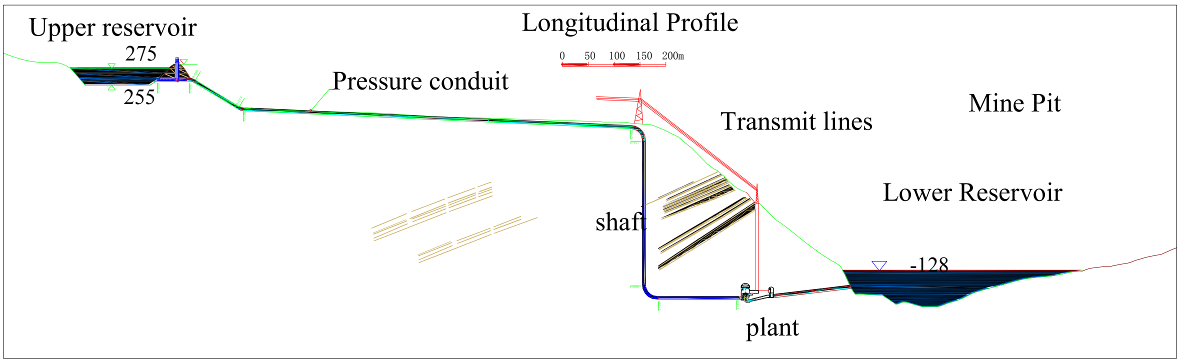

Figure3 Longitudinal profile of the PHS of Haizhou open-pit mine

The underground power plants are arranged in the rock-masses of the south of the mine pit, the main plant size is about 100m×21m×60m (length×width×height). The water diversion systems are composed of two pipelines on the ground and tow shafts in the underground rock-masses. The installed capacity of PHS is 1200 MW for 1st period, also the same for 2nd period, total 2400MW.

Table 1 The main technical parameters of PHS

Contents	Unit	1st period	2ndperiod	Total
Installed capacity	10^4 kw(kilowatt)	120	120	240
Unit and unit capacity	10^4 kw	4õ30	4õ30	8õ30
Productive head	m	400	400	400
Design flow	m3/s	360	360	720
Upper reservoir capacity	10^4 m^3	500	500	1000
Lower reservoir capacity	10^4 m^3	600	600	1200

Hours used in a day	h	5	5	10
Hours used in a year	h	1095	1095	2190
Annual energy production	10^8kw·h	13.14	13.14	26.28
Annual energy consumption	10^8kw·h	17.29	17.29	34.58
Overall efficiency	1.0 unit	0.76	0.76	0.76

2.2 Technical and economic challenges

PHS construction is facing the stability of the pit slope and the surrounding rock of the underground plant, the safety of the groundwater inrush to the adjacent mines, and economic rationality of the project.

Reinforcements of the slope: The comprehensive treatments of the south slope are considered as 100m expanding cutting in damaged rock of the slope, afterwards, consolidation grouting + systematic bolts + reinforced concrete slabs + partially anchor cables and concrete slabs with friction piles. For the north slope, combined treatments are designed as systematic bolts + anchor cables (inherent stress) + concrete slabs with anti-sliding piles to the areas with poor stability.

The stability of surrounding rock masses is a challenging technical problem for large wide underground plant constructed in coal-bearing layers damaged by adjacent underground mining[7]. The selections of excavation method and support types as well as lining structures are important subjects for further study.

When the mine pit is reconstructed a reservoir, the water leakage will threaten the safety of water inrush for adjacent underground mines. So, the reservoir needs to be constructed full closed type impervious system and the system should be flexibility to adapt the large deformation of the damaged rock masses.

Due to the construction of this PHS is facing many problems need to be solved, such as the comprehensive controls of mine environment, reinforcement of the high slopes, improving stability of surrounding rock masses of the underground plant in damaged coal-bearing layers, all of those will result in increasing the construction engineering quantity, the unit cost of this PHS will be more than ordinary PHS about 30% higher, the economic benefits of investment projects will be reduced. However, environmental and social benefits will obvious.

3 Conclusion

The construction of this PHS project will face some problems related to the stabilities about damaged rocks of the slopes and surrounding rock of underground plant as well as the economic investment. In spite of this, it has great significance to recycling of waste resources and environment restoration of the mining areas. At present, the design scheme is still in argument.

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