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Deposition of wastes from Bełchatów Power Plant in connection with overburden dumping and management of final excavation in Bełchatów Lignite Mine

Key words

Lignite, overburden dumping, management of final excavation

Abstract

Bełchatów Power Plant of the current capacity of 4420 MW is the biggest heat and power plant in the world. It uses nearly 40 mln tonnes of lignite per year. Burning of such a huge amount of lignite causes the problem with over 4 mln tonnes a year of wastes from furnaces. These are fly ashes and slugs that should be managed safely for environment.

In the first years of the power plant operation the power plant wastes were deposited using a hydraulic method at a special dumping area. The method required big forest areas and was harmful for environment due to dusting and pollution of earth waters. So, when Bełchatów Mine applied internal dumping system, a part of fly ashes from power plants has been dumped internally in the mine excavation in the form of specific proportion mixture of the ashes and overburden. Nevertheless, the method can not be applied for a long time, especially in the lower parts of the dumping area, because of the danger of water contamination in the water reservoir that is planned in a final management of the open cast. In the nearest future it is planned to stop dumping the ashes and slugs at the special dumping area of power plant. All the wastes will be deposited at the internal dumping areas of coal mine and in the final open cast of Bełchatów Mine — where the huge reservoir is to be arranged.

Three methods of ashes deposition are considered, namely: in the form of mixture of ashes and overburden, using a hydraulic technology in sealed reservoirs and in the form of emulsified ash that solidifies after deposition.

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Reviewed by Prof. Wiesław Blaschke

The research on the influence of the different methods of ashes deposition on environment, and especially on contamination of water in rock mass and in projected reservoir, are carried out. The results of the research will be decisive for the final choice of the method.

Introduction

The Bełchatów power plant of the current capacity of 4420 MW is the biggest heat and power plant in the world. It uses nearly 40 ml tones of lignite per year. Burning of such a huge amount of lignite causes the problem with over 4 ml tones a year of wastes from furnaces. These are fly ashes and slugs that should be managed safely for environment.

In the first years of the power plant operation the wastes were deposited using a hydraulic method at a special dumping area. The method required big forest areas and was harmful for environment due to dusting and pollution of underground waters. So, when the Bełchatów mine applied internal dumping system, a part of fly ashes from the power plant has been dumped internally in the mine excavation in the form of specific proportion mixture of the ashes and overburden.

As it is lack of reliable evaluation of the influence of the deposited mixture on the water conditions the method has been applied as a temporary solution. For that reason the deposition has been restricted to the three upper levels of the internal dumping area and the dumping would be finished before 2012.

In the nearest future it is planned to stop dumping the ashes and slugs at the special dumping area of power plant. All the wastes will be deposited at the internal dumping areas of lignite mine and in the final excavation of the Bełchatów mine — where the huge water reservoir is to be arranged.

Three methods of ashes deposition are considered, namely: in the form of mixtures of ashes and overburden — after evaluation the influence of the mixtures on water conditions, using a hydraulic technology in sealed reservoirs and in the form of emulsified ash that solidifies after deposition.

Final decision concerning the method of deposition will be taken after completing the research on the influence of different methods of ashes deposition on environment, and especially on contamination of water in rock mass and after determination the method of management the final excavation in the mine.

1. Geological and mining conditions of management the final excavations in Bełchatów and Szczerców mines

The lignite deposit in Bełchatów, that is the fuel basis for the Bełchatów power plant, is divided into three fields: the eastern one — Kamieńsk is not foreseen for opencast exploitation as it is not big enough and is deposited unfavorable, the middle one — Bełchatów of the length 12 km, which is currently exploited and the western one —

Szczerców of the length 8 km, the exploitation of which is currently prepared by building (since the autumn 2002) the first opening out. It is planned that the Szczerców field will be exploited since the end of 2007. Longitudinal shape of the Bełchatów field has determined the application of the parallel wall advance system. Salt diapir that separates Bełchatów and Szczerców fields precluded the possibility of exploitation both fields from one opening out. The first working of the Bełchatów field was located in the eastern bounder of the filed, while the first working of the Szczerców field is located in the western bounder. Wall advance in both open pits is planned towards the salt diapir. In the vicinity of the diapir two final excavations will arise (see fig. 1).

