The possibility of using underground chloride sodium brines in the territory of the Central Federal District to improve the efficiency, reliability and safety of power equipment of TPPs

To cite this article: A Y Burakov et al 2017 J. Phys.: Conf. Ser. 891 012273

Related content

- Preparation and optical properties of TPPS-doped metal-carboxylate-salts glasses
  Akio Makishima, Yuuichi Orihara, Kouhei Soga et al.

- Research on standardized evaluation model of status detection data on power equipment based on AHP
  Ke Meng, Guanghui Mao, Hongchi Liang et al.

- Portfolio Purchasing Decision for Mobile Power Equipment of B2C E-Commerce Export Retailer Based on CVaR
  Wan Yanchun and Chen Qiucen
The possibility of using underground chloride sodium brines in the territory of the Central Federal District to improve the efficiency, reliability and safety of power equipment of TPPs

A Y Burakov\(^1\), I A Burakov\(^2\), A E Verkhovsky\(^2\) and I S Nikitina\(^2\)

\(^1\)Russian Research Center of Medical Rehabilitation and Health Resort
Russia, 121099 Moscow, Novy Arbat, 32
\(^2\)National Research University "Moscow Power Engineering Institute"
Russia, 111250 Moscow, Krasnokazarmennaya, 14

Abstract. Long-term use of ground sodium chloride brine at power plants of "Mosenergo" for the purposes of regeneration Na-cation unit of water treatment plants chemical plants provides the preconditions for operation of underground brines and other power systems of our country. Underground sodium chloride brines used in "Mosenergo" since 1979, when the first wells for the extraction of brines in the territory of TPP-22 was drilled.

Currently production brines are well in 13 TPP of PJSC "Mosenergo". Underground sodium chloride brines can be used to regenerate the sodium cation filters under the following conditions: salinity brines should be not less than 100 g/dm\(^3\); the ratio of sodium ion content (in mg-Eq/dm\(^3\)) to the total rigidity brine (in mg-Eq/dm\(^3\)) should not be less than 3.5. Performed zoning district on the possibility of using underground brine for regeneration of the sodium-cation filters On the basis of these requirements. The analysis of the possibility of using underground brine directly to the location of CHP stations in the northern part of the Central Federal District on the basis of geological and hydrogeological data. Particular attention is drawn to the area of large cities, where the use of underground brines most effectively. The conclusion about the possibility of using sodium chloride brines underground in most parts of the Central Federal District for energy purposes.

The long-term use of underground sodium chloride brines at TPPs of PJSC Mosenergo for the purposes of regenerating sodium-cation exchanger filters of water treatment plants of chemical shops provides prerequisites for the operation of underground brines in other power systems of our country. Underground sodium chloride brines have been used in PJSC Mosenergo since 1979, when the first well for brine extraction was drilled on the territory of CHPP-22. At the present time, there are salt-water wells on the territories of 13 TPPs of PJSC "Mosenergo". Underground sodium chloride brines can be used for the regeneration of sodium cationite filters under the following conditions: 1) Brine salinity should be at least 100 g/dm\(^3\); 2) the ratio of the sodium ion content (in mg-Eq/dm\(^3\)) to the total brine hardness (in mg-Eq/dm\(^3\)) should not be less than 3.5.

On the basis of these requirements, zoning of the territory of the district was carried out, as far as possible, using underground brines for the regeneration of sodium cationite filters. An analysis was made of the possibility of using underground brines directly for the locations of CHP in the northern half of the CFD, based on geological and hydrogeological data. Particular attention is paid to the territory of large cities, where the use of underground brines is most effective. A conclusion is made about...
the possibility of using underground chloride sodium brines in most of the Central Federal District for energy purposes.

In the European territory of Russia, the exploitation of mineral waters and brines began from ancient times. On the existence of the northern Skifiai salt varnish mentions still Gerodot. It is well known that not only the waters of mineral springs and wells, but also specially drilled wells, have been used for salt preparation since the XII century. The oldest known well, "Stary istochnik", is located on the territory of the resort in the town of Staraia Russa. Already at that time, very original methods for concentrating the brine were used to save fuel and improve the profitability of production. The most famous centers of salt production in the territory of the Central Federal District (CFA) are Bolshaia Sol, Malaia Sol, Sol Galitskaia, Kineshma, Balakhna, Totma, Staraia Russa and others.

