Residual Mining Pits in Central Part of North Bohemian Brown Coal Basin

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Abstract
The open pit way of mining the brown coal deposit in the North Bohemian Brown Coal Basin has demanded big and large changes of original terrain by the removal of overburden layers over a coal seam. Many original water lakes were destroyed this way in last two centuries. But new lakes have originated in the residual pits of open quarries and on dumps surfaces after the end of mining which have protective (retention), industrial, water supply, and (last but not least) recreational functions. So called hydric reclamation comes to the fore with extinguishing mining activities. Landscape enhancing lakes have originated near inhabited developments to meliorate its ecological functions, aesthetical effect of landscape and architecture. The central part of the North Bohemian Brown Coal Basin is characterised with non-flow water lakes at which the water catchment must be provided to level the evaporation and to enable changing the quality of water. A system of shallow water lakes in the Rudý sever residual pit at the Krušné Hory Mountains foot is an exception where the mountain brooks make the flow rate. Significant number of existing water lakes has been established in residual pits of former open pit mines and it is why large sanitation works have had to be done before filling them in which the rest coal seams should be sealed, to enable an access, and a slope stability security after flooding. Redevelopment works concerning the landscape affected by mining activities are specific with using mining technology by the means of which it is possible to influence the landscape and ecology points of view aiming to full reconstruction of coal basin landscape. The area of former open pit mines is much large than the one on which normal building works take place. Large geo-morphological changes and the interrelating changes of hydro-geological, geo-mechanical, and hydro-chemical regimes in the areas of mining spaces and in protected deposit areas are projected to residual pits final improvement. This requires the rigorous evaluation and incorporation of mining condition, from beginning to liquidation works, in the final project of the way of reconstruction.

Key words: residual pits, North Bohemian Brown Coal Basin, Czech Republic

Introduction

Residual pits in the Most (central) part of the North Bohemian Brown Coal Basin originated with the end of small and medium size quarries after the second world war. The quarries were in outcrops and shallow layers of coal beams and in small separate basins. No small quarries are in operation any longer. The outcrop parts were not suitable for establishing water lakes. Quarried coal seam usually continued with the coal seam exploited by underground mining in the deeper position of the basin. The making of a lake could be a mining safety hazard in a case of water irruption. Shallow lakes originated in such localised residual pits only after their fulfilling by inner dumps and consolidation of overburden earth. On the other way, residual pits in little separate basins or in the places without a contact with the larger occurrence of a processed seam and where a basin base formed non outlet depression provided good hydro-geological conditions for a creation of the lakes. The Most (central) part of north Bohemian brown coal basin is the largest and deepest. Most of the coal seam was mined in the underground with the exception of the protection pillars of settlements, factories and communications. Open pit mining takes place in the both north and south seam outcrop. It touched heavily the southern edge of Most part of the north Bohemian basin (almost continually from Bílina to Most). The open pit mines of Bílina, Vršany, J.Ševerma, and that of Československé armády in the north outcrop, overburden soil of which is dumped to former Obránců míru mine, are in operation. Most and Ležáky mines on the southern edge stopped activities in 1999. As former small quarries at the Krušné Hory Mountains foot are concerned, S. K. Neumann mine was dumped internally and reclaimed as a forest, and residual pits of Pavel and Marie mines were dumped in. Rudý Sever mine residual pit was internally dumped and in its eastern part a system of shallow lakes was built. Saxonie mine residual pit serves for the deposition of the sludge from Komořany coal preparation plant (c. 2.5 km west from the Most town). Vrbenský mine residual pit (c. 1 km northwest from Most) was dumped internally and a recreational lake was build there supplied with the Ohře river water. The coal seam

was excavated in Jan, Richard, Bedřich, and later Most mines east from the Hněvín Hill. The mining took place in Ležáky mine – Nové pole panel farther to east. Residual pit of this mining, called Venuše, is used for ash rest floating (c. 4 km north east from Most). Residual pits of Elisabeth, c. 2 km from Most, which is used for the deposition of the sludge from a waste water treatment plant, and Benedikt, c. 1 km south east from Most, used as a recreational lake.

Rudý sever residual pit

Rudý sever mine field was at the Krušné Hory Mountains foot close to Hamr community in Litvínov – Hamr u Litvínova cadastral unit (western part of the mine field) and in Litvínov – Chudeřín u Litvínova (eastern part of the mine field). The coal seam in the Hamr I and Hamr II exploiting areas was mined by both Rudý sever underground and open pit mines from the point of view of the basin division to mine fields. Brown coal mining came to an end in 1962. The Rudý sever lake was designed as one of the retention reservoirs in 1963 to protect against flood. The Rudý sever retention reservoir catches the flood wave and decreases the flood through flow rates of the Bílý potok and Zalužanský potok streams (relays of Litvínov streams). Its capacity is 0.7 million m^3 and it can be increased up to 4.5 million m^3 by some hydro-geological conditions and 16 m^3s^{-1} outflow to Bílý potok stream.