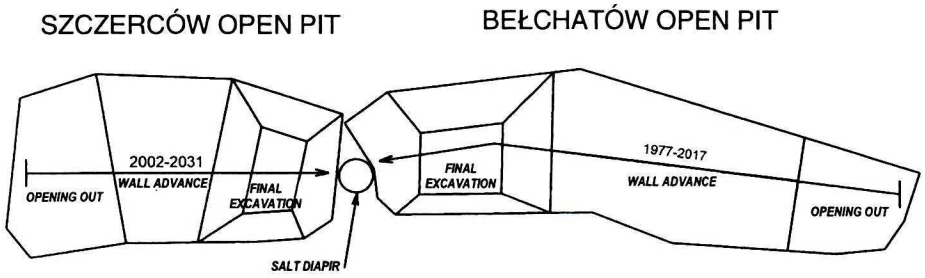

Fig. 1. Sketch of opening out areas and final excavations of Bełchatów and Szczerców open pits.

Rys. 1. Szkic rejonów udostępnienia i wyrobisk końcowych odkrywki Bełchatów i odkrywki Szczerców

At the beginning the general concept of the deposit exploitation was that just after achieving the full capacity of the Bełchatów open pit the Szczerców open pit was supposed to be opened. In such way the end of exploitation of the Szczerców open pit would be shortly after the end of exploitation of the Bełchatów open pit. Application of that solution would result that two depressions (of the Bełchatów and Szczerców open pits) arise and the waters in the vicinity of the diapir would be divided resulting in decrease the danger of leaching the salt from the diapir surrounded by clay and gypsum overlay. As a result of the delay in the Szczerców open pit building the exploitation in the Bełchatów open pit will finish in 2017 while in Szczerców open pit in 2031. As the diapir will be under one-side influence of the Bełchatów dewatering system first and than under dewatering system of the Szczerców, so there exist the necessity to protect it from leaching by a special barrier of wells.

In the final excavation of the Bełchatów open pit as well as in the final excavation of the Szczerców open pit is it planned to create water reservoirs.

The process of filling up the final excavation of the Bełchatów open pit with water will be complicated as at the same time there will be the necessity for dewatering in the vicinity of exploited deep excavation of the Szczerców pit. The depth of both pits will be about 250 to 280 m, while the salt in the diapir lies on the depth of 160 m. Therefore it is assumed that the excavations need to be partially filled up to make them shallower, so that the bottom of projected reservoir would, in the diapir vicinity, be at least 30 m above the salt top.

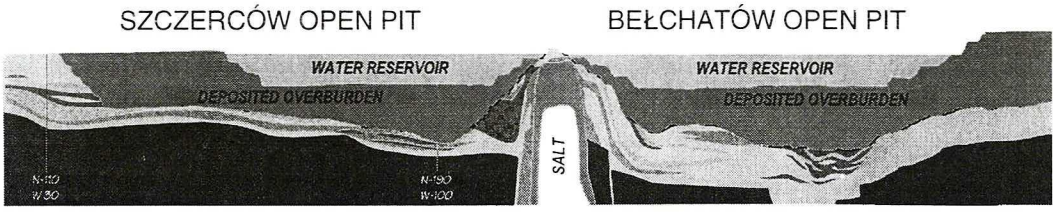

Fig. 2. Scheme of planned management of final excavations at Bełchatów and Szczerców open pits.

Rys. 2. Schemat planowanego zagospodarowania wyrobisk końcowych odkrywki Bełchatów i odkrywki Szczerców

The scheme of the planned management of the final excavations of the Bełchatów mine is shown in figure 2.

2. Preparation final excavations of Bełchatów and Szczerców open pits for reclamation using water

Management projects of final excavation at the Bełchatów open pit have been prepared for last few years. They have been adjusted to the changing general programs of lignite exploitation and overburden deposition that were the result of electricity production specification planes in the region.

The current program of electricity production in the region assumes that the Bełchatów open pit will end the exploitation in 2017 and the exploitation in the Szczerców open pit will start in 2007 and will end in 2031. Removing the overburden for the purpose of opening out the Szczerców field has started in 2002. Taking into account the general assumption of the project and connected masses of overburden both from the Bełchatów and Szczerców open pits as well as the striving towards maximum reduction of the reservoirs capacity and making them shallower due to existence of the salt diapir, the current variant of the reservoirs building in the final excavations is as follows.

