



Reduction of Saline Waters Discharge from Coal Mines Through Filling and Sealing of Underground Voids

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ABSTRACT

Drainage and discharge of mine waters belong to main environmental issues that must be appropriately addressed by underground coal mining industry. Large area of mine fields in Upper Silesia Coal Basin (USCB), which belong both to currently active and already closed mine, together with the geological and hydrogeological structure of the rock mass in USCB, create conditions requiring drainage and discharge of about 118 million m³/yr of mine waters of differentiated salinization. Increasing average depth of mining works and necessity of drainage of numerous closed mines results in increasing amounts of chlorides and sulphates being introduced into water environments, even then coal production of Polish mining industry is decreasing. Majority of mines waters are discharging directly to watercourses and the only significant environmental protection measure is control of the concentration of salt in main rivers. Balance of mine waters and Cl⁻ + SO₄²⁻ ions demonstrates weight of this issue and give a background, on which technology of filling of underground voids has been discussed as a method, which, under several conditions, may reduce the discharge of brines and highly salinized mine waters (mineralisation above 42 g/dm³) by about 30%. Although technology of filling of voids with mixtures of water and finely grained solids (mostly fly ash) is well known and adopted by most of coal mines, its potential in reduction of saline waters discharge is being wasting due to inconsequence in its use and underestimating its value in terms of saline waters management. Influence of waters salinity on the physical properties of the fill, as well as benefits gained by the coal mines as result of filling of voids, show that this operations should be conducted in the possibly largest extent, limited only by availability of fly ash and volume of voids, being created as result of coal extraction.

Keywords: mine waters management, salinized waters discharge, filling of underground voids, fly ash water mixtures, environment protection, protection of watercourses

1. INTRODUCTION

Upper Silesian Coal Basin (USCB) with the total area of 7500 km², from which 5500 km² belong to Poland, is one of the largest hard coal mining areas in Europe. Within Polish part of USCB, around 20% of its surface represent currently active mining areas and next 15% belong to areas of decommissioned mines. With the population of about 2,5 million people and highly urbanized northern part of the area, where the population density is over 2000 people per km² USCB is suffering from heavy mine damage caused by mining operations. To the environmental impacts of underground mining belong discharge of mine waters into watercourses. Mine waters from Carboniferous rock mass are contaminated above all else by chlorides and sulphates (Policht-Latawiec, 2014). Large volumes of mine water drainage as well as high concentration of salts heavily affect quality of watercourses and resources, water dependent ecosystems and overall environmental standards in the range of influence of contaminated water bodies (Molenda, 2014; Zgórska et. al., 2016). The problem is of all the more importance that it is not occurs only locally in the USCB, but one should keep in mind that all the mine waters are discharging, via regional watercourses, into two main rivers of Poland (Odra and Vistula), which flow more than 500 km northwards to Baltic Sea across the country (Policht-Latawiec, 2014). However yearly production of hard coal in USCB decreased strongly to round 70 million tons that equals round a half of the output noticed 25 year ago, discharge of saline waters and load of salts from coal mines do not follow this trend. Although there are not exists any solutions, which are able to solve the problem comprehensively, each available measure should be taken under consideration to reduce the amounts of salinized mine waters pumped from coal mines. Filling of mine voids with the use of mine waters represents practically adoptable technique of reduction of salt waters input into environment.

2. BALANCE OF MINE WATERS IN USCB

Currently in USCB operate round 35 coal mines (the exact number is uncertain due to continuing processes of structural transformations, fusions, ownership changes etc.), 16 mines have been permanently closed without necessity for further drainage of mine waters, in other 15 closed mines drainage is still conducting within a central system of mine drainage, created for the purpose of the protection of existing collieries (Bondaruk et. al., 2015). Data in Table 1, collected from the years 2008, 2013 and 2015, demonstrate that by decreasing total coal output by round 13% in the period of 2008 – 2015, the discharge of waters in terms of volume and concentration of salts did change significantly. The total volume of discharged saline waters in 2015 reached about 119 million m³, what was even higher than in 2013 with roughly 117,3 million m³, where the coal output decrease by 5,8% in similar time. Amount of salts discharged to watercourses increased from round 15,3 to almost 17,9 kg per ton of coal. Data in Table 1 do not include discharge of fresh ($(\text{SO}_4^{2-} + \text{Cl}^-) < 0,6 \text{ g/dm}^3$) and brackish waters, where salt mineralisation is between 0,6 and 8,2 g/dm³ (Palarski et. al., 2011).

Discharge of waters from decommissioned mines must be continued after mine closure to eliminate water hazard (flooding) of adjacent mine fields in presence of hydraulic connections, what is often a case between conterminous mines. Since 2013, yearly water output from closed mines is about 71million m³, where 53 million m³ are saline waters. It means that 45% of total water discharge from USCB comes from inactive mine areas.

Amounts of chlorides and sulphates being pumped out from the mines depend on their location on the hydrogeological map of USCB. Mines located in northern part of USCB participate in substantially smaller part of total output of saline waters than in its southern region. However, the northern area is densely urbanized, the number of mines is higher, and the saline waters are discharging mainly to smaller watercourses than in southern part of USCB, so the environmental impacts of saline waters are also noticeable significant (Molenda, 2014; Zgórska et. al., 2016; Gruszczyński et. al. 2014).

