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Geothermal Power Plant in Meshkin-Shahr Iran

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ABSTRACT

Simulation of geothermal power plant exergy is one way to calculate the amount of power generation possible and determine the wasted energy. According to calculation, the efficiency of the geothermal power plant in Meshkin-Shahr, Iran is 39.2%. The largest portion of energy loss is in brine fluid (34.9%). The energy loss is 16.3% in the condenser and 6.9% in cooling tower. Other energy losses occur in the separator, turbine and pumps (2.7%).

1. INTRODUCTION

One of the best ways to determine the important parameters of a geothermal power plant such as efficiency and power output is the exergy analyzing method. A single flash geothermal power plant was designed and modeled with HSYS software. In this exergy analysis, losses in the injection, flash, turbine, DC condenser, cooling tower and pump were calculated.

2. MESHKIN SHAHR GEOTHERMAL POWER PLANT

Iran has an abundance of fossil fuels in the form of oil and gas. It has the second largest natural gas reserves in the world and also huge oil reserves. In addition to this, Iran has good potential for renewable geothermal, wind, and solar energy that should be used for the benefit of its people.

The main benefits of renewable energy use in Iran are:

1. Better overall utilization of its energy sources;

2. Saving fossil fuel for export to other countries or for future generations;

3. These are environmentally benign energy sources, with low CO_2 emissions.

Iran has 14 vast areas with good potential for geothermal utilization, as shown in Figure 1.

One such area is the Meshkin-Shahr geothermal field. 5 exploration wells and 3 injection wells were drilled to determine the parameters of the reservoir and develop the field. 3 exploration wells were then tested, and the important characteristics of the geothermal fluid are shown in Table 1.

To increase knowledge and experience geothermal power generation, the installation of a 4 MWe single flash power plant was planned.

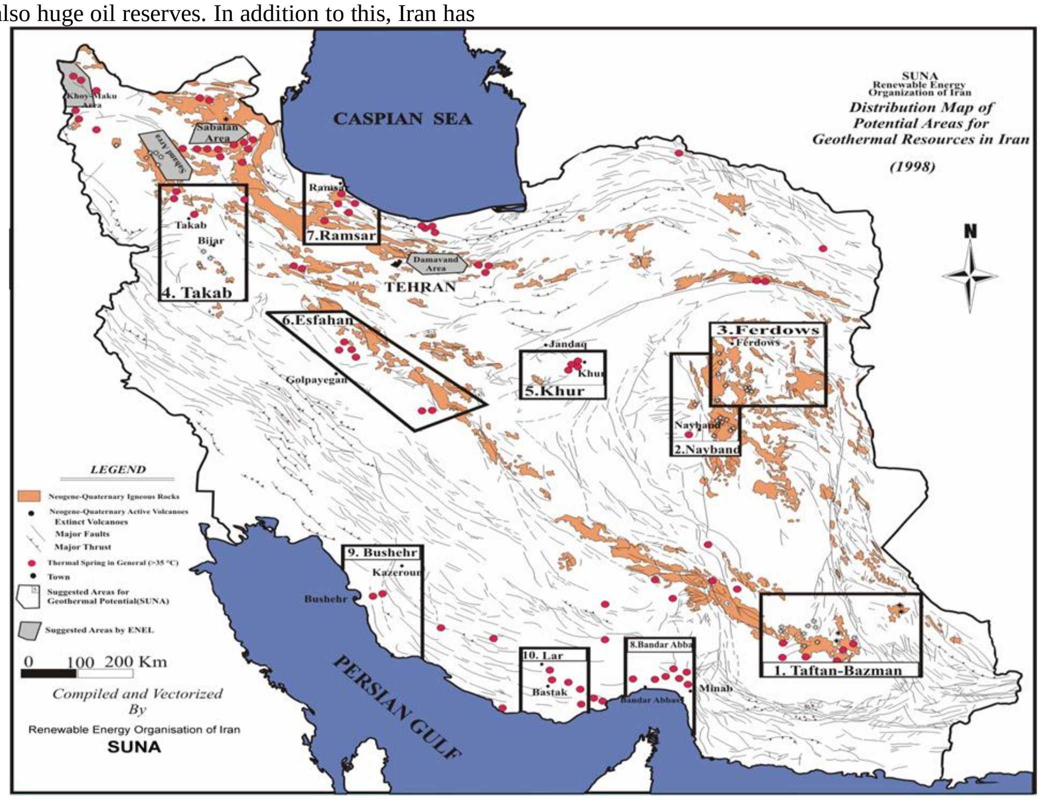

Figure 1: Map of high geothermal potential areas in Iran.