It is foreseen that the bottom of the final excavation of the Bełchatów open pit will be filled in the middle part up to +80 or +85 m above sea level and in western and southern parts up to +120 m above sea level. It will be done using 725 ml m^3 of overburden from the Szczerców open pit and by deposition below the ground level about 100 ml m^3 of power plant ashes. The filling up should be done immediately after finishing the exploitation in the years 2017—2030. When the planned filling up is accomplished the capacity of the water reservoir will be about 1600 ml m^3 and the surface area about 17.5 km^2. Filling up the Szczerców final excavation will start shortly before the end of exploitation in 2030 and will last till 2050. It will be done by deposition in the excavation 850 m^3 of overburden from the temporary external dumping area. The bottom of the reservoir will be then at +90 m above sea level, the capacity — about 1020 ml m^3 and the surface area — about 15 km^2. Out of different variants of management the final excavation the preferred is the one that maximizes making them shallower before they are filled up with water. There are two advantages of that solution:

the time of filling up the reservoirs with water is shorter and that the salt diapir is protected against leaching and subsequent water contamination.

Because there is need for exploitation of lignite in the Szczerców open pit in the vicinity of the diapir and the necessity of protecting the diapir by a special barrier of wells, it is impossible to fill the final excavation of the Bełchatów open pit with water earlier. It is therefore assumed that the final excavation of the Bełchatów open pit will be dewatered after the exploitation is finished until the end of exploitation of the Szczerców open pit.

The start of filling up both reservoirs with water is planned at the same time, i.e. after the Szczerców open pit is made shallow, in about 2050. If only the natural inflow is assumed, as a result of water table restoration, the time of filling in the reservoirs will be nearly 90 years. Such a long time of filling the reservoirs is unacceptable, because in the meantime the slopes of reservoir would scour as a result of wavy motions.

Looking for better solutions for making the time of filling up the reservoirs shorter the possibility of succor the natural inflow with the waters from outside of the water depression is considered — from the river Warta — 1 m^3/sec or 2 m^3/sec for each of reservoirs.

If external supply of 1 m^3/sec is provided it will be possible to shorten the time of filling up the reservoirs to 30 years and with supply of 2 m^3/sec the time of filling up the reservoirs would be 20 years.

3. Currently applied methods of power plant Bełchatów wastes deposition

In projects of the lignite the Bełchatów mine and power plant it is foreseen that in the first stage of the power plant operation and at the time when overburden from open pit is located at the external dumping area, ashes and slugs from power plant would be deposited using a hydraulic transportation at a special dumping area: Bagno-Lubień.

That method allows for continuous deposition of the wastes by hydraulic transportation technology regardless the weather conditions, also in the very low temperatures that preclude other methods of transportation, for example the transport of ashes by conveyors. The other reasons for separate deposition of ashes and overburden at the external dumping area was a result of former bad experience of the other lignite mine — Turów, where during the simultaneous deposition of power plant ashes and open pit overburden the problems had appeared (dusting, water contamination).

The Bagno-Lubień dumping area for ashes and slugs from the power plant occurred to be burdensome for environment due to dusting and leaking the contaminations to the ground waters. What is more, the dumping area occupied huge parts of land that were primarily agricultural areas or forests. For those reasons since the internal dumping area in the Bełchatów open pit have been advanced properly i.e. since 1993, the ashes from power plant are mechanically deposited as a mixture with overburden in three upper levels of the dumping area. This method is treated as a temporary solution before the sealed ash containers are

prepared inside the internal dumping area. The dumping of dry ashes together with the overburden is applied only if the following conditions are fulfilled:

— the ratio of ashes to overburden should not exceed 1:10,
— the 5 m thick layer of the uppermost level of the dumping area must be filled exclusively with overburden without addition of ashes,
— boundary 50 m wide parts of the internal dumping area must also be formed exclusively with overburden.

Those restrictions are aimed to the protection of waters in the region of the internal dumping area.

Ashes from power plant, after moisturizing them during the process of granulation, are delivered to the dumping area by special covered conveyors, so that practically there is no dusting during the transportation and deposition.

In 1993—2003 about 26.5 ml Mg of wastes from burning process were deposited mechanically at the internal dumping area in the way described above. It allowed decreasing the volume of hydraulically deposited ashes at the Bagno-Lubień external dumping area. The external dumping area has to function in parallel with the internal dumping area as in case of very low temperatures there is no possibility for mechanical transportation of the power plant ashes.

