International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 3 Issue 5, August 2019 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Analysis of Induction Generator for Geothermal Power Generation System

Aung Myo Naing

Department of Electrical Power Engineering, Technological University, Hmawbi, Myanmar

How to cite this paper*:* Aung Myo Naing "Analysis of Induction Generator for Geothermal Power Generation System" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-3 | Issue-5, August 2019, pp.1725-1727, **https://doi.org/10.31142/ijtsrd26756**

IJTSRD26756

ABSTRACT

Nowadays, renewable energy sources contribute approximately twenty-five percent of the world electricity supply. The challenge is the inevitable increase in energy consumption in the world with the risk of a major environmental impact and climate change as a results of the combustion of fossil fuels. Therefore, renewable energy has a very important role to play in the near future. Geothermal Power is one of the renewable energy sources, but it is largely ignored in favor of wind and solar energy. However, geothermal power is reliably predictable years in advance for power generation unlike wind and solar energy. Besides, it is convenient to supply the electricity sufficiently for rural and coastal areas which are far from national grid. The appropriate steam turbine to use in geothermal power plant is carefully selected. More importantly, the design calculation of a 0.5 MW, 6 poles induction generator is calculated in detail in order to generate electrical power concerned with the geothermal ranges of coastal areas in Myanmar. Geothermal power plant operations tend to be of three general kinds: dry stream plants and flash plants, applied to high-energy resources, and binary plants.

KEYWORDS: *Geothermal power, induction generator, Analysis of Geothermal Power Generation System*

I. INTRODUCTION

Electricity is a basic part of nature and it is one of our most widely used forms of energy.

It is generated by means of energy conversion technology from the conventional energy (petroleum, coal, oil, natural gas) and renewable energy (solar, wind, hydro, tidal, biomass, geothermal). Renewable energy is at the same geothermal). Renewable energy is rate it is used. Interest in renewable energy has been growing steadily over the past 30 years. This interest has been heightened by a number of concerns over the use of conventional energy technologies and their environmental impacts. Concern about the environmental impact and global warming upon it is greater now than it has ever been. Of the many environmental issues the production of electricity are amongst the most significant. Anxieties about the appropriate choice of electricity generating systems, from the viewpoint of the environmental global warming are highlighted by the current debate on the effects of pollution, climate change and acidification of forests, and depletion of the ozone layer. Renewable energy technologies are seen by many as part of a solution to these problems. But the mass production of electricity using renewable energy sources has become popular only recently, relatively the major threats of climate change due to pollution; concern about the exhaustion of fossil fuels and the environmental, social and political risk of fossil fuels and nuclear power. While geothermal is not immediately renewable like technologies such as solar and wind, it has a number of important advantages. Geothermal electric plants operate 24 hours per day and thus produce base-load electricity .There is no need for storage, and dispatch ability is not an issue environmental global. Geothermal plants are not vulnerable to weather effects except that cycle efficiencies (and hence plant output) tend to be higher in the winter (when heat is rejected to a lower sink temperature) than in the summer.

II. Geothermal Power Production

There are basically three types of geothermal plants used to generate electricity. The type of plant is determined primarily by the nature of the geothermal resource at the site.

A. Geothermal Power System

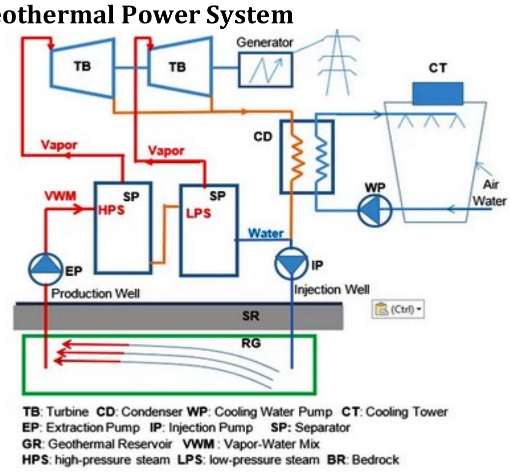

Figure (1) Geothermal Power System

The so-called direct steam geothermal plant is applied when the geothermal resource produces steam directly from the well. The steam, after passing through separators (which remove small sand and rock particles) is fed to the turbine. Unfortunately, steam resources are the rarest of the all geothermal resources and exist in only a few places in the world. Obviously steam plants would not be applied to low-temperature resources.

A geothermal system consists of three elements: a heat source, permeable rock, and a fluid to transport heat to the surface. The heat source is the only fundamental requirement because permeable rock reservoirs can be artificially created and fluids can be introduced. There are two main types of geothermal systems that can be used to generate electricity.