Quality of waters in main rivers in USCB is additionally affected by dischargers from the coal mines in Czech part of USCB (Harat et. al., 2015). Water in Odra River at the southern border of Poland contains already up to 350 mg/dm³ of chlorides and 200 mg/dm³ of sulphates, what creates unfavourable initial conditions for protection of the Odra river waters against exceeded concentrations of salt, however most of the Polish coal mines operate in the catchment of Vistula River (Policht-Latawiec, 2014).

Prospective balance of saline waters must be considered in connection with deepening of mines and vertical stratification of ground waters. In hydrochemical conditions of USCB geological structures the zone of buried brines starts at the depth of 450 to 850 m (Rózkowski and Rózkowski, 2015). Large extents of the roof of this zone results from variability of geological conditions in each mine. From the other side, average depth of mining works decreases from about 300 m in 1957, through 650 m in 1989 (Rózkowski and Rózkowski, 2015). Down to about 730 m in 2015. These factors together with very weak decreasing trend in total volume of saline water discharge explain increasing load of salt on one ton of coal.

Table 1. Load of saline waters and salt on coal output (Harat et. al., 2015; Palarski et. al., 2011; Environment 2009; Environment 2014; Environment 2016).

Year	Coal output million tons/year	Saline water discharge thousand m ³ /day	Salt discharge tons/day	Average concentration of salts in mine waters kg/m ³	Load of salts on tone of coal kg/tone
2008	83,6	342,2	3562	10,22	15,27
2013	77,0	321,4	3497	11,08	16,88
2015	72,5	325,7	3550	10,90	17,88

3. CONTROLLED DISCHARGE OF SALINE MINE WATERS

In aim to avoid degradation of the ecosystems of watercourses, as well as to keep quality of water at obligatory standards, the most attention has been given to control concentration of Cl^- and SO_4^{2-} anions in watercourses instead of reduction of the salt stream discharged to the rivers.

Effective control of saline waters discharge requires an infrastructure that consists of pipeline connections between a group of mines and an adequately large retention reservoirs, which retain a stream of saline waters during low water level in destination watercourse and release them during high water level periods. In USCB exists two such a systems, which solve the problem of enormous concentration of salt in mine waters (where the sum of SO_4^{2-} and Cl^- exceed 42 g/dm^3). The "Olza Collector", collects waters from eight coal mines, with a discharge rate of 30 thousand m^3/day , able to maintain the concentration of salts in Odra River below $0,5 \text{ g/dm}^3$ (Harat et. al., 2015). The system has an retention volume of about $0,292 \text{ m}^3$ offered mainly by settlements tanks of participating mines.

Another one system has been created in aim to protect Vistula River against contamination by highly salinized waters and brines from mines "Piast" and "Ziemowit" (Strozik et. al., 2016). These mines, together with already closed mine "Czeczott" are responsible for 2/3 of total salts discharge from all USCB coal mines (Gruszczyńska et .al, 2014). The retention reservoir are created by voids being left in the rock mass after closure of mine "Czeczott", in a volume of about $0,5 \text{m}^3$.

Controlled discharge of mine waters, especially from groups of coal mines, which generate majority of overall saline waters, makes them less intrusive for the environment of large watercourses, however it does not reduce the absolute mass of chlorides and sulphates being introduced into environment.

One should state that such systems could not be applied in case of scattered sources of relatively small volume and average mineralisation concentration of mine waters, as it is the case in northern part of USCB.

Available fragmentary data about costs of saline waters utilization in coal mines suggests that costs of the fees for use of environment in regard to saline waters may be quite substantial. Large coal company in the northern part of USCB (where the output of salts is considerably smaller than in southern part) owned 17 coal mines, has been charged by 9 million euro/yr (Palarski et. al., 2011). Another coal company that holds 5 mines in southern art of USB, which generate the largest stream of saline waters pays round 63 million euro/yr. in a form of environmental fees for discharge of saline waters. Pumping and discharge of waters from closed mines is organized by Central Mine Drainage Company by a cost of 4,3 million euro/yr.

4. METHODS OF REDUCTION OF SALT INPUT INTO ENVIRONMENT

In conditions of coal mining in USCB three ways of reduction of salt input into environment may be considered:

- Injection of saline waters into deep geological formations,
- Desalinization of mine waters,
- Use of mine waters for internal purposes of mines.

Saline waters from three mines undergo desalinization process in a plant of maximal capacity of 100 thousand t/yr., which produces round 75000 t/yr. of salts (Andrusikiewicz and

Tora, 2016). The plant reduces discharge of salt in to watercourses by nearly 6%. Technology adopted in the “Dębieńsko” desalinization plant is highly energy consuming. Production of one tone of salt requires almost 1 MWh of energy (Bobik and Labus, 2014). Experience collected from construction and operation of this facility unveiled a few serious obstacles against considering the desalinization as a general solution for mine waters problem. The main barriers are extremely high investment and operational costs of application of desalinization in desired extent and also, keeping in mind that total market of salt in Poland is about 2,1 Mt/yr., covered mainly by salt mines, desalinization products from mine waters would create overproduction of NaCl and other products of round 1,3 Mt/yr., fairly beyond consumption potential (Gruszczyńska et. al., 2014).

Another chance for significant reduction of saline waters discharge have been associated with brines and other highly salinized waters injection into deep absorptive geological strata. Potential of this method has not been yet scientifically proved in conditions of USCB, however costs of its application would be probably highly much above economical acceptance, as show preliminary studies (Gromiec et. al., 2014; Gruszczyńska et. al, 2014).

