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Re-injection By Building Brine Column: A case study of OW-901, in Olkaria, Kenya

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ABSTRACT

Geothermal energy is a renewable energy source with different applications depending on the actual characteristics of the resource. Utilization of geothermal resources is largely dependent on the resource temperatures. High temperature geothermal resources are commonly used for power generation by conventional geothermal power plants. Medium temperature geothermal resources are used for power generation through binary power plants. Low temperature geothermal resources are commonly used for direct applications such as heating and recreation. Majority of these geothermal resources are extracted from a geothermal well which includes steam, brine (hot water with minerals) and condensate (cooled steam/brine). The paper discusses re-injection of the utilized brine from the geothermal field by building brine column. Re-injection refers to taking the utilized brine back to the reservoir/ground. This re-injection requires different types of wells and zones. Re-injection wells at times build very high pressures up to 1500psi when shut in for long time or when little or no brine flow into them from production wells. Due to this factor they require quenching to suppress the pressures to allow re-injection. This led to a case study to alleviate the cost of quenching and re-inject the brine at a negligible expense. The following abbreviations will be used during the discussion. OW – Olkaria Well, asl – above sea level and SD - Separator Domes.

1. INTRODUCTION

Geothermal energy refers to the heat energy that emanates from beneath the earth's crust. Geothermal projects follow a carefully crafted exploration and development program. The scientific exploration methods quickly and at moderate cost assess vast potential areas that are then studied in detail followed by drilling to confirm the resource. During drilling of geothermal wells, they are classified into categories of production, make-up or cold/hot re-injection wells. These vary in depths as per their uses. Production wells give out the steam to be utilized by the power plants both conventional and binary. They range from 2000m to 3000m deep in Olkaria, Kenya. Make-up wells are just production wells drilled and put on standby just in case production wells collapse or more steam is required. Hot re-injection wells are used to get the brine after separation from steam back to the ground. They are as deep as production wells. Cold re-injection wells get back the fluids from power plant cooling towers and Condensate Drain Ports (CDPs) to the ground. They are fairly shallow and range from 1000m to 2000m deep and mostly drilled away from production zone to avoid cold front breakthrough.

High temperature geothermal power plants convert high temperature geothermal energy to electricity. The power plants use steam turbines to convert heat and pressure energies in the steam to mechanical energy. The generators then convert the mechanical energy to electrical energy. These turbines require quality (dry) steam to operate efficiently. When heat and pressure are utilized from the steam the remaining fluid is then mostly taken back to the ground through cold re-injection wells. This concept also applies to brine that is, hot water after separation from steam at the separator station.

The paper discusses about re-injection by building brine column to overcome the shut in pressures of the independent wells.

2. DEVELOPMENT PLANNING AND DECISION MAKING

After confirmation of the potential of the well through discharge tests, the field developer will have to decide and plan for its utilization. Utilization of a geothermal well is mainly dependent on the temperatures, pressures, permeability, amount of fluids discharge (steam and brine in t/hr) from the well and the depth. In this case study the best hot re-injection well is the one that is permeable and has high or moderate pressures with depths exceeding 2000m. This is because at this depth we are likely to encounter the production aquifers which are the main target for recharge to sustain our geothermal resource.

3. TYPES OF GEOTHERMAL WELLS

The geothermal wells in Olkaria, Kenya can be classified into two main categories:

a. Production wells; These have depth ranging between 2000m and 3000m, highly permeable, high temperatures higher than 150°C with high discharge fluids (steam + brine). Make-up wells are grouped here because they are production wells on standby.
b. Re-injection wells;
    i. Cold re-injection wells; These have depths from 2000m and below, highly permeable with low temperatures less than 100°C.
    ii. Hot re-injection wells; these are basically production wells with temperatures ranging from 150°C to 200°C but drilled specifically for re-injection.

4. PRINCIPLE OPERATION OF A HOT RE-INJECTION WELL

A hot re-injection well is generally located at lower elevations in relation to the production wells from which it takes brine. This is aimed at utilizing flow of brine by gravity. After two phase separation from the production well, the steam goes to the power plant while the brine goes to the hot re-injection well. Table 1 below shows some typical examples of elevations of hot re-injection wells in relation to separator station at Olkaria geothermal field, Kenya. The separator station is at an elevation of 1985m asl.

Table 1 showing elevations.

OW907 (SD1)	**Aprox. elevation in metres asl**	**Difference in level in metres**
OW906	1923.2	61.8
OW906A	1919.8	65.2
OW901	1880.7	104.3

