VERY LOW PRESSURE FLASH CYCLE GEOTHERMAL POWER GENERATION

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ABSTRACT

VLP Flash Cycle to utilize low and medium temperature geothermal hot water for power generation is proposed as an alternative to binary cycle which is currently used for the same purpose.

The features of the VLP System are 1) does not use any working fluid, and therefore 2) the parasitic load is low An example of the system using 130°C of hot water from high pressure separator of an existing geothermal power plant is presented In this case, the net output is 3,250kW to the gross output of 3,500kW using 1,000t/h of hot water.

1.0 INTRODUCTION

Efficient use for power generation of low and medium temperature geothermal resources which are more abundant than high temperature resources is essential for the promotion and the increase of the share of geothermal power generation. Currently, most commonly used method for this purpose is binary cycle which employs a working fluid of low boiling temperature. Although the binary cycle has been contributing a lot for the purpose said above, and its feature is that no NCG is emitted into surrounding air because it is a totally enclosed system, there exists some problems with the system. The rate of plant parasitic load is high and that more maintenance work is required because there are more auxiliaries including the pump installed in the production well to pressurize geothermal brine before it goes into heat exchangers. The storage and the makeup of the working fluid may also cause an operational and safety problem. The Very Low Pressure flash cycle proposed here will eliminate all of these problems.

2.0 OUTLINE OF THE SYSTEM

There may be two cases for getting law and medium temperature geothermal hot water for power generation. Figure 1 shows the case where hot water fiom a production well is directly used for the system. In case of Figure 2, hot water from the high pressure separator is used to give an additional plant output. This can be retrofit to an existing geothermal power plant, or can be integrated in the engineering of a new power plant fiom the beginning. In any case, the flashing pressure will be lower than atmospheric pressure, and is optimized based on the hot water temperature to maximize the output.

Figure 3 shows a cross sectional view of the VLP turbine. As can be seen, the blade rows of the turbine are such that the high pressure stages of ordinary geothermal steam turbine are removed. The turbine is skid-mounted type to simplify the installation work, and has dual steam entries to reduce the influence on the output while the stem-free test of the valves are being carried out, and particularly for the VLP turbine, since the volume flow of incoming steam is high.

A double flash turbine of which LP inlet pressure is below atmospheric pressure already exists. The inlet pressure of LP steam of Yan-Ba-Jing unit is 0.9 bara. There is no new element or design to be verified or need to be newly developed. The flasher will be installed close to the turbine to make the vacuum steam piping length minimal to reduce the possibility of leaking in of atmospheric air.

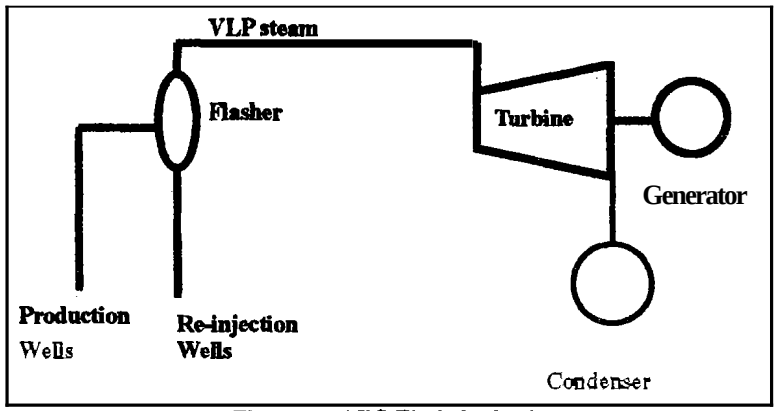

Figure 1. VLP Flash Cycle (1)

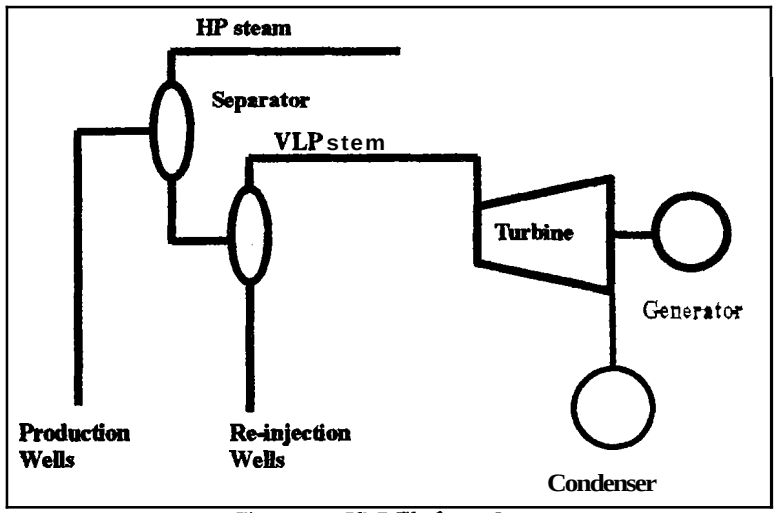

Figure 2. VLP Flash Cycle (2)