The last option represents a group of methods, where utilization of saline waters occur inside a coal mine. Saline mine waters may be used as an own source of fresh waters after desalinization in small scale plants (Bodzek and Konieczny, 2011). Such an installation implemented in a mine in northern part of USCB is producing round 60 thousand m³/yr. of fresh water and 1300 tons of chlorides, sulphates, and other ions. The savings on fresh water delivery and environmental fees for discharge of waters are reaching more than 100 thousand euro/yr.

Use of saline waters in coal processing and underground air conditioning is insignificant, since such systems are operating in closed circuits. Relatively large area of mine activities, where water consumption is reaching substantial volumes is widely understood filling of mine voids.

5. TECHNOLOGY OF UNDERGROUND VOIDS FILLING

In 2016, total number of 91 longwalls have been running in Polish coal mines, from which only about 6 used to run hydraulic backfill. Number of longwalls with grouting of cavings is hardly to be identified, while frequently filling of voids (grouting) takes place temporary, only during increased probability of spontaneous coal ignition (endogenic fires) in longwalls.

Filling of underground or voids occurs in variety of mining operations accompanying the main process of extraction of a mineral. Except descendent and rarely used technology of pneumatic placement of fill material, hydraulic transport is used to deliver fill materials and place them in the voids. Water may be used only as a carrier medium for hydraulic transport of solids or also as a compound, which interacts with the fill material. In most cases the fill material is expected to create a solid body after placement, so appropriate proportions of water to solids are required, to ensure best conditions for either hydration of cement and pozzolanic reactions, which are commonly used in binding of water-solids mixtures.

From the point of view of maximized saline water utilization, only these underground technologies may be of interest, which consume regularly significant quantities of water. In

this approach all occasional or small-scale backfill related operations, like liquidation of shafts or construction of backfill plugs remain out of scope of interest.

Reason for the use of backfilling is to keep the roof of a seam in relatively undisturbed conditions. Alternatively, in the system with caving, the roof rocks over a seam are supposed to collapse in a controlled manner. Rubble of fractured rocks is often called as gob area (Figure 1). While backfilling in underground coal mining is considered as inefficient for economic reasons, the only beneficial way of utilising saline waters is grouting of cavings in gob and voids of large dimensions. Considering differences between mining with backfill and grouting of cavings, one should noticed that in typical hydraulic backfill systems most of water is circulating in a closed circuit between backfill preparation plant, longwall panels, and drainage system of a mine.

