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Geothermal wellhead maintenance: A statistical model based on documented Icelandic experience

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ABSTRACT

Icelandic geothermal industry has been shown to operate in an efficient manner. We investigated how geothermal wellheads are maintained at the largest geothermal power plant in Iceland. Interviews were conducted with maintenance personnel on site, maintenance diaries were retrieved where detailed description on the maintenance activities had been recorded. Also, maintenance data was gathered from the dynamic maintenance management system (DMM). Methods of major overhauls and maintenance activities were identified, as well as the frequency of these activities. Using this data, a statistical analysis was conducted to see the estimated intervals between maintenance activities and compare them to the recommendation provided to staff. This paper concludes by recommending a wellhead maintenance management system based on the results from the statistical analysis.

1. Introduction

Icelandic geothermal power plants have been shown to operate in an efficient way (Atlason and Unnthorsson, 2013a). The industry has also been shown to be systematically innovating and seeking new ways to further optimise its operations (Atlason and Unnthorsson, 2013b). Geothermal wellheads play an important role in the overall efficiency at geothermal power plants (Atlason and Unnthorsson, 2013c). Where they serve the role of allowing the steam and fluid to flow from the ground to the separators and subsequently to the turbines (DiPippo, 2008). Maintenance of the wellheads is therefore of great importance so the operation of the power plant can go without major incidents. At first, wellheads come across as simple equipment, but when interviews are conducted with maintenance staff, the wellheads are often referred to as Christmas trees, referring to the complexity of all the components. Wellheads used in the Icelandic geothermal sector are often designed for the oil industry, and have therefore some characteristics of that particular industry. Various problems, not frequently observed in the oil industry have been experienced at geothermal power plants with regards to wellheads. Some of these problems are listed in Section 2.2. In this study, wellhead maintenance at the Hellisheidi Power Plant is investigated. The power company has developed maintenance management methods throughout the years. These methods have been developed to address and minimise the possible negative effects the geological conditions on the area can have on the wellheads. Even though methods have been developed, they consist greatly within local knowledge of the maintenance staff. In this study, this knowledge is documented, diagnosed and statistically analysed. Subsequently a statistical model describing wellhead maintenance is developed based on the findings of this research. Geothermal projects are currently under way in different parts of the world. When such geothermal power plants will begin operating, it should prove valuable to possess the wellhead maintenance plan from another successfully established power plant. Even though the plan is tailored to the corrosion and scaling effects of the particular field the plant is located at. It is also valuable to see how the maintenance has developed from the original recommendations throughout the years. This can be seen in this article, as original recommendations are shown as well as statistical analysis to visualise how wellhead maintenance procedures have developed to date. In theory, such model should be usable by geothermal power plants operating under similar conditions as described in this article. The literature is essentially void of such documentation and analysis as is presented in this article, however, general recommendations are presented by Thorhallsson (2003) where general problems associated with wellheads are listed. However, the objective of this paper is not to present a list of common problems related to geothermal

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Table 1
Brine chemical composition of the studied power plant (Gunnlaugsson, 2013).

mg/kg	Hellisheidi
pH/°C	9.2/100
SiO_2	822
Na	213
Cl	170
K	38.4
SO_4	19
Al	1.7
F	1.1
B	1.039
Ca	0.456
As	0.09
Ba	0.078
Fe	0.03
Zn	0.0097
Cu	0.002
P	0.004
Mg	0.0035
Pb	0.0035
Ni	0.0003
Cd	0.00017
Cr	0.00008
Hg	0.00002
H_2S[a]	20

[a] Gas.

wellheads, but rather to provide a model to maintain them to minimise problems.

2. Methods and materials

This section will discuss the main components of geothermal wellheads and list the main problems associated with them. Subsequently it will go through the method used to retrieve and analyse data from the power plant under study.

2.1. Description of the power plant and the brine chemical composition

One of the major causes for the difference in maintenance activities and problems with the mechanical equipment at geothermal power plants are the different geological conditions. Data showing the chemical composition of the brine was gathered from Reykjavik Energy, which owns the Hellisheidi Power Plant. Table 1 shows the chemical composition from the power plant under study. Reykjavik Energy provided data about the fluid chemical composition when it leaves the separators. One can see that the fluid consists mostly of SiO_2 (822 mg/kg), Na (213 mg/kg), Cl (170 mg/kg), K (38.4 mg/kg), and SO_4 (19 mg/kg) (Gunnlaugsson, 2013). Further clarification of the fluid composition is shown in Table 1.

2.1.1. Hellisheidi Geothermal Power Plant

The Hellisheidi Geothermal Power Plant is owned by Reykjavik Energy and began its electric production in 2006 (OR, 2014a). The plant is located on the southern part of the Hengill geothermal field, a detailed location can be seen on Fig. 1. It produces approximately 303 MW of electric power and 133 MW of hot water through a double flash process. Around 50 wells have been drilled to harness hot water for the power production (OR, 2014b).

2.2. Geothermal wellhead at Hellisheidi

A typical geothermal wellhead at Hellisheidi consists of the following 9 parts is shown in Fig. 2. These are (1) survival valve. This valve is used for temperature and pressure measurements. It is also used to prevent too much pressure in the wellhead by allowing it to blow. (2) Working valve. This valve has the role of opening and closing flow from the well. This valve is located on top of the head valve. (3) Choke valve. As the name suggests, the choke valve has the role of allowing the well to be choked by injecting cold water into it (Mannvit, 2010). (4) Head valve. This valve is located on top of the expansion spool and has the role of being the closing valve for the well. (5) Expansion spool, allowing for thermal expansion of the wellhead assembly and casings, (6) casing head and (7) silencer valve. The silencer valve allows the flow to enter the silencers. This is merely done when the hole is allowed to blow full steam but not entering the gathering system. This is often done when holes have been dormant and attempts are made to activate them again. (8) Control valve. The role of the control valve is to control the flow from the well as is needed by the power plant. (9) Gathering system valve. Normally, two gathering system valves are located at each wellhead, one on each side of the control valve. This is done so the steam system can be isolated from the well or if the control valve needs repairs. By closing both gathering system valves the control valve can be isolated and removed (Mannvit, 2010).

Fig. 1. Location of the power plant under study. The lake north-east of the power plant is lake Thingvallavatn.

2.3. Common geothermal wellhead problems

Even though many valves are located on the wellheads, only one is regularly or continuously moved. This is the control valve, which controls the amount of flow from the well (Thorhallsson, 2005). This valve is often located outside the well house. Scaling is one of the most common problems known within geothermal power plants and the wellheads are no exception. To avoid scaling to occur in the control valve, a special design is used that wedges against the seats