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POSSIBILITIES OF UTILIZING UNDERGROUND MINES FOR ENERGY PURPOSES

Summary. At present, the basic problem in the Czech Republic is the protection and the creation of socially acceptable state of the environment, above all in areas affected – in the past and in the present – by the great concentration of heavy industries and the mining of mineral raw materials.

MOŻLIWOŚCI UTYLIZACJI KOPALŃ PODZIEMNYCH DLA CELÓW ENERGETYCZNYCH

Streszczenie. Jednym z najbardziej palących problemów rozważanych w Czechach jest ochrona środowiska naturalnego oraz przywrócenie środowiska do stanu akceptowalnego społecznie. Problem ten dotyczy przede wszystkim obrazów o dużej koncentracji przemysłu ciężkiego a zwłaszcza górnictwa węgla i zasobów mineralnych.

1. Introduction

At present, the basic problem in the Czech Republic is the protection and the creation of socially acceptable state of the environment, above all in areas affected – in the past and in the present – by the great concentration of heavy industries and the mining of mineral raw materials. They are in the Czech Republic primarily (mainly Ostrava region❶, Most region ❷, Sokolov region ❸, Stráž pod Ralskem ❹, region of South Moravian lignite basins ❺ and region of South Moravian oil fields ❻, etc.).

This environmental burden does not merely consist in a hazard to groundwater and surface water sources, landscape devastation by undermining effects and slope instability, but also in the considerable contamination of air caused by energy producing companies (especially on the base of fossil fuels). Just in these areas, a possibility of utilizing one of alternative energy sources presents itself. This corresponds to conclusions drawn in the report of European Commission of November 2007 which determines some ambitious objectives containing "Key technological challenges in EU for the next 10 years" to meet its energy and climate targets determined for the year 2020 [2].

Great attention is also paid to low temperature sources that would be utilized by means of heat pumps. To be effectively used they should have such volume and flow capacities that would compensate the low thermal quality of the source.

2. The utilization of low temperature sources

Here a possibility of utilizing the geothermal energy from underground mines arises. In principle, three applications come into question, namely the **air–water, water–water and ground–water systems.**

In the **air–water** system, the heat of mine air is utilized. This variant is possible by means of application of heat pumps taking heat released from a rock mass and heat from mine equipment operation away from the extracted air. The application is possible practically only in the case of active mines and mines being phased out.

In the **water–water** system, the heat of mine waters pumped for operational reasons to the surface is utilized. Part of the mine waters can be used by means of heat pumps to warm up

water for heating and to warm up domestic hot water for suitable buildings. Used mine waters will be discharged into watercourses or balancing retention reservoirs.

What may be a complication is the unsteady regime of mine water pumping (from the point of view of water discharge) or priority pumping which can occur mainly in night hours when electricity is cheaper.

A solution can be the utilization of mine water as a source of heat in the retention reservoir from which the water is discharged into watercourses. In the case of mine waters utilized like that, the chemical composition that has negative effects on the technology used must be taken into account.

In the **ground–water** system, the heat from the rock mass is directly utilized, namely from tube heat collection systems placed in mine workings, through which a medium transporting the heat to the surface will circulate.

Generally, mines can be divided into underground mines and opencast mines. From the point of view of minerals mined they are divided into coal, ore and nonmetallic mines. As for possibilities of utilizing the geothermal energy obtained in connection with the existence of mine workings in the framework of Moravian-Silesian Region, it is the utilization of underground mines that presents itself as the most suitable and practically the only possible utilization.

In the whole of the Czech Republic, the underground mining of minerals is considerably phased out at present; of underground mines merely coal mines are operated. The only non-coal active mine is the uranium Rožná Mine of state enterprise DIAMO, o.z. GEAM at Dolní Rožínka.

3. Division of mines and mine cavities

Underground mines and mine cavities can be divided, according to the characteristics of present state as follows: under construction, active, under preservation, under decommissioning, decommissioned (former) and mines with special functions [1].