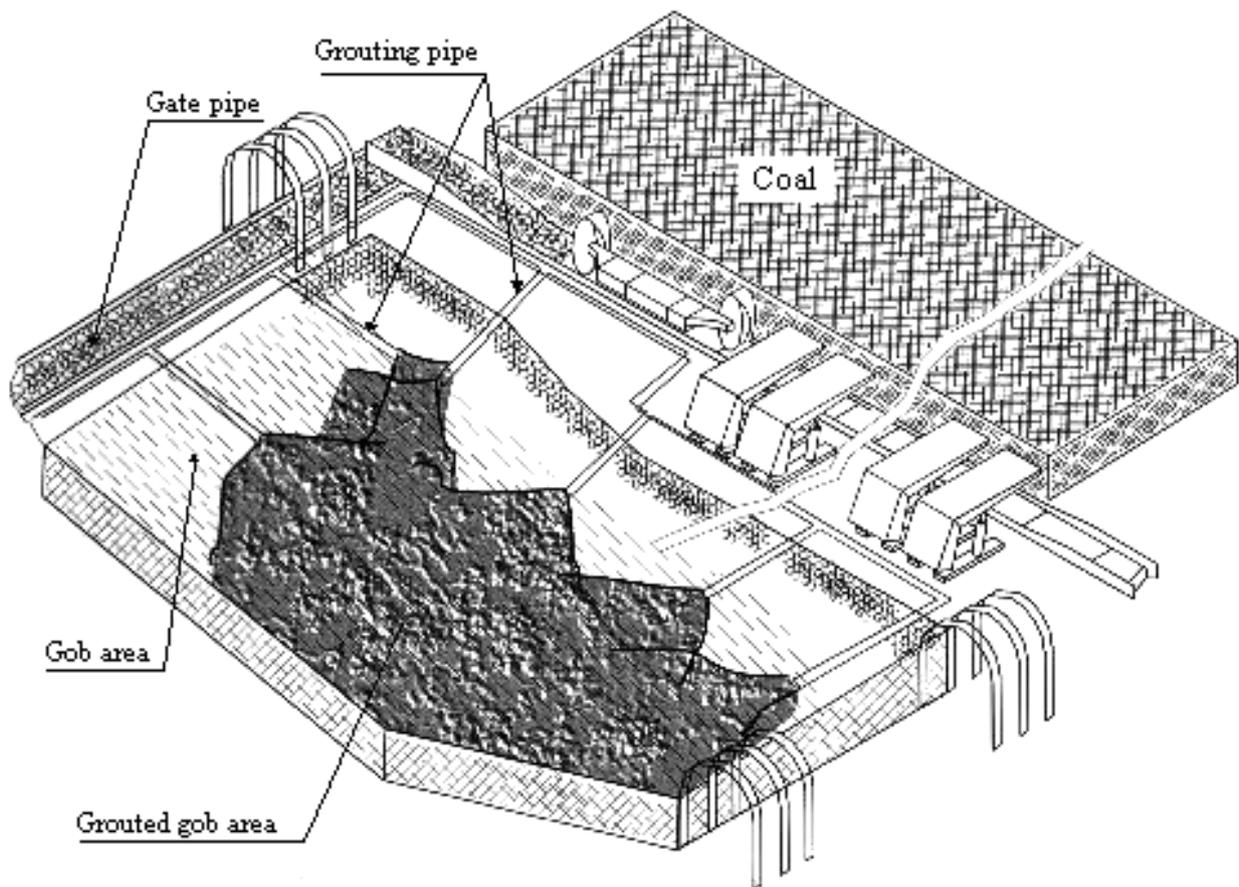


Figure 1. Schematic diagram of a longwall system with caving and grouting of the gob area.

Grouting of cavings in a gob are behind a longwall front can be arranged in several ways, dependently on geometry of the seam and technical preferences related to space

limitations, interference of grouting with other mining operations, available equipment etc. Most often, transport pipeline is located in the tail gate and grout is injected into cavings with use of short pipe outlets placed at the side of the gob area (Figure 1). In some variations of longwall systems, the tailgate is backfilled subsequently to advance of longwall. In such a case grout could be also used for filling of the tail gate. Another method requires location of the pipeline in the longwall, mounted on the face conveyor or hanging under the shields, with pipe outlets directed into the gob between the shields. Grout injections are especially effective in inclined coal seams, where elevation differences increase range of flow of slurries in voids.

After extraction of certain part of a seam is possible to fill all redundant adjacent workings and consequently, all main access roads after completion of mine works on a given level. Such subsequent liquidation of mine workings extends significantly total volume of voids, which can be filled with a mixtures with high amounts of brines and saline waters.

5. 1. Preparation of fill mixtures

Around 70% of mines are equipped with distribution systems for slurry injection into cavings. Most of them are based on old hydraulic backfill plants with gravitational hydraulic transport of mixtures. In a slurry preparation plant on the surface, fine grained waste like fly ash are mixed with water and eventually binders and other components. In addition crushed waste rock or tailings can be fed into the slurry silo or the hopper via a conveyer belt. The mixture preparation can be fully automated (Figure 2) and allowed to mix slurries with a wide range of components.

Fill slurry preparation plants can be arranged in many ways, to accommodate specific requirements, depending on the number of components, ways of their delivery, operational flow rate, and other factors. The main components of a fill slurry preparation plant are presented on Figure 2.

A fill slurry preparation plant shall contain at least:

- vehicles discharge utilities,
- tanks and silos for all solid and liquid components,
- conveyors and feeders for transportation of components from tanks to mixer,
- an ample water supply,
- mixer,
- control system.

Tanks for fly ash and other components must have at least a volume required for a single operation cycle. The water supply must be enough to produce the required amount of slurry and to clean the mixer and pipelines at the end of an operation cycle. Slurry tanks are necessary when the capacity of the mixing system is lower than the expected injection capacity. They can also be used as retention tanks in the case of irregularities in the injection flow rate. As already mentioned, Polish coal mines use mainly gravitational transport of slurries. Such a solution reduces operational costs of grouting operations, but limits the ability to control slurry parameters and fill efficiency.