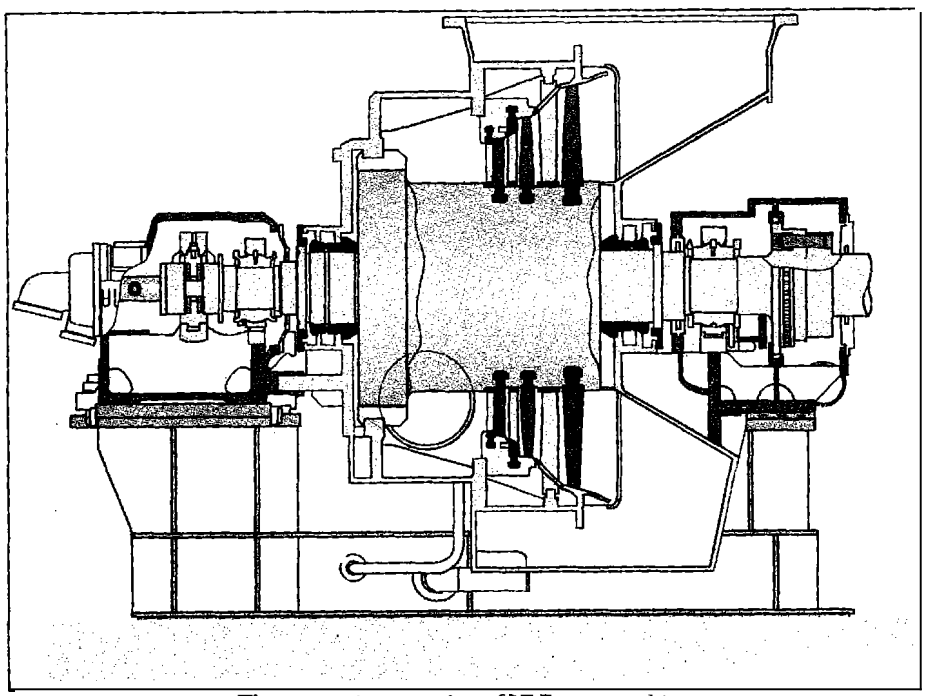

Figure 3. *Cross* section of VLP *steam* turbine.

21 Example

Figure 4 shows relationships between Flash Pressure and Steam Flow, and Flash Pressure and Gross Output for 100% hot water of 130°C. Although the maximum output would be achieved at 0.65 bara, the flash pressure of 0.7 bara is selected since at 0.65 bara the steam flow exceeds the maximum steam admission of this particular type of turbine (Last Stage Blade length is 467mm.) which is also shown in Fig. 4. The design Wet Bulb Temperature is 20°C and the Condenser pressure is selected as 0.11 bara employing a wet type cooling tower of which approach is 9°C. Figure 5 is Heat and Mass Balance Diagram of this system. The steam pressure at turbine inlet is 0.67 bara including the pressure drop between the flasher and the turbine inlet. The geothermal hot water in this example is from the separator of an existing geothermal power plant, and therefore does not contain NCG. A vacuum pump is provided to extract small quantity of leaked air and accompanying steam. In case that the hot water comes from production well directly and contains NCG, either vacuum pump or water jet pump system whichever more favorable from the point of view of saving the parasitic load will be used for gas extraction because there is no steam of which pressure is high enough to drive a set of steam jet ejectors.