B. Binary System

Geothermal power plant is called the binary plant. The name derives from the fact that a second fluid in a closed cycle is used to operate the turbine rather than geothermal steam presents a simplified diagram of a binary type geothermal plant. Geothermal fluid is passed through a heat exchanger called a boiler or vaporizer (in some plants, two heat exchangers in series the first a preheater and the second a vaporizer) where the heat in the geothermal fluid is transferred to the working fluid causing it to boil. Past working fluids in low temperature binary plants were CFC (Freon type) refrigerants. Current machines use hydrocarbons (isobutene, pentane etc.) of HFC type refrigerants with the specific fluid chosen to match geothermal resource temperature. The binary cycle is the type of plant which would be used for low temperature geothermal applications.

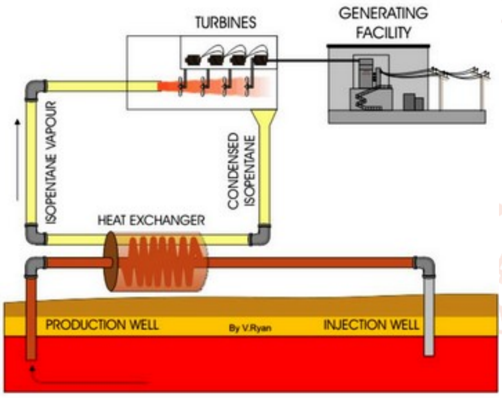

Figure (2) Binary Geothermal Power Plant

C. Dry Steam Plants

In a few places on earth Larderello and Geysers are the bests-known instances-wells yield comparatively high-quality steam. At the Geysers, according to folklore, even pipe fence posts and gateposts sometimes vent free steam, recalling the generous though fanciful place celebrated in the old hobo song where cigarettes grow on trees. Stream produced from the wells is collected, polished and used to drive turbines directly. Geothermal steam turbines are typically designed and fabricated to make effective use of the comparatively low pressures and high volumes produced in these resources.

D. Flash Stream Plants

Though geothermal dry stream resources represent the acme of thermodynamic possibility and cost-effectiveness for geothermal projects, most hard-working geothermal plants get their energy from liquid-dominated resources such as those underlying the Imperial Valley in California. These plants get their steam from a process of separation in which superheated fluids accessed by wells are '' flashed'' in wellbores and separators. The resulting steam is routed to a turbine or turbines, and the resulting fluids are routed to reinjection or further flashinh in lower-pressure regimes.

III. Power Plant Efficiency

One of the most important concepts governing the operation of a power plant is that the efficiency of the process is determined by the temperature difference between the boiler and the condenser. For example, in a conventional fossil fuel power plant, the temperature of the steam leaving the boiler may be 1,000oF. The condenser may operate at 100oF. The theoretical efficiency of the cycle may be calculated from the following formula:

Equation 1

$$TCE = \left(\frac{T_h - T_l}{T_h}\right) \times 100$$

where: TCE = Theoretical cycle efficiency,
Th = absolute temperature of the steam leaving the Boiler
Tl = absolute temperature of the condenser (or) Note: Absolute temperature (or) is determined by adding 460°F to the temperature in.

Example: A power plant is operated with a steam temperature of 1,00°F and a condenser temperature of 100°F. Calculate the theoretical efficiency.

Ts = 1000 + 460 = 1460 or
Tc = 100 + 460 = 560 or
Efficiency = ((1460 - 560)/1460) x 100 = 61.6%

This means that, in theory, 61.6% of the energy contained in the steam would be converted.

IV. Power Plant Fundamentals

The process of generating electricity from a low temperature geothermal heat source (or from steam in a conventional power plant) involves a process engineers refer to as a Rankin Cycle. In a conventional power plant, the cycle, as illustrated in figure 1, includes a boiler, turbine, generator, and condenser, feed water pump, cooling tower and cooling water pump. Steam is generated in the boiler by burning a fuel (coal, oil, gas or uranium). The steam is passed to the turbine where, in expanding against the turbine blades, the heat energy in the steam is converted to mechanical energy causing rotation of the turbine. This mechanical motion is transferred, through a shaft to the generator where it is converted to electrical energy. After passing through the turbine the steam is converted back to liquid water in the condenser of the power plant.