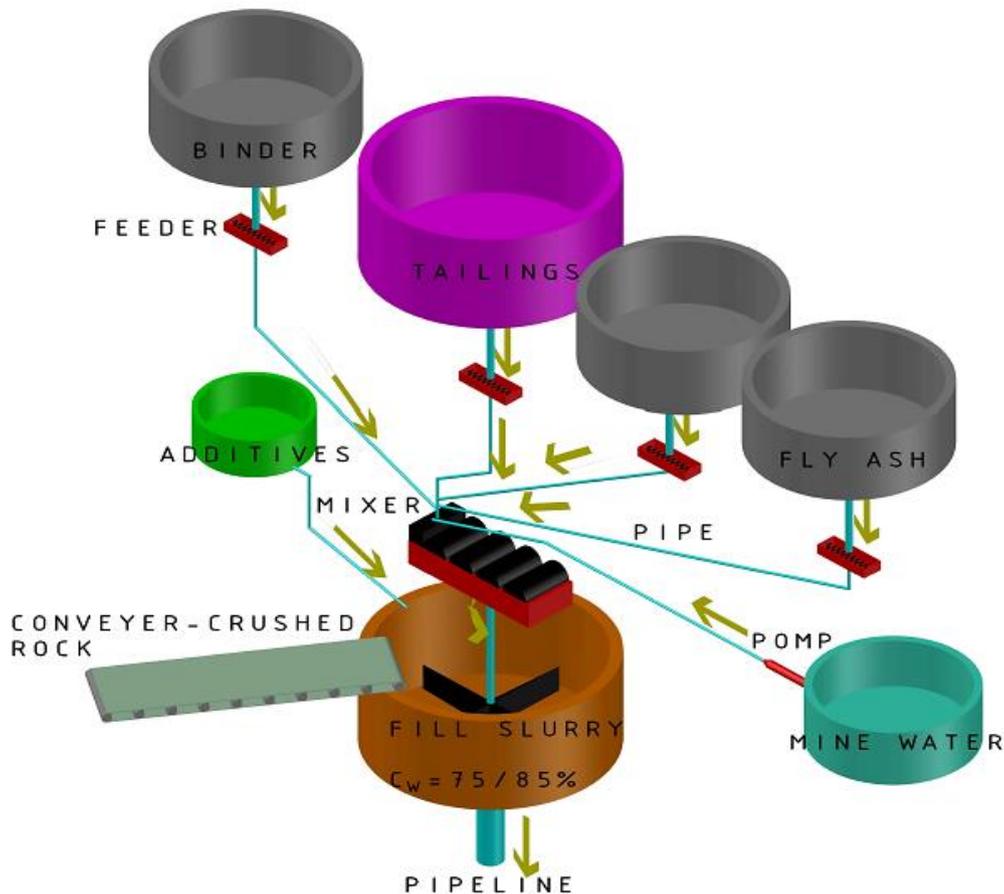


Figure 2. Schematic diagram illustrating the different components of cemented backfill - fill slurry preparation plan (Palarski, 2013).

If the grouting of voids is aimed mainly on the utilization of a maximum volume of saline water, then there is no need to use highly concentrated slurries, which could require precise adjustment of mixture parameters during its preparation and transport.

For the purposes of grouting of cavings in conditions of Polish coal mines the preparations plants may be much simplified than shown in Figure 2 and consists only of fly ash unloading and storage part, water delivery part, a mixer, and control panel (Figure 3). Sometimes fly ash is being delivered to mixer directly from railway or truck cisterns without intermediate storage tanks.

5. 2. Requirements for grouting mixtures

Composition of a mixture has to meet the requirements for both pipeline flow and penetration in the gob area. Material for the grout must be also available in quantities adequate to volumes of voids, must meet environmental standards, and be able to create a solid body with mechanical properties expected by the conditions of application. Considering all factors, fly ash from hard coal combustion in power plants represents a raw material, which is able to meet all mentioned requirements. In general, the penetration of grout depends on many parameters such as composition of the slurry, applied grouting methods, pipe

spacing, configuration of the roof fall rocks (porosity and surface roughness) and inclination of the footwall. The quality of the grouting mixture has an influence on the binding time, flow ability to migrate through caving fractures, sedimentation of the grout, amount of excessive and other. Binding time and sedimentation of a mixture for this technology should not be too short since the processes would cause a quick plugging of roof fall rocks. On the other hand an excessive amount of water, which cannot be absorbed neither by solidifying mix nor surrounding rocks would return to the drainage system.

In similar way as in longwalls, old inaccessible cavings can be filled with mixtures containing large volumes of saline waters. If these abandoned parts of mine fields are isolated from the active mining areas, then it is possible to maximize amount of saline waters in the mixture with resignation from their beneficial physical properties, within mentioned above limitations.



Figure 3. Fly ash – water slurry preparation plan at “Szczygłowie” mine. On the left: fly ash tank and main building behind binder tank, right up: pneumatic fly ash discharge from tank wagon. Right down: control room (Palarski et. al., 2011).

5. 3. Influence of water salinity on properties of grouting slurries

When backfill operations are undertaken to reduce mine subsidence or improve the insulation properties of the rock mass, a maximized concentration of solids in the fill slurry is the target. When maximum deposition of saline waters has to be achieved by grouting operations, the composition of a fill mixture must be determined according minimal bleeding (excessive water presence) and the water absorptivity of the rock mass. The presence of chlorides and sulphates in water also influences the chemical processes of cement hydration and pozzolanic reactions of fly ash and binders with water.

Laboratory tests show that the presence of salt in water in a concentration up to about 60 g/dm³ (as is the case for most mine waters from underground Polish coal mines) significantly increases the compressive strength of cured fly ash-water slurries and reduces their binding time, both in the presence of cement (Figure 4) or without an additional binder (Figure 5). Compressive strength and other properties of fly ash – water mixtures (binding time and table spread) have been measured accordingly to standard PN-G-11011:1996

