World Academy of Science, Engineering and Technology
International Journal of Mathematical and Computational Sciences
Vol:14, No:12, 2020

Performance Improvement of a Single-Flash Geothermal Power Plant Design in Iran: Combining with Gas Turbines and CHP Systems

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Abstract : The geothermal energy is considered as a worldwide important renewable energy in recent years due to rising environmental pollution concerns. Low- and medium-grade geothermal heat (< 200 ºC) is commonly employed for space heating and in domestic hot water supply. However, there is also much interest in converting the abundant low- and medium-grade geothermal heat into electrical power. The Iranian Ministry of Power - through the Iran Renewable Energy Organization (SUNA) – is going to build the first Geothermal Power Plant (GPP) in Iran in the Sabalan area in the Northwest of Iran. This project is a 5.5 MWe single flash steam condensing power plant. The efficiency of GPPs is low due to the relatively low pressure and temperature of the saturated steam. In addition to GPPs, Gas Turbines (GTs) are also known by their relatively low efficiency. The Iran ministry of Power is trying to increase the efficiency of these GTs by adding bottoming steam cycles to the GT to form what is known as combined gas/steam cycle. One of the most effective methods for increasing the efficiency is combined heat and power (CHP). This paper investigates the feasibility of superheating the saturated steam that enters the steam turbine of the Sabalan GPP (SGPP-1) to improve the energy efficiency and power output of the GPP. This purpose is achieved by combining the GPP with two 3.5 MWe GTs. In this method, the hot gases leaving GTs are utilized through a superheater similar to that used in the heat recovery steam generator of combined gas/steam cycle. Moreover, brine separated in the separator, hot gases leaving GTs and superheater are used for the supply of domestic hot water (in this paper, the cycle combined of GTs and CHP systems is named the modified SGPP-1) . In this research, based on the Heat Balance presented in the basic design documents of the SGPP-1, mathematical/numerical model of the power plant are developed together with the mentioned GTs and CHP systems. Based on the required hot water, the amount of hot gasses needed to pass through CHP section directly can be adjusted. For example, during summer when hot water is less required, the hot gases leaving both GTs pass through the superheater and CHP systems respectively. On the contrary, in order to supply the required hot water during the winter, the hot gases of one of the GTs enter the CHP section directly, without passing through the super heater section. The results show that there is an increase in thermal efficiency up to 40% through using the modified SGPP-1. Since the gross efficiency of SGPP-1 is 9.6%, the achieved increase in thermal efficiency is significant. The power output of SGPP-1 is increased up to 40% in summer (from 5.5MW to 7.7 MW) while the GTs power output remains almost unchanged. Meanwhile, the combined-cycle power output increases from the power output of the two separate plants of 12.5 MW [5.5+ (2×3.5)] to the combined-cycle power output of 14.7 [7.7+(2×3.5)]. This output is more than 17% above the output of the two separate plants. The modified SGPP-1 is capable of producing 215 T/Hr hot water (90 ºC) for domestic use in the winter months.

Keywords : combined cycle, chp, efficiency, gas turbine, geothermal power plant, gas turbine, power output
Conference Title : ICSRD 2020 : International Conference on Scientific Research and Development
Conference Location : Chicago, United States
Conference Dates : December 12-13, 2020