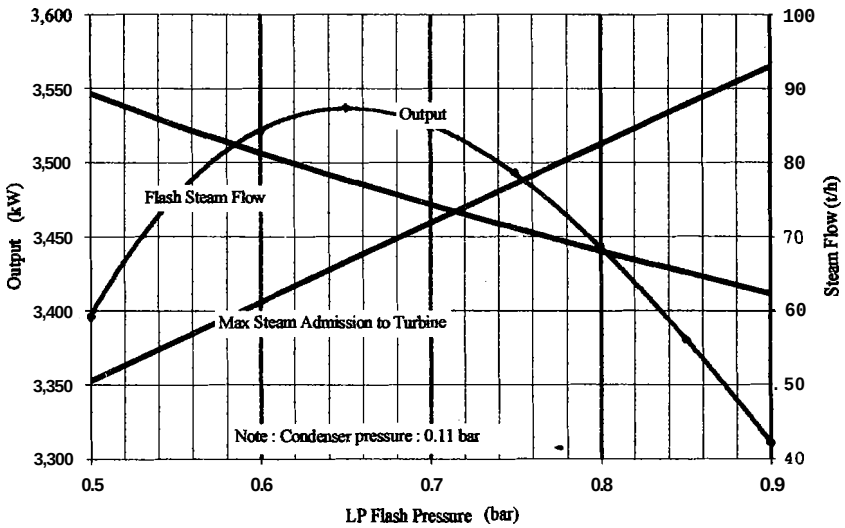

Figure 4. LP Flash Pressure - Optimization (Hot water temperature at 130°C)

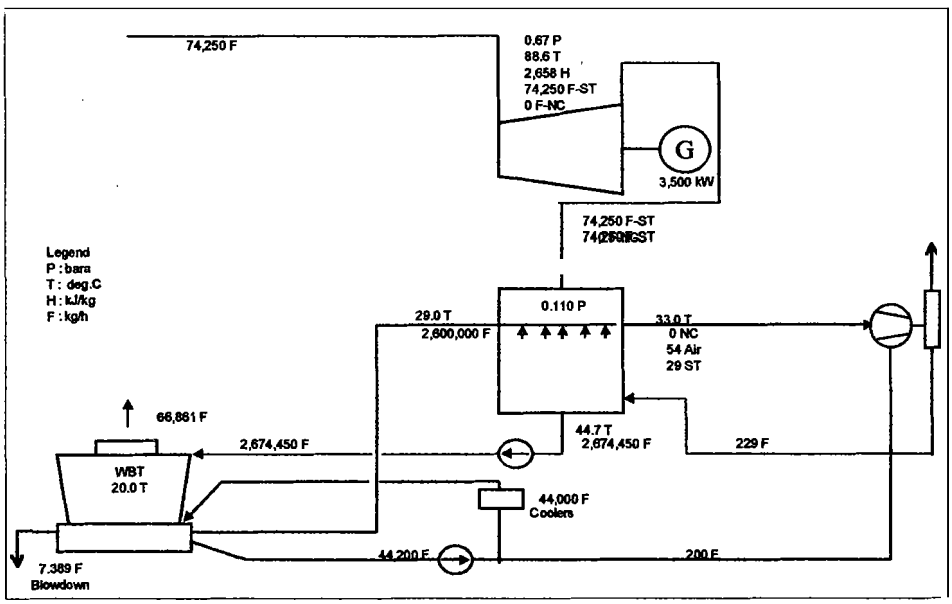

Figure 5. Example of heat and mass balance diagram.

Parasitic loads of this plant except lighting and air conditioning are, Hotwell Pump (110kW), Auxiliary Cooling Water Pump (5.5k W), Cooling Tower Fans (110kW), Vacuum Pump (15kW) and power for the control systems (ca. 10kW) such as an air compressor, making the total approximately 250kW which is roughly 7% of the gross output. The loss at the main transformer needs not to be counted as a parasitic load in this case because the terminal voltage of the generator is 6.6kV, and will be connected directly to the outside line.

3.0 CONCLUSION

There may be a variety of cases other than the example described m the previous section. If geothermal hot water contains some percentage of steam, the turbine inlet pressure can be raised to, for example 0.9 bara, and the gross output will be considerably increased although more power must be consumed for the gas extraction, because in such a case usually some NCG is contained in stem. The condenser pressure plays a very important role in determining the output since the heat drop across the VLP turbine is quite low compared to the ordinary geothermal turbine. For the VLP flash system it is more effective than ordinary geothermal power generation to lower the design condenser pressure to increase the output under the same brine condition.

Nature of geothermal resources varies area to area, and the site conditions also differ. What is important is to select the most suitable system under the given conditions. The VLP flash cycle will contribute to widen a range of the selection for geothermal power generation with low and medium temperature resources.