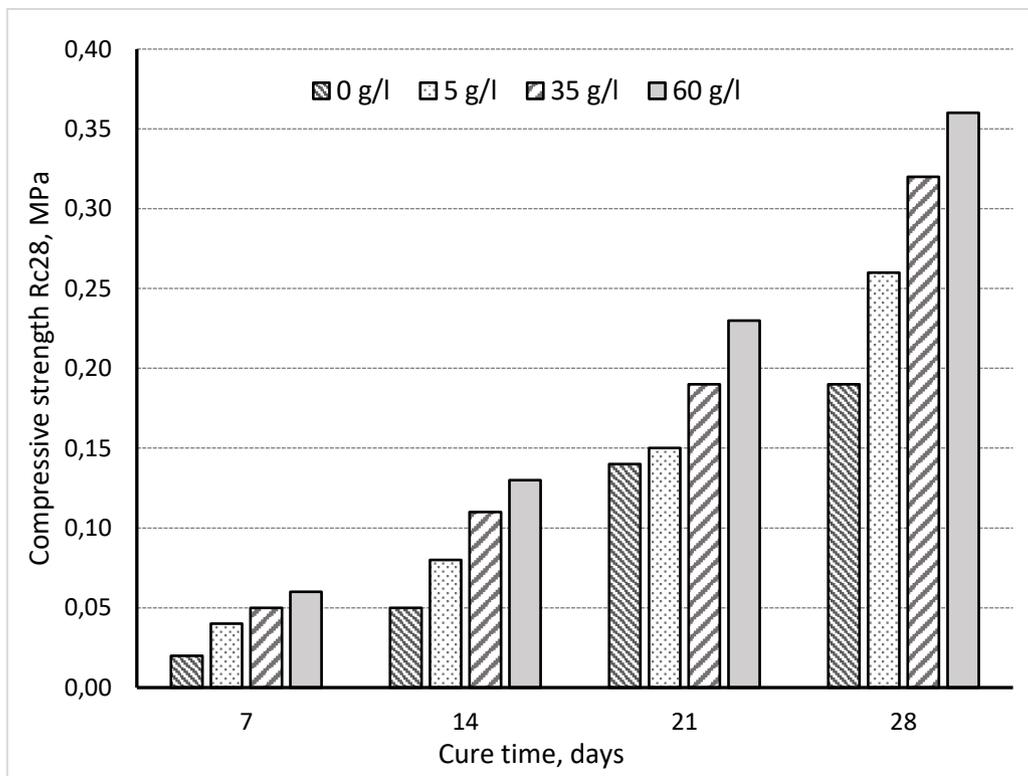


Figure 4. Compressive strength of fly ash-water slurries in relation to cure time and salinity of water; parameters of the slurry: solids to water ratio 1:1 slump 250 mm, fly ash from fluidal bed vessel.

Figure 4 presents solidifying process of a typical fly ash – water mixture as a function of compressive strength. Presence of chloride and sulphate ions increases compressive strength of fly ash – water mixtures in relation to their percentage in water and cure time. Compressive strength, which can be considered as a factor of solidifying process, is growing

far beyond the 28 days cure time and is still visible even after few months after placement in void (Plewa et. al., 2013). Faster development of compressive strength of fly ash – saline water mixtures is accompanying by retarded binding time (Figure 5), however the delay of start and end of binding between samples made with fresh water and mine water containing 60 mg/dm^3 of does not exceeds $1 \div 1,5$ days (around 6 to 9% of a cure time).

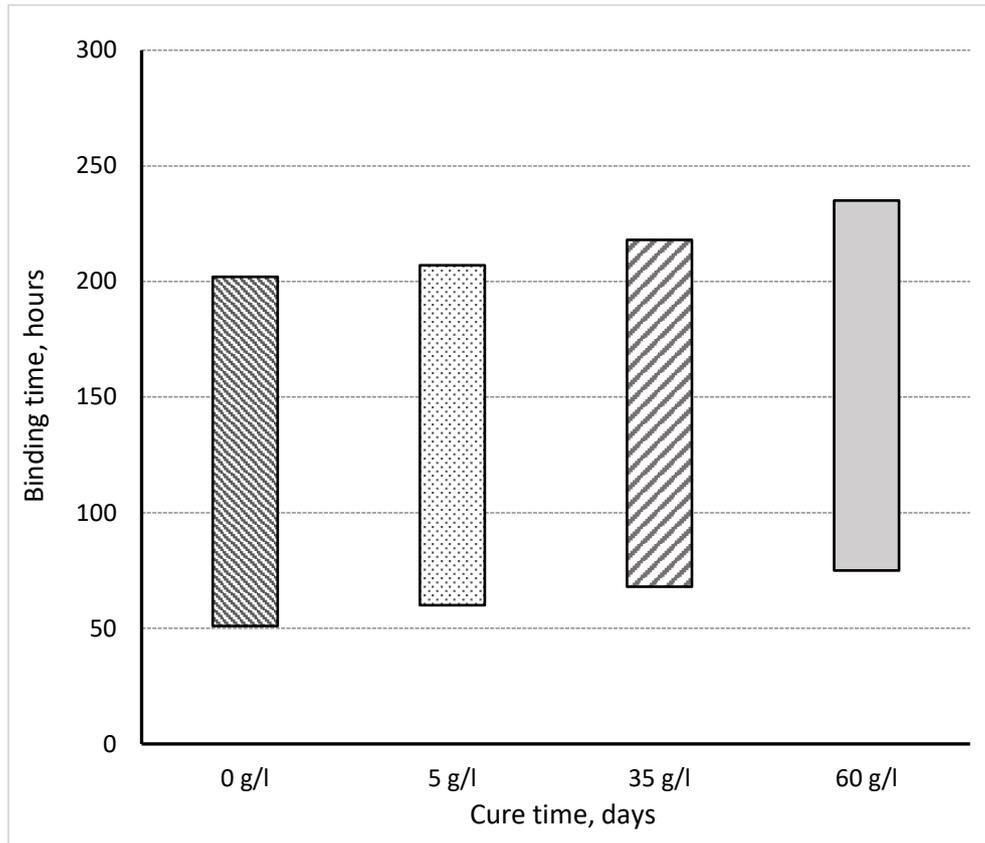


Figure 5. Binding time of fly ash-water slurries in relation to cure time and salinity of water, parameters of the slurry the same as in Figure 4.

Figure 6 illustrates behaviour of fly ash – water slurries intended to absorb large amounts of saline waters places in a mine working. The mixture shown on the picture was delivered about two weeks earlier, has a depth of about 1 meter and is able to withstand safely weight of a man, although is still not solidified.

