

Problem Set for “Harnessing the Heat” Lectures (use steam tables)

1. A binary power plant has been installed at the Teapot Dome oilfield (WY) to generate electricity from water co-produced with oil. The flow rate from the wells is about 25,000 bbls/day (~40 kg/s) of 194F (~90C) water. The power plant is air-cooled, and the outflow temperature averages around 68F (20C).



Ormat binary power plant (250 kW) at Teapot Dome, WY

- It's electric output is 250 kW. What is the overall thermal efficiency?
2. A boiling spring is suspected of being fed by upward flow from high temperature geothermal water on a fault zone. Assuming boiling conditions with depth, what is the pressure (bar) and temperature (C) at 100 m depth? Assume the average density down to 100 m depth is 900 kg/m^3 . Once the temperature and pressure are calculated, is the estimate of 900 kg/m^3 for the average density good? If not, recalculate the pressure and temperature with an improved value.
 3. A geothermal well produces 100 kg/s of steam and water, originating from an all-liquid feed zone at 240 °C. The well feeds a separator operating at 7 bar gauge. What is the pressure when first boiling occurs? What is the temperature of the residual water flowing from the separator? What are the flows of water and steam coming out of the separator?
 4. A typical flash steam plant with a condensing turbine converts steam to electricity at the rate of 2 kg/s per MW. What is the thermal efficiency of the turbine (assume inlet pressure of 8 bar absolute)?
 5. If the well in Q3 produces 16 kg/s of steam (at 8 bar abs.), how much electricity is the turbine in Q4 generating?
 6. What is the overall thermal efficiency when you compare the total heat output of the well and electricity produced by the turbine?
 7. The feed zone of the well in Q3 has a chloride content of 1000 mg/kg, and is also saturated with silica (quartz) at 400 mg/kg. Both chloride and silica stay in the residual liquid as steam separates. What will their concentrations be in the water that flows from the separator? What are the implications of this?