



Cascade utilization of low temperature geothermal water in oilfield combined power generation, gathering heat tracing and oil recovery

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ABSTRACT

Oil wells at the high water-cut stage are used as geothermal wells and geothermal power plants in oilfield have their own advantages. A new compound system combining the organic Rankine cycle (ORC) plant with the gathering heat tracing (GHT) station and the oil recovery system is presented. First, the exergy destruction of the system is calculated and the reason for the low efficiency of the ORC with R123 is pinpointed through exergetic analysis. The plant is optimized numerically and working fluids investigated are R601a, R601, R123, R141b, R245fa, and R600. A new objective function is defined, reflecting both technical and economic performances. The feasibility of replacing oil boilers with geothermal water is then analyzed. Finally, the overall economic performance is calculated. Results show that the exergy destruction of the ORC with R123 is the highest. The optimized plant with R601a increases the net power output by about 40%. About 8163 tons of oil is saved and about 34.6 thousand tons of oil is recovered per year. The payoff period is only about 3.2 years whereas it will be sharply shortened if the earnings of oil are also considered. The new system is rational in technology and profitable in economy, which can be used as a way to increase economic benefits for oilfields at the high water-cut stage.

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1. Introduction

With the rapid progress of the society, power demand increases sharply causing acute conflicts between supply and demand. Meanwhile, fossil fuels are largely used resulting in critical environmental problems such as global warming, ozone layer destruction, atmospheric pollution and so on. The ultimate way to alleviate the issue between energy and environment is to develop renewable energy sources.

Geothermal energy is one of the renewable forms of energy being used today in various applications. As a natural resource, its usage is expected to grow more in the future. It can be first used to generate electricity and then the tail water can be used as the heat source of heating systems, which is more efficient and competitive than other energies both in technology and in economy. The high temperature reservoirs are the ones most suitable for commercial production of electricity [1]. Geothermal binary power plants expand the scope of geothermal resources to generate electricity [2–6]. For the low and medium temperature geothermal water, geothermal binary cycle can be used and the thermal energy is converted into work by an ORC or Kalina cycle [7–11]. The suitable

working fluids for the ORC are hydrocarbons or fluorinated hydrocarbons, whereas for the Kalina cycle an ammonia water mixture is used. Heat sources between 350 and 450 K reach a thermal efficiency ranging from 5 to 15% [12]. The main problem of low temperature geothermal power generations is their poor economic efficiency because the drilling cost accounts for more than 50%.

At present, numerous oilfields in the world enter the high water-cut stage, and the average water-cut is close to 95%, or even higher than 98%. How to increase the economic benefit of such oilfields is a significant research subject. The GHT system needs a great deal of thermal energy, and heat sources are mainly oil boilers. The energetic efficiency is relatively low due to the equipment aging, incomplete combustion, corrosion, scaling and so on. The running and maintenance costs increase with the oil price. Moreover, the issue that it brings subsequently is serious environmental pollution.

Oil wells at the high water-cut stage are used as geothermal wells, and the utilization of geothermal water in oilfield can not only save the drilling cost for plants but also save large quantities of oil to increase the economic efficiency, which is a way to solve the problem of the low economic performance for oilfields at the high water-cut stage. Geothermal power plants in oilfield have their own advantages shown as follows [13]:

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