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ENERGY SAVING, NEW, AND RENEWABLE ENERGY SOURCES

Problems Relating to Operation of Geothermal Power Stations Stemming from the Presence of Admixtures in the Geothermal Heat Carrier

G. V. Tomarov[a], A. A. Shipkov[a], and B. E. Parshin[b]

[a] *Geoterm-EM, Lefortovskii Val 24, Moscow, 111250 Russia*

[b] *Kamchatskenergo, Naberezhnaya ul. 10, Petropavlovsk Kamchatskii, 683000 Russia*

Abstract—The effects the specific features of chemical composition and the thermophysical properties of geothermal heat carrier have on the metal erosion–corrosion processes and on the formation of deposits during operation of a geothermal power station are analyzed. Methods for preventing the formation of deposits and making the geothermal power station equipment more resistant to erosion and corrosion are considered. Results from calculation and experimental investigations aimed at studying how the concentration of silicic acid and other admixtures vary in the working loop and turbine flow path at the Verkhne-Mutnovsk geothermal power station are presented. The possibility of using surface-active inhibitors to prevent the formation of deposits and erosion–corrosion processes in the geothermal power station equipment is demonstrated.

Keywords: geothermal power station, heat carrier, erosion–corrosion, deposits, flow path, turbine, concentration of impurities

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The specific features relating to the chemical composition and thermophysical properties of geothermal heat carrier give rise to certain problems during operation of geothermal power stations (GeoPSs) connected with damage to metal and formation of deposits.

More than 70% of GeoPSs installed around the world, including those in Russia, operate on a two-phase (wet-steam) heat carrier [1]. Owing to interphase redistribution of substances, the major part of admixtures and salts is in the liquid phase and nondensables are contained in the vapor phase.

Most frequently, a geothermal heat carrier contains such chemical compounds and elements as Cl^-, SiO_2, CO_3^{2-}, HSO_4^-, Fe^{2+}, Ca^{2+}, and others, as well as nondensables, such as H_2S, CO_2, NH_3, H_2, N_2, etc. [2]. In the majority of cases, the content of admixtures and salts in geothermal heat carriers from different fields is from 1.5 to 10.0 g/dm^3, and the concentration of nondensables varies usually in the range 0.1–0.3%. Tables 1 and 2 give comparative data on the chemical composition of admixtures and nondensables in geothermal heat carriers from different fields around the world.

The phase state of the geothermal working fluid and the concentration of admixtures and nondensables taken in combination with the flow hydrodynamics and the erosion–corrosion properties of metal are the factors that determine to a considerable degree the possible occurrence and intensity of damage inflicted to GeoPS components, as well as the formation of deposits on the surfaces of equipment and pipelines. The scheme shown in Fig. 1 reflects the influence of admixtures and gases on the occurrence of different mechanisms through which damage is inflicted to metal and on the formation of salt deposits in single- and two-phase geothermal heat carriers. Some methods for preventing the occurrence of these undesirable phenomena at GeoPSs are also shown in this figure. It has been found that the physicochemical properties and the concentration of admixtures and nondensables determine the location of zones and intensity of erosion–corrosion thinning and formation of deposits in the working loop, and that they have an effect on the metal corrosion and cracking processes in the GeoPS equipment [2]. The mechanisms of droplet impingement and cavitation erosion depend on them to a lesser extent.

An analysis of the problems encountered during operation of the Mutnovsk GeoPS with a capacity of 50 (2 × 25) MW and the Verkhne-Mutnovsk GeoPS with a capacity of 12 (3 × 4) MW [3] testifies that erosion–corrosion thinning and stress corrosion cracking of metal are the main factors that caused abrupt fractures and failures of the equipment and pipelines of these GeoPSs, and that the formation of deposits degrades their performance efficiency.

Rapid clogging of the Mutnovsk GeoPS turbine flow paths with deposits and damage inflicted to them