The ashes and slugs deposited at the internal dumping area consisted about 49% of all wastes from burning process that the Bełchatów power plant produced till 2003. The current method of ashes deposition together with overburden is treated as transitional method before the final technologies introduction that would allow for complete suppression of hydraulic deposition at the Bagno-Lubień external dumping area.

4. Planned methods of deposition ashes and slugs from power plant in final excavations

In the period from 2004 till 2031 or 2035 (depending on realized variant of production) there will be the necessity to locate next 110 ml Mg ashes and slugs from the power plant. The current method of deposition ashes as a mixture with overburden at the internal dumping area may be applied till 2012, i.e. before the upper levels of the Bełchatów dumping area are filled up. The dry method of mechanical deposition of ashes together with overburden will allow for location about 30 ml Mg of ashes, so this method does not solve the problem.

The main objective of research undertaken on the methods of deposition ashes and slugs was to combine this process with the process of internal dumping and the management of final excavation of the Bełchatów open pit. The management of the final excavation of the Bełchatów and located nearby final excavation of the Szczerców open pit will be one of the most complicated engineering projects in the opencast mining worldwide. The project concerns the management of two huge excavations of the total capacity over 4 billion (10^9) m^3 and the depth of 250—280 m separated by the salt diapir at the depth of 160 m that causes the threat of water contamination in the vicinity.

As a final result of land reclamation the excavations, as it usually happens in the world opencast mining, are foreseen to become two huge water reservoirs. In this case the main problem is to make them shallower before they are filled in with water due to possible hazard of water contamination by the salt and due to the prolonged time of filling the reservoirs with water.

It is assumed that the reservoirs should not be deeper than 130 m, so that the projected bottoms of reservoirs would be at least 30 m above the ceiling of the salt in the salt diaper.

Having in mind huge masses demanded to make the reservoir shallower it is planned to locate as much ashes as possible inside the internal dumping area below ground level with the aim to make the capacity of reservoir smaller. Nevertheless the present state of mining in the Bełchatów open pit does not allow starting location all the ashes below the ground level, so for some time it would be necessary to locate them in the above ground level part of the internal dumping area. In the above ground level part of the dumping area that will elevate 30 m three ash containers are projected in which ash will be located using hydraulic method since 2006. Those containers are designed in the body of the uplift part of the internal dumping area and it is projected that the bottom and sides of the containers will be properly insulated by a clay layer to protect ground waters from contamination by filtering off waters from the containers.

The projected mineral screen should obey the following conditions: the layer must be done from the material of the filtering coefficient not higher than 1×10^{-9} m/s. Clay or loam for the insulating screen should be properly grinded, wetted and thickened.

The bottoms of ash containers in the above ground parts of the internal dumping area will always be above the restored underground water level and the protection against rain water is projected through an adequate insulation and growing forest on top of the containers after covering them with 3 m layer of overburden.

The projected containers are of the following capacities:

— Container I — 17.8 ml m^3,
— Container II — 22.1 ml m^3,
— Container III — 28.8 ml m^3.

The total capacity of the containers will be 68.7 ml m^3, what allows (if assumed weight by volume deposited power plant wastes equals to 0.56 Mg/m^3) locate in them about 38 ml Mg of ashes and slugs in 2006—2015.

Therefore there exist the necessity to locate somewhere additional 40 ml Mg ashes and slugs in 2016—2035. It is projected that the amount will be used for filling the final excavation with the aim to make the reservoirs shallower. Three methods of ashes deposition are considered:

— depositing them in the form of mixture of ashes and overburden located below the bottom or on sides of projected reservoir,
— depositing them using a hydraulic technology in the sealed containers,
— depositing the ashes in the form of emulsified ash that solidifies after deposition.

Deposition of ashes in the form of mixture with overburden below the restored level of ground waters demands for analysis concerning the influence of the deposited ashes on those waters. The research are being done basing, among other things, on current monitoring of water quality near deposited mixtures at the internal dumping area and at the Bagno-Lubień power plant dumping area.