Figures 7 and 8 present data from laboratory measurements of compressive strength and binding time of slurries intended to utilize brines. Fly ash from semi-dry desulphurization process and brines of concentrations 0, 165 and 330 g/dm^3 have been mixed in solids to water ratio $2,4 \div 2,9$ to obtain constant table spread of 180 mm.

The result show that after 28 days cure time, slurries containing sale in concentration 165 g/dm^3 exhibit twice higher compressive strength than mixtures with fresh water – figure 7. Also addition of cement gives the mixture with brine of concentration 165 g/dm^3 more intensive dynamics of compressive strength development than mixture with fresh waters.



Figure 6. Fly ash – saline water slurry two weeks after placement in an underground working during liquidation works. The slurry is still liquid but able to withstand a pressure of no less than about 20 kPa.

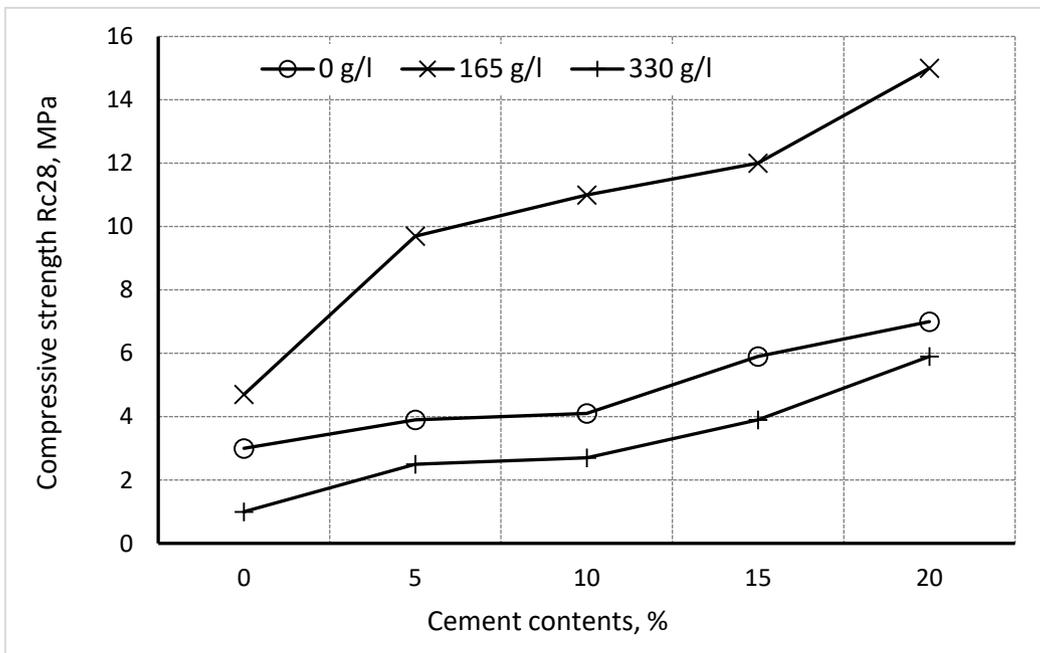


Figure 7. Compressive strength of fly ash – cement – brine slurries after 28 days cure time in relation to concentration of brine and percentage of cement (see text for details).

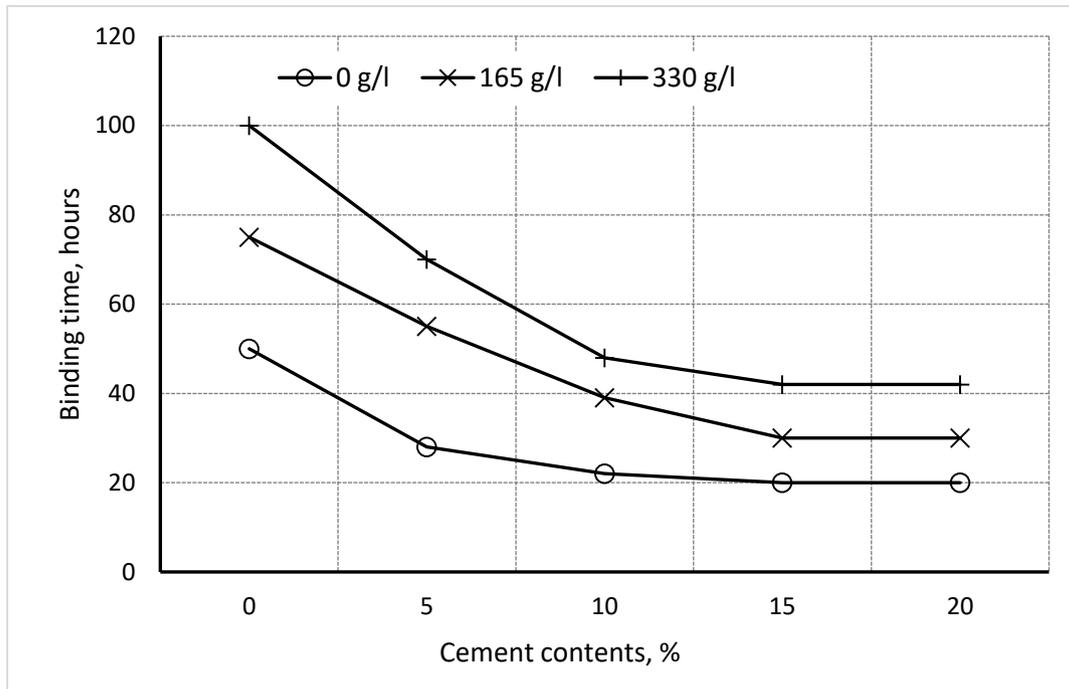


Figure 8. Binding of fly ash – cement – brine slurries after 28 days cure time in relation to concentration of brine and percentage of cement (see text for details).

