Steamfield Management and Challenges: Kenya Case

Gideon Gitonga

Kenya Electricity Generating Company

ggitonga@kengen.co.ke

Keywords

Steam field, challenges, lessons, Olkaria

ABSTRACT

Kenya Electricity Generating Company owns and operates four conventional geothermal power plants and sixteen wellhead power plants with a total installed capacity of 533.4MW within Olkaria and Eburru geothermal field. This installed capacity is bound to increase with the commissioning of ongoing projects like the Olkaria V power plant of 158MW capacity. Proper management of the steam supply network is essential to deliver sufficient and quality steam to these power plants in order to meet the generation targets.

This paper describes the experience of steamfield management activities in Olkaria and also focuses on challenges and valuable lessons that have been learned from the experience of managing the complex steam gathering and brine reinjection system that serves these power plants.

1. Introduction

Steamfield management involves operation and maintenance of steam gathering and brine reinjection system. The key purpose of doing this is to ensure delivery of quality and adequate steam to the power plants. Presently there are four conventional geothermal power plants and sixteen wellhead units with a total installed capacity of 533.4MW within Olkaria and Eburru geothermal field. The amount of steam required to meet that generation target for all the plants is 3,990 t/h. This installed capacity is set to increase further with the addition of Olkaria V (158MW), Olkaria IAU Unit 6 (70MW) and proposed modular wellhead units (50MW). This will increase the field's power output from 533.4MW to 811MW electricity production and consequently steam production will increase from the current 3,891 t/h to about 5,400 t/h.

Recent reservoir numerical model for Olkaria prepared by Mannvit Consortium in 2012 showed that the Olkaria reservoir within the KenGen concession area can support between 800 to 1,200MW subject to well-planned field development and management strategies. These strategies include careful siting of wells, drilling and connection of makeup wells, careful selection of reinjection locations for hot and cold reinjection, maximizing reinjection and minimizing wastage of steam.

Management of an expanded Steamfield such as Olkaria comes with its share of challenges ranging from resource related challenges to infrastructural and skills challenges. Silica scaling and corrosion are some of the major challenges experienced in managing the Olkaria Steamfield which will form the centerpiece of the discussion of this paper. Skills and knowledge gap has also been mainly the reason for outsourcing consultancy and construction services. Capacity building has enabled steam field staff to carry out design and construction activities especially connection of make-up wells which has helped bring down the cost of such projects by over sixty percent and has also reduced the period required to execute the projects which highlights the importance of continuous capacity building throug training and practice.

2. Steamfield System Description

All of the geothermal power plants owned and operated by KenGen utilize the single flash steam cycle technology. The principle here is to flash the geothermal fluid in a separator and harness steam that goes to the power plant for power generation. The brine is reinjected back to the reservoir. Steam is normally transmitted using insulated steam pipelines that are designed to minimize pressure and heat losses. Drain pots and steam traps are normally installed along the steam pipelines to collect and remove any condensate that forms on the steam pipeline. Interline pressure controllers are installed at the power plant interface to maintain desired steam pressure and protect the system against unexpected steam pressure surges. The steam operating pressure is set by desired design turbine inlet pressure.

The steam enters the turbine through governing valves and then expands through the series of alternating rotating and stationary blades through which part of the energy in the steam is transformed into mechanical energy by rotating the turbine rotor. The turbine rotor in turn rotates the generator which transforms the mechanical energy into electrical energy. The steam exits the turbine with reduced energy and is exhausted into a condenser where it is condensed into liquid. The condensers can be direct contact (mixing of steam and cooling water) or indirect contact (no mixing).

Geothermal power plant systems are designed and customized to match the production and chemical characteristics of the wells. Other variations from one plant to another emanate from design improvements aimed at optimizing the project cost and improving overall system efficiency. As a consequence of this each plant in Olkaria has a distinct steam gathering system with different layouts and different operating conditions explained below and summarized in table 1;

- The main features for Olkaria I and II power plants are that they majorly have a separator for each well and the separation pressure is about 6.0bar_a.

- The new power plants Olkaria IV and Olkaria I additional units 4&5 have central separator stations and the separation pressure is about 12bar_a.
- The wellhead plants are modular installations mostly fed by one well although in some cases one powerful well can serve two units. The separation pressure for the wellheads is about 15bar_a.