Hard coal underground mines of the company OKD, a.s. (Ostrava-Karviná Mines, a.s.) can be divided, according to the above-given characteristics, into the following:

a) Mines under construction (and preservation).

A non-mining locality is the Frenštát Mine, where two shafts have been sunk and air ways have been closed. Yet neither development work nor methane production has been commenced or permitted. Substantially, this mine is under construction; it has been operated in preservation regime on a long-time basis.

b) Active mines.

It is especially a case of active mines in the Karviná Partial Basin, specifically the Lazy Mine, ČSA Mine, Darkov Mine and ČSM Mine.

In the Podbeskydí area, the Paskov Mine with the mining locality of Staříč is active.

These mines are active; in them, hard power and coking coal is extracted.

c) Mines under decommissioning.

At present, it is a case of the Dukla Mine that is part of branch plant Odra (DIAMO s.p.). Due to the quick progress of decommissioning works, this locality will not be utilized for the given purpose.

d) Decommissioned mines.

In the Czech Republic, the number of these mines is the greatest; nevertheless, for the purpose observed these mines are usable with difficulty.

The former mines in the Ostrava-Karviná Coalfield are prevailingly in the administration of state enterprise DIAMO s.p., branch plant ODRA.

They are largely former mines in the Ostrava Partial Basin (fig. 1), Petřvald Partial Basin and partly in the Karviná Partial Basin [3].

They are all former mines in the area of the town of Ostrava (about 73 km^2), the mining locality of Paskov Mine at Paskov, mines delimited by the Petřvald I and Petřvald II mining claims, Žofie Shaft in the Poruba mining claim, František Mine at Horní Suchá and the Barbora Mine in the Karviná Doly II mining claim [4].

e) Mines with special functions – pump shafts

For technical reasons, to protect the Karviná Partial Basin from flooding with the mine waters from the phased out Ostrava Partial Basin, two so-called pump shafts are operated on a long time basis, i.e. those of the former Jeremenko Mine in Ostrava and the former Žofie Mine at Orlová. But these mines are under the administration of DIAMO, s.p.

Necessary mine cavities are ventilated by a through-circulating current and mine waters are pumped discontinuously, which may cause certain problems in the utilization of their heat content.