Saxonie residual pit

Saxonie residual pit (originally Vrbenský mine – Saxonie district) is located at the southern edge of the central part of north Bohemian coal basin south of Třebušice village mostly in cadastral unit Most – Třebušice (northern part) and partly in the unit Most – Hořany (southern part). The coal seam in the Souš I and Holešice exploiting areas were mined by Vrbenský open pit mine – Saxonie district from the point of view of the basin division to mine fields. Brown coal mining came to an end at Saxonie locality in 1978. Saxonie mine residual pit serves for the floating deposition of the sludge from Komořany coal preparation plant since 1979. Final arrangement, sloping, and reclamation of the area nearby was carried out only in 1992 after finishing the northern dam which enables up-filling to its capacity at 240 m above sea level. It still serves as a floating place and after finishing it the residual pit is to be reclaimed as a forest and incorporated in the complex of surrounding reclaimed areas.

Vrbenský residual pit

Vrbenský residual pit is located in the Most – Souš cadastral unit. The coal seam in the Souš I exploiting areas was mined by Vrbenský open pit mine from the point of view of the basin division to mine fields. Brown coal mining came to an end at Saxonie locality in 1978. The Vrbenský residual pit water reservoir was originally designed as a part of the water resources system substitution of a liquidated Dřínov retention reservoir. The lake with the area of 38.7 ha and the average depth of 3.5 to 4.0 m was filled in from the industrial water supply line from the Nechranice dam lake in 1992. The residual pit is used as a water reservoir with recreational and economical function nowadays.

Venuše residual pit

Venuše residual pit is located c. 4 km north east from the Most town, mostly in the Bílina – Jeníšův Újezd cadastral unit and partly in the Most – Konobrže (northern part), Most - Střimice (southern part), and Braňany (southern part) units. The coal seam in the Most exploiting areas were mined by Ležáky open pit mine – Venuše district from the point of view of the basin division to mine fields. The residual pit is used for ash waste floating. The Venuše floating place was constructed in the first half of the seventies of last century and it was put into operation in December 1976. Mining hydro-geological and operational troubles were expected already at the floating place preparation because neighbouring Venuše underground mine which is connected through cross drifts with Kohinoor mine and at that time active Mír (Masaryk) mine. A measure was accepted based on a suitable ash floating technology to minimise the water ingress to Venuše mine through overlaying sands. The Venuše floating place operation started in December 1976 and the floating has been still in operation.

Benedikt residual pit

The Benedikt mine field was located close to the Vtelno village which is c. 1 km south east from Most and it took almost all the Vtelno cadastre and a little part was in the Most town cadastre. Its boundary was defined by the outcrop of the seam of a little basin and a Vtelno limited pillar. Brown coal mining

came to an end at Vtelno locality in 1964. The space of a Benedict open pit mine should have been used for a retention reservoir according to a layout planning scheme, but the decision has been changed. A water lake for recreational purposes was designed in the place of former Benedict open pit mine and its realisation began already in seventies. The finished residual pit served for recreational purposes since its filling with water (1974) to 1994. The city stopped giving water from near water distribution tank and the lake level began to fall strongly. The reason of the level fall was the water leakage from the lake. All the range was reconstructed in 2001. The original water area has not been kept and two smaller lakes originated in the depressions of the bed after decreasing the water level. The rest surface of the dry bed was used for sports and games facilities.

Elisabeth residual pit

The Elisabeth mine field was located c. 2 km south east from Most and c. 500 m east from the Vtelno village and it was mostly in the Vtelno cadastre and it partly was in the Chanov cadastre. Its boundary was defined by the outcrop of the seam of a little separate basin. The coal deposit took an oval shape with longer north-south axis and its thickness decreased to its edges. Main part of the separate little basin was mined in 1958 to 1962. An agricultural and forest reclamation should have been carried out in the place of former Elisabeth open pit mine. The original intention was changed and a sludge lagoon was built here for a water treatment station sludge deposition. The lagoon is in operation nowadays.