Plant	Plant Capacity MW	No of Connected Production Wells	Seperation pressure (6 bara)	Av. Total Steam Flow t/h	Plant consumption t/h	Av. Total Brine Flow t/h	Av. Enthalpy kJ/kg	No of Hot Reinjection Wells	No of Cold Reinjection Wells
Olkaria I	45	19	6	561	450	258	2166	3	0
Olkaria II	105	18	6	850	793	631	1840	5	2
Olkaria IAU	150	23	12	1367	1056	524	2314	5	2
Olkaria IV	150	21	12	1084	1002	815	1892	7	2
Wellheads	83.4	14	13	756	689	402	2013	0	5
Total	**533.4**	**95**	**13**	**4,358**	**3990**	**2246**	**2045**	**20**	**11**

Table 1: Summary of steam demand status of all the power plants

2.1 Steam field management operational and maintenance activities

Steamfield operational involves all activities that modulate the quality and quantity of steam supply to sustain maximum power plant output. This involves wells start up, isolation, throttling, discharging and air lifting of choked wells to aid them to recover etc. and actual monitoring of well conditions by patrolling the field and collecting data and recording observations. Maintenance activities involves taking care of the physical state of the equipment and entails all tasks essential to keep an equipment or system in operation or repair works carried out to restore it to its operational mode in case of a break down. Maintenance activities falls under two categories – preventive maintenance and corrective maintenance. All operational and maintenance activities are guided by operating procedures and work instructions that provide reference to the steps to follow.

3. Steamfield management challenges

Steamfield challenges are encountered right from the project development stage. Resource feasibility studies forms an essential input to the conceptual designs and formulation of an appropriate design criteria for the system. A properly structured design process safeguards against errors generated as a result of omitting steps or through careless fast tracking (Cristo 2015). The inherent challenges to the designer at this stage include well production uncertainty, fluid characteristics, injection well permeability, silica polymerization and environment and community issues among others. While some of these challenges are one off encounters during project development stage, the challenges discussed below have to be managed though out the life of the plant.

3.1 Silica Scaling

Silica scaling problems are linked to the chemistry of the fluids. One way to eliminate the risk of scaling is to operate the steamfield at a pressure and temperature above the silica saturation point. It is essential to get these process parameters right at the design stage since it is difficult and costly to correct the situation afterwards. All steamfield systems have been optimally designed to address this concern. Although an observation made over the years of operation is that loss of continuous flow brine to reinjection wells leads to carryover of that brine to the steam lines which causes scaling all the way to the turbines. To mitigate this it is important to have a program of monitoring the reinjection wells to be able to get early warning of pressure build up that would impair reinjection.

.

3.2 Corrosion of carbon steel pipes

Corrosion is another problem similarly linked to the chemistry of the fluid being conveyed in the pipe lines. The problem has been noted to be severe on the cold reinjection lines and on the section of steam pipe lines between the pressure let down stations and the scrubber. The condensate tapped from the cooling tower is transported through high density polyethylene (HDPE) pipes but terminates to the reinjection wells through a section constructed of carbon steel pipes. Due to inexact PH control of the condensate this section of carbon steel pipes is prone to severe corrosion and leakages. The cooling tower condensate is also used for de-superheating after stepping down steam pressure from 12 bar to 5 bar at the pressure let down station. Since this fluid is corrosive this pipe line section has suffered leakages that have led to huge revenue losses when the plants are shut down for repairs

3.3 Decline of wells output and change of production characteristics

Well output declines with time leading to under generation by the power plants due to steam shortage. Conventional power plants are usually designed with a reserve margin of steam to cater for the wells decline and also to grant the room required to isolate and carry out maintenance on wells without interrupting generation. Reservoir numerical models forecast fairly accurately the resource response to exploitation. As a result an interval at which a make-up well needs to be connected to a conventional plant is known. Therefore planning is straight forward and it is economical since one make up well is adequate for a single conventional power plant until there is need to connect another one. On the contrary wellhead power plants are normally served by one well and are normally scattered in the field. Owing to this it is less economical to connect a make-up well to a wellhead power plant compared to the conventional power plant. Unless in cases where the wellhead plants are clustered together and their steam systems are interconnected making sharing of the make up steam possible and economical. Currently there are two wellhead plants operating below the installed capacity because the feeding wells have declined in output. Supply of make up steam is being connected to compensate for the deficit and return the plants to full load conditions. Previously works of this nature and magnitude would go to external consultants and contractors. But adequate capacity building has been achieved to carry out such works in-house in less time and cost.

Fig 1 Eburru new separator - Engineering and construction undertaken by Steamfield Staff

Fig 2. OW-39D make-up well connection to wellhead plant KWG-15

3. Conclusions

Characteristics of geothermal fluids are different depending on the geothermal resource being tapped from. Proper understanding of the fluid chemistry and proper process analysis is important in order to achieve a custom design for the resource available. Proper material selection is also very important from the onset to avoid costly reworks and revenue losses due to plant downtime when the repairs are being undertaken. Finally huge cost savings and less project periods are fundamental benefits being realized by having internal capacity to carry out design and construction works especially for small scale projects like connection of make- up wells. The huge savings justifies the cost and effort spent in trainings, benchmarking and other capacity building activities.

REFERENCES

Cristo, U., Alex. H., Rory, B., and Nicetos, R. "Piping Design Considerations for Geothermal Steamfields. "*Proceedings: Word Geothermal Congress* , Melbourne, Australia (2015).