Table 1: Important characteristics of the geothermal fluid.

P_1(kpa)	$T_1(^\circ c)$	$\dot{m}_1(\frac{kg}{s})$	$\dot{m}_8(\frac{kg}{s})$	P_8(kpa)	X_1
620	160.2	50	100	30	0.2

3. EXERGY ANALYZING:

Conceptual modeling has been performed with mass and energy balance equations, as displayed in Equations 1 – 15. HYSYS software was used to design the conceptual model, a schematic diagram of which is displayed in Figure 2.

$$m_1 = m_2 + m_3 \quad (1)$$

$$m_3 = m_1(1-x) \quad (2)$$

$$m_2 = m_1 - (1-x)m_1 \quad (3)$$

$$m_1h_1 = m_2h_2 + m_3h \quad (4)$$

$$h_1 = x.h_2 + (1-x)h_3 \quad (5)$$

$$m_2 = m_4 \quad (6)$$

$$W_T = \frac{m_4(h_2 - h_4)}{\eta_T} \quad (7)$$

$$h_4 = h_2 - \frac{W_T.\eta_T}{m_1 - (1-x)m_1} \quad (8)$$

$$m_5 = m_8 + m_4 \quad (9)$$

$$m_5 = m_8 + m_9 \quad (10)$$

$$m_4 = m_9 \quad (11)$$

$$m_8h_8 + m_4h_4 = m_5h_5 \quad (12)$$

$$h_5 = \frac{m_4h_4 + m_8h_8}{m_5} \quad (13)$$

$$m_7 = m_8 + m_9 \quad (14)$$

$$m_6 = m_7 \quad (15)$$

$$Ex = \dot{m}[h_i - h_\circ - T_\circ(S_i - S_\circ)] \quad (16)$$

$$\eta_{Ex} = \frac{Ex_{out\ put}}{Ex_{in\ put}} = \frac{Ex_{Net\ power}}{Ex_{Brine}} \quad (17)$$

The thermodynamic parameters of the geothermal power plant as given by the conceptual model in HYSYS software and the mass and energy balances are displayed in Table 2.

Table 2: Thermodynamic parameters in the geothermal power plant.

State	T ($^\circ$C)	P (kpa)	$\dot{m}(\frac{kg}{s})$	h($\frac{kJ}{kg}$)	$S(\frac{kJ}{kg^\circ k})$
1	160.2	620	50	1092.77	2.901
2	160.2	620	10	2758.3	6.748
3	160.2	620	40	676.40	1.944
4	76.76	41.44	10	2384.75	6.922
5	59.18	30	110	289.52	0.944
6	29	10	110	121.59	0.422
7	29	30	110	122.20	0.424
8	29	30	100	122.20	0.424
9	29	30	10	122.20	0.424

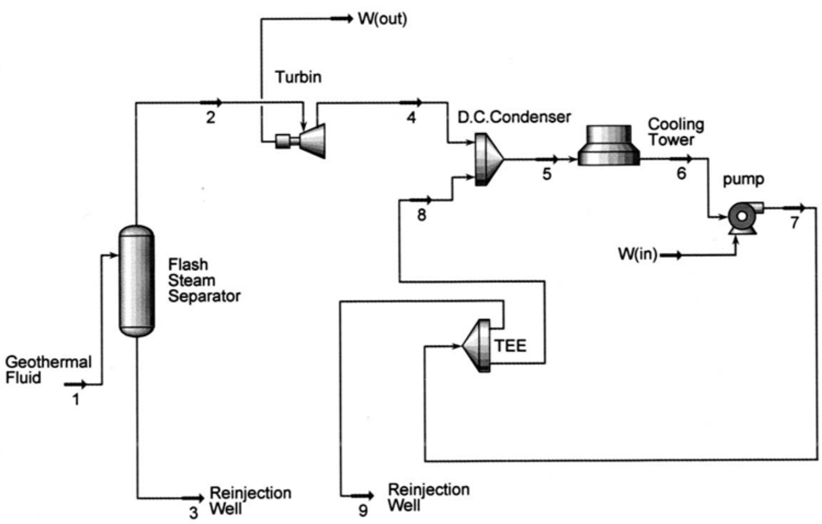

Figure 2: Schematic diagram of the single flash geothermal power plant.

where m is mass flow, h is enthalpy, x is quality of the geothermal fluid, w is power of turbine, η_t is the efficiency of the turbine, Ex is Exergy, S is entropy and W_{pump} is the pumping power.