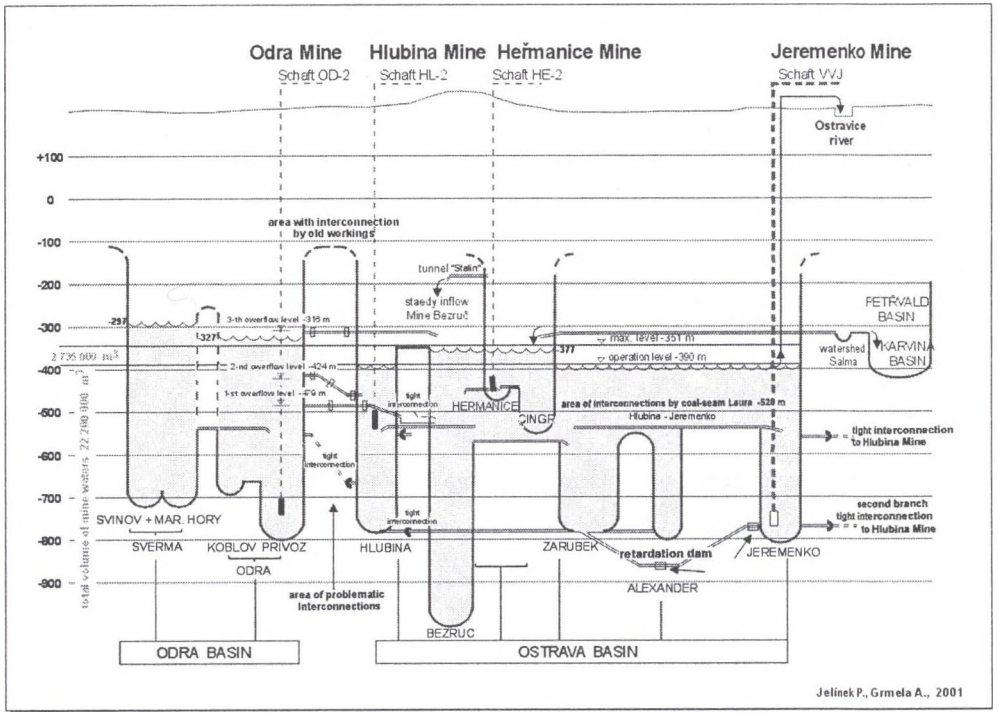

Fig. 1. Diagram of flooded Ostrava Partial Basin in the Czech part of the Upper Silesian Basin. Surface area - 73 km^2; total flooded volume - 24 935 000 m^3; water temperature - min 24 °C

Rys. 1. Schemat zalanej części Niecki Ostrawa w czeskiej części Zagłębia Górnośląskiego. Obszar powierzchni: 73 km^2, łączna objętość wody zalewającej: 24 935 000 m^3, temperatura wody: -24 °C

The other brown coal and lignite underground mines can be characterized in a simplified way as follows:

- The brown coal Centrum Mine in the Most area that is a part of the Mostecká uhelná společnost, a.s. company. This mine is active and produces the low-sulphur brown coal from one face; its final closure is expected in the year 2008 or 2009.
- Phased out brown coal mines in the Most area with mine water pumping.
- The lignite Mír Mine at Mikulčice; this is the last active lignite mine in the Czech Republic that is developed by the inclined mine working and the vertical shaft.

Non-coal underground mines

Merely the uranium Rožná Mine at Dolní Rožínka, which is a part of DIAMO state enterprise, belongs to the non-coal active underground mines in the Czech Republic.

4. Real utilizability of mine cavities for obtaining geothermal energy

It is evident that the geothermal potential of some underground mines is well utilizable in certain cases. For the sake of clarity, we shall present the division into very suitable, well utilizable, conditionally utilizable and completely unsuitable – non-utilizable.

Criteria of utilizability:

a) the continuity of a heat energy source,

b) the availability of a heat carrier medium,

c) technical feasibility.

As supporting but very important criteria, the following ones must be stated:

α) demand for energy for warming the domestic hot water (DHW) and for heating,

β) time optimum of energy supplies

- continuous all-year-round,
- seasonal – winter heating,
- process heat – discontinuous demand,

γ) energy quantity demanded.

Supporting criteria must be evaluated individually when assessing specific localities.

4.1. Very suitable

Utilization of mine air in active mines

What seems well utilizable is especially the utilization of mine air in active mines in air–water regime.

Satisfaction of criteria of utilizability:

a) the continuity of a heat energy source – ventilation of mines is a continuous process and the heated return air taken from mines by forced ventilation is practically available all the time,

b) the availability of a heat carrier medium – the heat carrier medium is the return air that is relatively easy to obtain; the utilization is possible only in active mines,

c) technical feasibility – heat obtaining is technically feasible. Because at present, only 5 active mines are operated (Paskov, Lazy, ČSA, Darkov and ČSM), from the long-term point of view, the utilization of this system in mines seems to be best.

4.2. Well utilizable

Utilization of mine waters in active mines

The utilization of mine waters in active mines in water–water regime seems to be well utilizable too. Nevertheless, it is necessary to solve a problem of discontinuous pumping of mine waters, because the pumping is performed for energy reasons especially in night hours. Satisfaction of criteria of utilizability:

a) the continuity of a heat energy source – mine water pumping is not a continuous process and mine waters heated by the mine environment are drained by the pumping system to the surface; the mine waters are pumped prevailingly in night hours, this matter must be solved further,
b) the availability of a heat carrier medium – the heat carrying medium is the pumped mine water that is relatively easy available, the utilization is possible in active mines,
c) technical feasibility – heat obtaining is technically feasible.

In the operated 5 active mines (Paskov, Lazy, ČSA, Darkov and ČSM), from the long-term point of view, the utilization of this system seems to be best in the Dukla Mine, and also in the Darkov Mine; nevertheless, the utilization in other mines is not excluded.