To establish the conditions of hydraulic deposition of ashes in the excavation below ground the following research have been undertaken:

- — choice of possible locations of the ash containers in the excavation in respect of wall advance in lignite exploitation, dumping of overburden from the Bełchatów open pit and from the Szczerców open pit, possibilities of supply the insulation materials (clay and loam) to the area of projected containers, qualification preparation methods of the top of the containers using mine equipment,
- — verification of the forecast of the average weight by volume of the ashes in the containers,
- — evaluation the possibilities of self sealing up of ashes in containers,
- — evaluation the influence of the rheological and rock mechanical processes in the dump on the insulations and installations of ash dumping,
- — evaluation the technical possibilities and the choice of the methods of container insulation with preference of the local clay materials from the overburden of the Bełchatów open pit.

If the method of deposing the ashes and slugs in the form self solidifying emulator from ashes and needed amount of water is chosen, it would be necessary to built appropriate containers within the final excavation and to establish the method of ashes delivery from power plant to the emulate plant located near the place of deposition. Advantages of the method of ashes deposition in the form of dense emulator that solidifies shortly after its delivery to the dumping area are the following: it eliminates dusting, allows to make the process of ashes deposition independent from the process of overburden stripping, and also the emulator might be used for improving the stability of the excavation slopes. The disadvantage of the method lies in necessity of building special pipes for transportation ashes or applying two — phase moisturizing if the mechanical transportation method is used.

The research on the method of ashes deposition have been undertaken and are carried both in technical and ecological aspects. The research may last for some time as for the nearest future the technologies of ashes deposition are already decided.

Basing on up to date experience and on the preliminary results of researches it can be stated that in the Bełchatów mine the majority of power plant rejects will be utilized for the final excavation management.

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ZBIGNIEW KOZŁOWSKI, LIDIA GAWLIK, ZBIGNIEW GRUDZIŃSKI

SKŁADOWANIE ODPADÓW Z ELEKTROWNI BEŁCHATÓW W POWIĄZANIU ZE ZWAŁOWANIEM NADKŁADU I ZAGOSPODAROWANIEM WYROBISKA KOŃCOWEGO KOPALNI BEŁCHATÓW

Słowa kluczowe

Węgiel brunatny, zwałowanie nadkładu, zagospodarowanie wyrobiska końcowego

Streszczenie

Elektrownia Bełchatów o aktualnej mocy 4420 MW jest największą elektrownią cieplną na świecie zużywającą blisko 40 mln Mg węgla brunatnego rocznie. Zużycie tak znacznych ilości węgla powoduje powstawanie rocznie ponad 4 mln Mg odpadów paleniskowych, czyli popiołów i żużli wymagających odpowiedniego bezpiecznego dla środowiska składowania.

W pierwszym okresie działalności Elektrowni składowanie odpadów elektrownianych odbyło się metodą hydrauliczną na specjalnym składowisku elektrownianym. Rozwiązanie to nie było jednak zadawalające z uwagi na konieczność przejmowania na ten cel znacznych terenów leśnych, a także na niekorzystny wpływ na środowisko naturalne (pylenie, zanieczyszczenie wód gruntowych). Z tych powodów po przejściu na zwałowanie wewnętrzne w Kopalni Bełchatów część popiołów składuje się tam w formie mieszaniny nadkładowo popiołowej w odpowiedniej proporcji. Tej metody nie można jednak przez dłuższy czas stosować, zwłaszcza w niższych piętrach zwałowiska, ze względu na niebezpieczeństwo zanieczyszczenia wód w zbiorniku wodnym projektowanym w wyrobisku końcowym. W najbliższym czasie przewiduje się całkowite zakończenie składowania popiołów na osobnym składowisku elektrowni i całość popiołów składować się będzie w obrębie zwałowiska wewnętrznego oraz wyrobiska końcowego odkrywki Bełchatów, w którym ma powstać olbrzymi zbiornik wodny.

Rozważa się trzy metody składowania popiołów, a mianowicie; w formie mieszaniny nadkładowo-popiołowej, w technologii hydraulicznej w uszczelnionych zbiornikach oraz w formie emulgatu popiołowego zeskalającego się po składowaniu.

Ostateczny wybór sposobów składowania nastąpi po zakończeniu badań związanych z określeniem wpływu składowanych różnymi sposobami popiołów na środowisko a zwłaszcza na zanieczyszczenie wód w górotworze oraz w projektowanym zbiorniku wodnym.