Through the process of condensation, heat not used by the turbine is released to the cooling water. The cooling water is delivered to the cooling tower where the "waste heat" from the cycle is rejected to the atmosphere. Steam condensate is delivered to the boiler by the feed pump to repeat the process. In summary, a power plant is simply a cycle that facilitates the conversion of energy from one form to another. In this case the chemical energy in the fuel is converted to heat (at the boiler), and then to mechanical energy (in the turbine) and finally to electrical energy (in the generator). Although the energy content of the final product, electricity, is normally expressed in units of watts-hours or kilowatt-hours (1000 watt-hours or 1kW-hr), calculations of plant performance are often done in units of BTU's. It is convenient to remember that 1 kilowatt-hour is the energy equivalent of 3413 BTU. One of the most important determinations about a power plant is how much energy input (fuel) is required to produce a given electrical output. To make this calculation, it necessary to know the efficiency of the power plant.

V. Analysis of Power Plant

The forgoing discussion is valid for direct steam type power plants. In binary plants, the type appropriate to low temperature resources, the temperature of the vapor leaving the boiler is always less than the temperature of the geothermal resource fluid. This temperature difference is necessary to allow the transfer of heat out of the geothermal fluid and into the working fluid. It also has an impact on the efficiency of the cycle since it results in a lower T_h in Equation.

Figure (3) is a plot of binary power plant performance based on data from a manufacturer of this equipment (Nichols, 1986). It is apparent that at very low resource temperatures, plant efficiencies are less than 10%, meaning that over 90% of the heat delivered to the machine is rejected to the atmosphere. The values plotted are representative of net plant efficiency exclusive of the well pumping power necessary to produce the geothermal fluid.

One calculation of interest in the course of evaluating a power generation application is the quantity of water flow required. It is possible to make this determination knowing the desired plant output (in kW or MW), the probable plant efficiency and the resource temperature.

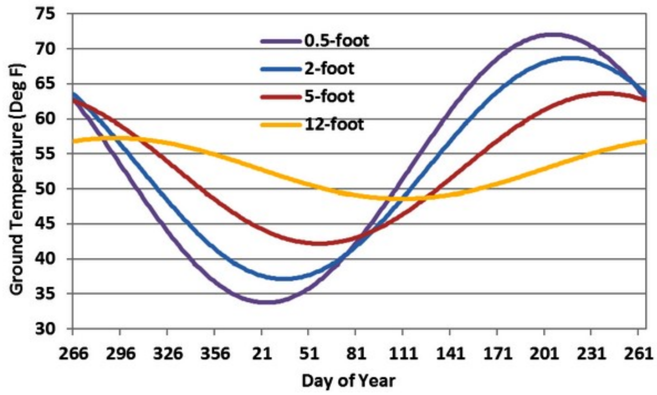

Figure (3) Resource Temperature

The approximate geothermal Fluid

A binary power plant will be designed to produce an output of 500 kW using a resource temperature of 100^oF. From Figure- 2 we can determine that the likely plant net efficiency at 100^oF would be approximately 7.5%.The required plant heat input is determined by

Dividing the output by the efficiency as follows:

= (500 kW x 3413 BTU/kWhr)/ 0.075

= 22760, 000 BTU/hr

The required geothermal water flow can be calculated by dividing the required heat input by 500 T, where ? T is the temperature drop of the geothermal fluid (entering temperature - leaving temperature) in ^oF. Most binary plants are capable of achieving leaving geothermal water temperatures of approximately 60^oF. The entering water temperature can be assumed to be the same as the resource temperature.

Required geothermal water flow

= 22760,000 BTU/hr / (500*(100 - 60))

= 1138 gpm

VI. Geothermal Power generation System

The type of electricity generation power plant used depends on the volume of fluid available and its temperature. Where a lot of high temperature water or vapor is available, steam power plants are used.

Australia does not have the wet, high-temperature geothermal environments found in volcanically active countries. Consequently, Australia's hydrothermal systems are neither hot enough or under enough pressure to produce large amounts of steam. As Hot Rock systems use a closed loop to conserve water and energy. In binary power plants, a heat exchanger is used to transfer energy from the geothermal-heated fluid to a secondary fluid (called the 'working fluid', e.g. iso-pentane or ammonia) that has a lower boiling point and higher vapour pressure than steam at the same temperature. The working fluid is vaporised as it passes through the heat exchanger, and then expanded through a turbine to generate electricity. It is then cooled and condensed to begin the cycle again. Advances in binary plant technology have enabled lower temperature geothermal resources to be exploited for electricity generation.

CONCLUSION

At the present time, the generation of electricity using low to moderate temperature geothermal resources is an established technology. Successful applications in the U.S. are characterized by resource temperatures of greater than 100^oF, plant sizes of greater than 0.5MW (500 kW) and sales to a utility (as distinct from generation for onsite use). The application of this technology to lower resource temperatures or in very small plant sizes, absent unusual considerations, while technically feasible, is unlikely to be a wise economical choice for the owner.

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