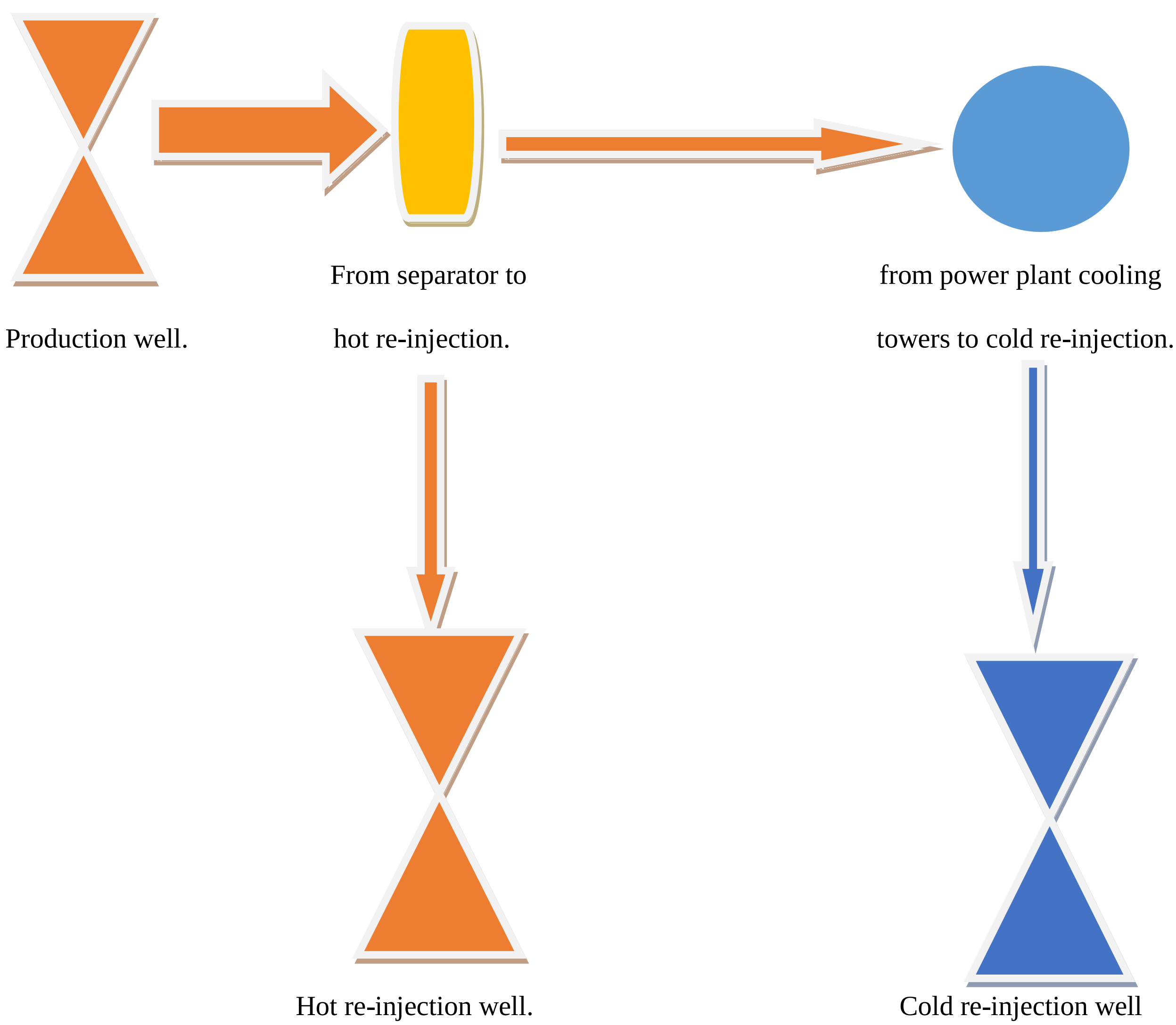

Figure a. Schematic diagram showing hot/cold re-injection process

Hot re-injection wells at times build very high pressures up to 1500psi when shut in for long time or when little or no brine flow into them from production wells. Due to this factor they require quenching to suppress the pressures to allow re-injection.

Figure b. Quenching OW916B in progress.

The approximate cost of quenching a single well is very high as indicated in the breakdown by table 2 below from data obtained from KenGen steamfield, drilling and logistics, and equipment maintenance sections respectively in Olkaria, Kenya.

Table 2 showing quenching cost.

RESOURCES	COST IN USD
1. Personnel (30 staff)	30,000
2. Fuel (vehicles, crane and quenching truck)	10,000
3. Raw water (10,000 cubic metres)	100,000
4. Victaulic pipes connection	40,000
GRAND TOTAL	**180,000**

Due to this high cost in quenching per well (180,000USD) the case study can help a lot in cost saving as a single hot re-injection well can be quenched at least three times per annum and in Olkaria we have not less than ten wells quenched annually. Diesel engines used are also not friendly to the environment.

5. BUILDING BRINE COLUMN

The high cost in quenching and the high risks involved in enabling re-injection process, we carried out a case study in Olkaria whereby we backfilled the re-injection pipeline with brine to create a header. As all the hot re-injection wells are at lower elevations, it became easier to create a header which is greater than the shut in pressures of the well in target for re-injection. In this case study we managed to re-inject OW901 which was at elevation 1880.7m in relation to separator station, SD1 (SD – Separator Domes) 1985.0m approximate ground level. This had a difference in level of 104.3m which when filled with brine on a 10inch pipe diameter created a header enough to overcome a shut in pressure of 150psi.

Pressure = P

Rho = $1050 kg/m^3$
g = $9.81 m/s^2$
h = 104.3m

$$P = Rho*g*h = 1074342\ N/m^2$$
$$= 10.74\ bar$$
$$= 155.84\ PSI$$

This case study guides in calculating elevations of other wells with similar characteristics to avoid unnecessary quenching costs and the risks it poses both to personnel and the well itself. The risk in quenching the well with cold water is a possibility of losing the well due to casing collapsing because quenching is done with cold water between 10°C and 20°C unlike building column with brine at 180°C and above.

6. CONCLUSION

There is increased drive for clean energy. Geothermal energy is in this category. Despite delivering the energy for industrialization there is also need to look into the cost incurred. The case study here if properly utilized will adversely reduce the cost in clean energy production and eradicate the pollution involved while using the diesel engines.

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