In the 16th and 17th centuries, the importation of cheaper salt from Priurale ("permianka") led to a decline in salt production in the center of the European part of Russia. However, the local population, especially during periods of wars and various social upheavals, continued to evaporate salt for their own needs.

At the end of the eighteenth and nineteenth centuries, old saltworks in the central part of European Russia began to be used as resorts (Staraia Russa, Soligalich, Totma). However, the great popularity of mineral water treatment at that time was not received and the economic situation of the resorts was difficult.

Only from the end of the fifties of the twentieth century drilling of the salt-water wells began to expand the hydromineral base of sanatorium and spa facilities and resort construction. The first well was specially drilled for the purposes of balneology in the resort of Dorokhov in 1958. Employees of the Central Scientific Research Institute of balneology and physiotherapy (CRIICiF) developed methods for using brines in sanatoriums for outdoor balneological procedures for the treatment of chronic diseases of the organs of motion and support, diseases of the cardiovascular system, diseases of the central and peripheral nervous system, chronic Gynecological and urological diseases, skin diseases and some others. Only in the territory of the Moscow region the methods of CRIICiF for treating these diseases are used in more than fifty sanatoria, rest homes and hospitals. In total, 61 wells were drilled in the Moscow region to operate brine for balneotherapy purposes.

What is the relationship between energy and underground chloride sodium brines? This connection can be traced through the heat networks. Thermal networks of the city of Moscow are the largest in the world. The volume of heat networks of the city is currently about 3 million cubic meters. Heat supply of the housing sector of the city of Moscow, industrial enterprises and other heat consumers is provided by 13 thermal power plants.

To supply thermal networks in the chemical shops of the thermal power plants of PJSC Mosenergo, about 63 million tons of chemically purified water are produced annually. In the technological process of water treatment for the production of chemically purified water, plants using one- or two-stage Nacationing are used. When water is filtered through Na-cation exchangers, an exchange reaction occurs, during which the Ca$^{2+}$ and Mg$^{2+}$ ions of water are replaced by Na$^+$ ions of the filter resin. As a result, the hardness of the water decreases. Gradually, during the operation of the filters, the exchange capacity of the cation resin is reduced, and to restore the efficiency of the filters, it is necessary to regenerate the resin. Regeneration of filters is carried out by a solution of sodium chloride salt.

In 1979, for the first time, a salt-water well was drilled on the territory of CHP-22 in the city of Dzerzhinsk (Moscow region), whose sodium chloride brines were used instead of dry technical salts for the regeneration of sodium cation exchanger filters of the water treatment plant. Thanks to the use of natural brines, the process of water treatment has become less labor-intensive. At present, Mosenergo extracts up to 115 000 cubic meters of brines from the salt-water wells of Mosenergo, which corresponds to 24 000 tons of dry salt. Due to the exploitation of the salt-water wells, PJSC Mosenergo covers its demand for dry chloride sodium salt by 90%. The use of natural underground brines instead of dry salt has a number of advantages: low prime cost, no costs for transportation and storage, obtaining a ready brine, no dependence on salt supplies.
For the purposes of regeneration, Mosenergo's thermal power plants use brines of sodium chloride composition \([1-4]\). In addition, Y.E. Mishenin proposed in 1994, based on a large volume of performed experimental work, to use sodium chloride brines for the purposes of regenerating sodium cationite filters with the ratio of the sodium content (in mg-Eq/dm\(^3\)) to the total brine rigidity (in mg-Eq/dm\(^3\)) is not less than 3.5. Scientists of the National Research University "MPEI" established the minimum technologically and economically effective concentration of regenerative sodium chloride brine equal to 14% on the basis of the performed experimental work. Many years of experience in the operation of the salt-water wells of PJSC Mosenergo \([1, 4]\), research of employees of PJSC Mosenergo, JSC ORGRES Company, National Research University MEI allow the formulation of technical requirements for underground brines for use in the regeneration of sodium cationite filters as follows Way. Brines should by composition refer to a chloride sodium hydrochemical type with a total mineralization of at least 165 g/dm\(^3\) and a ratio of the sodium content in the brine (in mg-Eq/dm\(^3\)) to the total brine hardness (in mg-Eq/dm\(^3\)) not Less than 3.5.

