Geothermal Energy Utilization

Unit 4: Answer Bank

Short Answer Questions

1. List different types of Geothermal Power Plants.

Ans:

1. Vapor Dominated Geothermal Power Plants
2. Liquid Dominated flashed steam type Geothermal Power Plants
3. Liquid Dominated binary cycle Geothermal Power Plants
4. Liquid Dominated total flow type Geothermal Power Plants
5. Hot Dry Rock (Petrothermal) Geothermal Power Plants
6. Hybrid Geothermal fossil fueled Power Plants

2. Distinguish between Flashing Units and Dual Flashing Units.

Ans:

Comparison:

Efficiency :

Dual Flashing Units : Dual flashing units are more efficient than single flashing units as they allow for more complete utilization of the geothermal fluid by extracting steam in two stages, resulting in higher electricity generation capacity.

Single Flashing Units : Single flashing units are less efficient compared to dual flashing units as they extract steam only once from the geothermal fluid.

Complexity and Cost :

Dual Flashing Units : Dual flashing units are more complex and expensive to design, install, and maintain compared to single flashing units due to their two-stage flashing process.

Single Flashing Units : Single flashing units are simpler and more cost-effective compared to dual flashing units, making them suitable for geothermal power plants with lower-pressure hot water resources.

3. What is Hybrid Geothermal-Fossil Power Units.

Ans: A Hybrid Geothermal-Fossil Power Unit is a combined power generation system that integrates both geothermal energy and fossil fuel-based energy sources to produce electricity. This hybrid system is designed to leverage the benefits of both geothermal and fossil fuel technologies to provide a more reliable, flexible, and efficient energy supply.

4. What are Environmental Benefit of Geothermal Power Plants.

Ans: 1. Low Greenhouse Gas Emissions:
2. Renewable and Sustainable Energy Source:
3. Reduced Air Pollution:
4. Minimal Land Use and Environmental Impact:
5. Water Conservation:
6. Energy Efficiency:

Long Answer Questions

1. Explain the various Geothermal resources available.

Ans: Geothermal energy harnesses the heat from the Earth's core, and there are several types of geothermal resources that can be utilized to generate electricity, heat buildings, and provide hot water. Here are the main types of geothermal resources:

1. Hydrothermal Resources: These are the most common and widely exploited geothermal resources. Hydrothermal resources use naturally occurring hot water or steam from the Earth's crust. They can be categorized into:

a) **Steam Reservoirs :** These are high-temperature geothermal systems where steam is readily available. Wells are drilled to bring the steam to the surface and used directly to drive turbines for electricity generation.

b) **Liquid-Dominated Reservoirs :** In these systems, hot water is prevalent rather than steam. The hot water is pumped to the surface and its heat is extracted using heat exchangers to produce electricity or for direct heating applications.

c) **Enhanced Geothermal Systems (EGS) :** These are engineered reservoirs where water is injected into hot, dry rock formations deep underground to create artificial steam or hot water reservoirs. EGS expands the potential locations for geothermal energy production beyond natural hydrothermal reservoirs.

2. Hot Dry Rock (HDR) Resources : HDR systems extract heat from solid, impermeable rock formations deep underground by creating artificial fractures and circulating water through them. This technology is still in the experimental phase but holds significant potential for widespread geothermal energy production.

3. Geopressured Resources : These are found in sedimentary basins where water is trapped under high pressure beneath impermeable rock layers. As the hot, pressurized water is brought to the surface, its heat can be used for electricity generation or direct heating applications.

4. Magma Resources : In areas where there is active volcanic activity, molten magma close to the Earth's surface can be tapped to produce geothermal energy. This type of resource is less common and more challenging to exploit due to the extreme temperatures and conditions involved.

5. Co-Produced Resources : Some oil and gas wells produce geothermal fluids (hot water or steam) along with oil and gas. This co-produced geothermal fluid can be harnessed for energy production, making the extraction of fossil fuels more efficient and environmentally friendly.