Utilization of mine waters – pump shafts

The utilization of mine waters pumped in pump shafts in water–water regime proves to be well utilizable as well. However, it is necessary to solve a possible problem of mine water discontinuous pumping (limited possibility of discharging into watercourses).

Satisfaction of criteria of utilizability:

a) the continuity of a heat energy source – mine water pumping is not a continuous process and mine waters heated by the mine environment are drained by the pumping system to the surface; mine waters could be pumped prevailingly in night hours (cheaper electric energy), this matter must be solved further,
b) the availability of a heat carrier medium – the pumped mine waters that are relatively easy available are the heat carrier medium; utilization is possible in active mines,
c) technical feasibility – heat obtaining is technically feasible.

As far as this system is concerned, the utilization of it proves best on the above-mentioned Jeremenko and Žofie premises, where pump shafts are built and pumping systems are in operation. The pumping of waters in these localities is considered approximately by the year 2032. As for the future development, the locality of ČSA Mine seems to be the best

suitable (with regard to the position of seams in the Karviná part of the Coalfield) for the establishment of pump shaft.

4.3. Conditionally utilizable

Utilization of geothermal energy of rocks – active mines

What is meant is practically a classical realization of ground–water system, when heat exchangers will be installed in not used mine cavities on relevant horizons and will be connected with the surrounding rocks with a suitable filling material having good heat conductivity. Heat exchangers will be connected with the heat pump on the surface by the circulating pipes. Circulation will be ensured by a circulating pump located on the mine surface. Satisfaction of criteria of utilizability:

a) the continuity of a heat energy source – is practically permanently ensured but it is necessary to verify the balanced state, which is produced by the thermal energy removal by means of heat exchanger and the supply of energy from the rock mass (heat flow),
b) the availability of a heat carrier medium – the heat carrier medium is a fluid in the circulating system; a certain problem can be the service life of exchanger and the maintenance of circulating pipes,
c) technical feasibility – heat obtaining is technically feasible.

This ground–water system would be utilizable best in the ČSM Mine or Darkov Mine owing to its long-term prospects. The utilization in other mines is not excluded.

Utilization of geothermal energy of rocks – decommissioned mines

Utilization is the same as with the previous case; merely circulating pipes will be inaccessible, left in the space of shaft and other selected mine workings backfilled with a chosen material. Satisfaction of criteria of utilizability:

a) the continuity of a heat energy source – is ensured practically permanently; however, it is necessary to verify the balanced state which occurs due to heat energy removal by the heat exchanger and the supply of energy from the rock mass,
b) the availability of a heat carrier medium – the heat carrier medium is a fluid in the circulating system; a certain problem can be the service life of exchanger and the circulating pipes that will be permanently inaccessible,
c) technical feasibility – heat obtaining is technically feasible.

It is realistic to install this ground–water system after verification in the period of preparation of the mine for decommissioning.

Completely unsuitable – non-utilizable

All other cases (e.g. completely decommissioned mines backfilled fully, localities without a possibility of disposing pumped waters in the protected zones of water resources, in areas of already heavily burdened surface watercourses, etc.) prove to be unsuitable.

5. Conclusions

Pilot facility realization

The next works should aim to propose specific localities for the realization of pilot facilities that must be further supplemented, more specified and also corrected. According to the determined criteria of utilizability, the localities will be selected from the point of view of method of geothermal energy obtaining.

However, no less important is the analysis of supporting criteria that cannot be evaluated from the general point of view, but that are to be evaluated according to specific conditions, possibilities and requirements.

In terms of broader relations, and also for practical reasons and owing to the better knowledge of environment, in the Czech Republic it is proposed to realize pilot projects directly in the Ostrava-Karviná agglomeration.

In the article, the knowledge acquired in the framework of the TANDEM project "Využití geotermální energie hlubinných dolů v souladu s trendy udržitelného rozvoje" FT-TA4/040 implemented thanks to financial support coming from the means of state budget by means of Ministry of Industry and Trade was used.

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