The thermal power plants of PJSC "Mosenergo" use brines of the water-bearing Vendian-Ryazhsky terrigenous complex. The roof of the Vendian-Ryazhsky water-bearing complex in the northern half of the territory of the Central Federal District lies at a depth of 900 – 1200 meters from the surface of the earth. The main inflow of brines comes from the deposits of the Ryazh aquifer of the lower section of the Devonian system. Water-bearing rocks are quartz sand and sandstones with interbeds of siltstones and mudstones. The thickness of the rocks of the Ryazh aquifer on the territory of the Moscow Region varies from 8 to 77 meters, but is usually 50 – 60 meters. The depth of the salt-producing wells of PJSC “Mosenergo” is 1250 – 1300 meters. Well productivity varies from 0.3 to 10.0 l/s with a decrease from 1.4 to 101 m. Specific well rates are 0.01 – 1.4 l/s. The water-bearing complex contains strong bromine chloride sodium brines, the mineralization of which within the Moscow region varies from 173 to 293 g/dm\(^3\). The ratio of sodium to total brine hardness varies from 3.2 to 8.2, an average of 5.6. Similar brines are also contained in other aquifers in the territory of the Central Federal District \([5]\).

To determine the possibility of using underground sodium chloride brines for the purpose of regenerating sodium cationite filters of water treatment plants of chemical plants of thermal power plants, we analyzed hydrogeological and tectonic maps on the territory of the Central Federal District from the FSUE "VSEGEI" site \([6]\), materials of the Department for Subsoil Use in the Central Federal District \([7]\) And JSC "Moscow Research and Production Center for Geological and Ecological Research and Use of Geocenter-Moscow" \([8]\). As a result, a scheme for the regionalization of the territory of the Central Federal District has been drawn up on the possibility of using underground brines to regenerate sodium-cation exchanger filters of chemical power plants (Fig. 1).
The scheme of zoning of the CFD on the possibility of using underground brines for the regeneration of sodium cationite filters chemical workshops of thermal power plants.

North of the AB line is the territory of the CFD, where there are conditioned underground chloride sodium brines, which can be used for regeneration purposes. In this territory except Moscow and Moscow region are located Kostromskaia, Yaroslavskaia, Ivanovskaia, Tverskaia, Vladimirskiaia, Smolenskaia, Riazanskaia, partially Kaluzhskiaia, Tulskiaia and Tambovskaia regions. Here it is possible to use natural underground brines at thermal power plants. In the territories of Brianskaia, Orlovskiaia, Lipetskaia, Kurskaia, Voronezhskiaia and Belgordkskaia regions there are no conditioning brines.

References
[1] Burakov A.Y. Bromine chloride sodium brines of the Moscow Region (distribution and formation conditions). M: MGGM, 2002.
[2] Burakov A.Y., Khramchikhin AM, Rodionov IV, Moiseyev Y.V. Problems of the use of underground natural brines in the technology of preparation of additional water for the heating network. News of heat supply. - 2000. - # 2 - pp. 12-14.
[3] Burakov A.Y., Yaremchenko S.M. State of development, use and conservation of hydromineral resources of the Moscow artesian basin Labor Safety in Industry. - 1999. - # 8 - pp. 17-18.
[4] Burakov A.Y. Analysis of the experience of the operation of the salt-bearing wells of MOSEN-ERGO. Geological Herald of Central Regions. - 2000. - # 4 - pp. 39-42.
[5] Catalog of mineral waters of the USSR. M: CRIICIF, 1969.
[6] The official website of the Federal State Budget Institution "All-Russian Geological Research Institute. A.P. Karpinsky "(FGBU" VSEGEI ") www.vsegei.ru
[7] The official website of the Department for Subsoil Use in the Central Federal District of the Federal Agency for Subsoil Use (Centrendra) www.centrntdra.ru
[8] Official site of the Joint Stock Company "Moscow Research and Production Center for Geological and Ecological Exploration and Use of Subsurface Resources" Geocenter-Moscow "(Geo-Center-Moscow JSC) www.geocentr-msk.ru.