Beneficial relation between concentration of salt in water and growth of compressive strength is not linear and after exceeding certain value of concentration, the influence of salt in a mixture starts to be negatively affecting the compressive strength, down to values even below the parameters measured for mixture made with fresh water, as it is shown on Figure 7.

Figure 8 depicts influence of salinity of brines and percentage of cement, for the same slurries as presented in Figure 7 on binding time. It shows that any concentration of salt retards the binding process. By unfavourable conditions, binding time may be even infinite, it means that the slurry will demonstrate properties of viscous fluid rather than a solid body. In some specific conditions such slurries may generate risk of flooding of workings being in use. This risk is particularly pertaining slurries made with other than fly ash kind of industrial waste, like REA gypsums (originated from flue gas desulphurisation plants) or other finely grained waste or by-products, which do not exhibit binding properties without addition of binders. However, addition of binders, mainly cement, increases significantly costs of filling of voids, so preferable are waste materials, which exhibit binding properties alone.

6. ASSESSMENT OF POTENTIAL SCALE OF APPLICATION, ENVIRONMENTAL EFFECTS AND TECHNICAL ISSUES

The only critical factor for much more wider implementation of grouting of cavings is availability of fly ash. Consumption of fly ash by underground coal mining in Poland keeps in range between 2,35 and 2,60 Mt/yr during last decade, however with total production of fly

ash on the level 4,5 Mt/yr., it makes about a half of it, which is utilized by coal mining industry (Palarski et. al, 2011).

A research on efficiency of filling of voids in cavings demonstrated that the coefficient of filling in longwalls (volume of grout being injected to expected absorptivity of cavings ratio) changes between 0,03 and 0,62 (Strozik, 2015). That means that even in longwalls where grouting voids was implemented, filling operations had been conducted occasionally.

Considering output of coal as equal 70 Mt/yr. the primal underground space of voids is round 50 million m³/yr. Available space for filling is reduced by an empirically determined factor of 0,484 (Strozik, 2015), so the potentially available space for filling has a volume of 24,2 million m³/yr. Even if a realistic coefficient of filling is only 0,154 (volume of slurry being injected to volume of available emptiness in longwalls determined on statistical data from industry), there is still 4 million m³/yr. voids to be filled. From the point of view of fly ash utilization, if the consumption of fly ash by coal mines is round 2,5 Mt/yr., then 2,5 million cubic meters of saline waters may be utilized by production of fill slurries, while most often solids to water ratio in fill slurries is about 1 : 1. Total volume of saline water being actually utilized by production of fill mixtures may be increased up to a maximum of 4 million m³/yr if the power generation industry would offer adequate deliveries of fly ash to coal mines.

In the environmental aspect, in first point should be noted that for preparation of fly ash – water slurries mines use any waters they actually drain, so potential of this technique to utilize brines is frequently neglected. However, assuming that only 7% of total mine waters are brines ($Cl^- + SO_4^{2-} > 42 \text{ g/dm}^3$) (Gruszczyński et. al., 2014), volume of mine waters, which should be eliminated from the environment at first place is round 8,3 mln m³. From this amount round 30% up to 48% could be utilized as a component of fill slurries in technology of grouting of cavings and filling of workings. Although the upper limit is only theoretical, utilization of about one third of total heavy salinized waters in technology discussed in this paper seems to be attractive and realistic solution. Utilization of brines in technology of filling of voids with fly ash - water mixtures is also economically valuable. Operational costs of filling of voids are low and fully justified due to its benefits: improvement of ventilation conditions, methane emission reduction, and endogenic fire prophylactics. Most of mines are equipped with mixture preparation plants and underground pipe distribution networks, if not – construction of a new preparation plant and piping does not implicate substantial investments. In some extent such an investment could be co-financed by environment protection sources.

The only problem, which must be solved by implementation of discussed technology, is providing measures to collect and separate most salinized waters (brines) from the general stream of mine waters in drainage system of mines.

7. CONCLUSIONS

It must be clearly understand that the general success of utilization of highly mineralized mine waters in fill slurries depends on wide application of the technology in all mines, in respect to the coal output of each mine. It would allow fully (or at least almost fully) accommodate highly salinized waters streams from scattered sources. Few mines, which generate the majority of salt input into environment, should use filling of voids in an extend

adequate to their coal output, although controlled discharge into watercourses will be still the dominant way of their utilization.

Filling of mine voids with use fly ash – water slurries, where brines and highly salinized waters are to be utilized, is not expected to create opportunity for complete solution of saline waters input into environment. However, coal mines should take advantages from its application both in terms of mine hazards control and environment protection, and use it in as far as possible scale. In contrary to other methods of utilization of mine waters, this one does not generate significant costs, concentration of streams

Use of saline waters in technology of filling of mine voids belongs to highly appreciated category of waste management, described as use of waste at the source of origination, without any going into interference with environment.

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(Received 06 March 2017; accepted 20 March 2017)