Issue of future residual pits

The geological, mining, hydro-geological, and water resources - last but not least – issue were not the object of research works until recently. It used to be solved by design studies or directly by operational designs. The existing watered residual pits are relatively small in size. The original intention of North Bohemian Brown Coal Mines, national enterprise, was a total mining of the north Bohemian brown cal basin and that is why the number of residual pits should have been smaller, the time of their creation should have been much later, and a future hydro-geological position relatively simple. The issue of variously situated residual dumps already comes to the foreground of the interest currently as a result of the mining coal limitation and thus a liquidation of open pit and underground mines.

The **geological** issue includes laying situation of overburden, coal seam, and rock bed and their petrographical composition and geo-mechanical properties. Their geological position (in depressions or elevations, near faults or seamless parts) may be important from the residual pits point of view and it can make the separation of residual pits from old mine works. The selection of proper sealing matter and determining the space of its mining, way of its storing, compaction, consolidation time, floatability etc will have a fundamental significance. The content of sulphides and other compounds in a coal seam, overburden and inner dumps including their tendency toward oxidation, decomposition, and leaching will be important for the development of the water composition in residual pits and old mine works. The leachability of overburden and dump soils with the assessment of their possibility to influence the chemical composition of the water in residual pits will be a separate problem, see water resources issue.

The **mining** issue will be directed firstly to the fact that most of residual pits will be in a close vicinity to underground processed coal seam or at least that with drifts with its overlaying formation partly disturbed with caving depressions. Inner dumps will make the significant part of residual pits slopes where stability problems can be expected during pit flooding intensified by the acting of huge waves in stepwise heightening bank zone of future water reservoirs. An additional caving can be caused by self-ignition of an open seam. It will ever be necessary to close the mine drifts properly which outlet to the residual pit and to seal non caved holes after the underground mining. A self standing problem will be the way of sealing the rests of coal seam and covering its base. The classic mining activity of the method of creating inner dumps during the deposit mining must be combined with civil engineering way to seal problem parts.

The **hydro-geological** issue of the residual pits and close neighbourhood will be influenced a lot in the flooding time and later. The fundamental task will be the selection of the part of the residual pit from the hydrological point of view to create a water reservoir. The prognoses of hydrological situation at the time of stopping the mining, stripping, and dumping and a sequential flooding will have to be elaborated. The influence of the water lake on water bearing collectors which will contact the water in the residual pit will have to be estimated, too. These will imply the proposals for the need and size of

sealing works etc. The protection of the flooded residual pit against the inflow of underground and/or rainfall waters from near surroundings will be very important to solve. Waste water from the old mines will be an integral part of the hydro-geological issue of residual pits. The prognosis of the range and speed of the flooding self-fill, the determination of the outflow to a terrain and the relation to further water bearing collectors will have to be solved, too.

The **water resources** issue will be also significant. From the hydrological point of view the flooded residual pits will constitute anthropogenic lakes with through-flow and non through-flow regime. The easily destroyable slopes and banks of the reservoirs will be destructed by the waves which will tend to create geo-morphological shapes typical for lake shores. The transferring capacity of the inlet water must be counted from the beginning which will lead to clay particles sedimentation at the bottom and slopes of the water reservoirs. The stability situation on the slopes of dumps and overburden bodies can be worsened markedly and erosion furrows can be created.

The main source of the high mineralisation of mine waters in the coal mines is the coal seam enriched with iron sulphides (pyrite, marcasite) and some other elements and minerals in smaller size. Economically non-recoverable part of coal seam left on the quarry bottom is usually affected by previous mining to the depth of some meters and moreover eroded to be fallen to pieces. The areas of the mine are dried up and that is why the iron sulphides decompose on the surface of the coal layer without the presence of water first. The decomposed coal surface comes into a contact with precipitation water from time to time and locally (in the depressions of the bottom of the pit) even for long term. The sulphides transform in iron sulphate, iron hydroxide, and sulphuric acid by the action of aerial oxygen and water. The presence of some bacteria accelerates markedly these processes. The "acidification" of water is then a result. The issue of water "acidification" is very significant in the condition of the north Bohemian coal field. Clays (fewer sands) usually occur in the overburden of a coal seam, they contain essentially fewer amount of sulphides than the coal seam. The chemical reactions run much less intensively or in the isolated places only. Clays mainly, sands, gravel sands, and loams at less volume are deposited in the inner dumps. The surface of dump materials is substantially structurally changed to some depth according to its pattern (petrographical composition), acting time of climatic factors, and eventually according to the rate of its consolidation. The described physico-chemical processes run more intensively in the dump matter than in the original overlaying rocks. Next problem for water quality safety in the residual pits lakes will be the prevention of eutrophication.

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