The exergy at each point and the heat losses in the separator, turbine, condenser, cooling tower, and pump were calculated according to the thermodynamic parameters in Table 2 and the appropriate equations (Equations 16 and 17 for exergy and Equations 18-22 for the heat losses). These values are displayed in Table 3. An exergy diagram for the plant is displayed in Figure 3.

$$HL_{sep} = Ex_1 - (Ex_2 + Ex_3) \quad (18)$$

$$HL_{tur} = Ex_2 - (W_t + Ex_4) \quad (19)$$

$$HL_{cond} = (Ex_4 + Ex_8) - Ex_5 \quad (20)$$

$$HL_{ct} = (E_{x5} + W_f + E_{air.in}) - (Ex_6 + Ex_{air.out}) \quad (21)$$

$$HL_{pump} = W_{pump} - (Ex_7 + Ex_6) \quad (22)$$

Table 3: Exergy and heat loss values for the single flash geothermal power plant.

State	T(°C)	P(kpa)	$\dot{m}(\frac{kg}{s})$	$h(\frac{kj}{kg})$	$S(\frac{kj}{kg^{\circ}k})$	Ex(kw)
0	25	96	-	104.87	0.367	0
1	160.2	620	50	1092.77	2.901	11638.4
2	160.2	620	10	2758.3	6.748	7518.92
3	160.2	620	40	676.40	1.944	4063.36
4	76.76	41.44	10	2384.75	6.922	3264.9
5	59.18	30	110	289.52	0.944	1397.44
6	29	10	110	121.59	0.422	36.3
7	29	30	110	122.20	0.424	37.84
8	29	30	100	122.20	0.424	34.4
9	29	30	10	122.20	0.424	34.4
Air_{in}	25	96	670	298.46	6.862	0
Air_{out}	58	96	670	331.64	6.967	1266.3

4. **CONCLUSIONS:**

HYSYS software was used to perform the exergy analysis for a single flash geothermal power plant in Meshkin-Shahr, Iran. The characteristics of the geothermal fluid in Meshkin-Shahr site show that the two biggest energy losses occur in the geothermal brine (34.9%) and the condenser (16.3%). However, it is suspected that conditions would be better for direct use applications.

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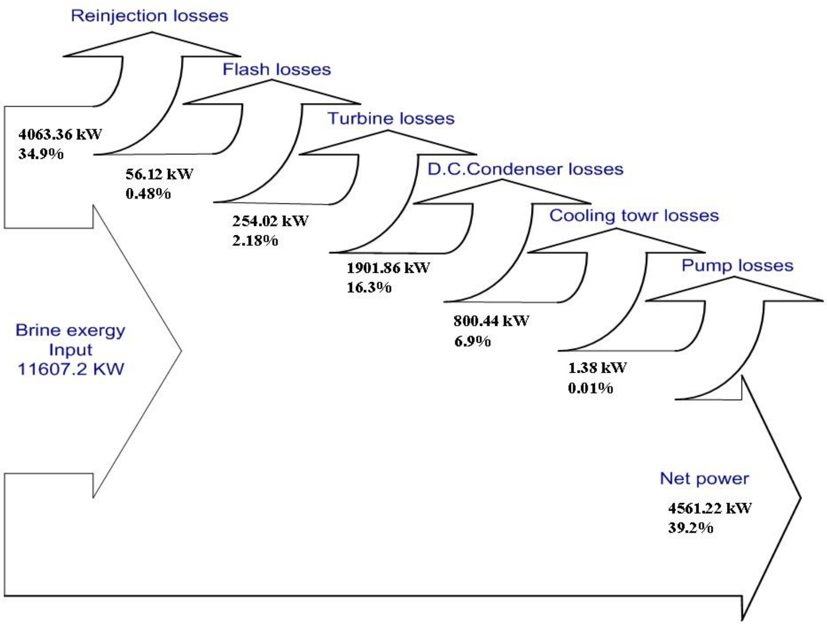

Figure 3: Exergy diagram for single flash geothermal power plant