2. Illustrate with Neat Sketch Hybrid Geothermal-Fossil Power Units

Ans: The construction and working of a Hybrid Geothermal-Fossil Power Unit involve integrating both geothermal and fossil fuel-based power generation technologies to create a more versatile and reliable energy system. Below is a detailed explanation of the construction and working of such a system:

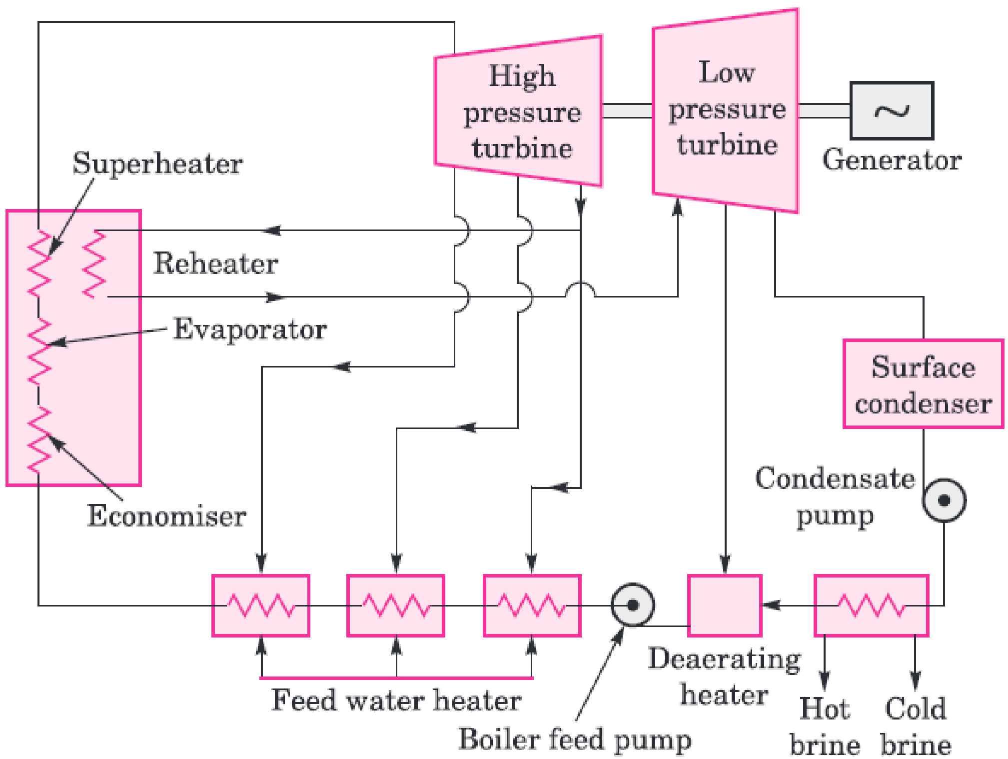

Fig. **Hybrid Geothermal-Fossil Power Units**

Construction:

The feed water of a conventional fossil-fueled steam plant is heated by low temperature geothermal energy. Geothermal heat replaces some or all, of the feedwater heaters, depending upon its temperature. A cycle operating on this principle is illustrated schematically in Fig , In it, geothermal heat heats the feed-water throughout the low- temperature end prior to an open-type deaerating heater. It is followed by a boiler feed pump and three closed-type feedwater heaters with drains cascaded backward. These receive heat from steam bled from higher-pressure stages of the turbine. No steam is bled from the lower pressure stages because geothermal brine fulfills this function.

Advantages:

1. Reliability : The hybrid system ensures continuous power generation by switching between geothermal and fossil fuel modes based on the availability of resources.

2. Flexibility : The system can adjust the power output based on the demand by varying the contribution from geothermal and fossil fuel sources.

3. Environmental Benefits : By utilizing geothermal energy, the system reduces greenhouse gas emissions compared to a solely fossil fuel-based power plant.

Challenges:

1. Initial Cost : The construction of a hybrid system involves higher initial capital investment compared to individual geothermal or fossil fuel power plants.

2. Maintenance : Operating and maintaining a dual-mode system can be more complex and may require specialized skills and equipment.

In summary, a Hybrid Geothermal-Fossil Power Unit combines the benefits of both geothermal and fossil fuel-based power generation technologies to create a more reliable, flexible, and environmentally friendly energy system.

3. Discuss the effects of Impurities in the Geo thermal Fluid.

Ans: Impurities in geothermal fluid can have various effects on the efficiency, reliability, and environmental impact of geothermal power plants. These impurities can originate from the underground reservoir or can be introduced during the drilling and extraction process. Here are the effects of some common impurities found in geothermal fluid:

1. Scaling:

Effects : Minerals and salts dissolved in the geothermal fluid can precipitate out and form scale deposits on the walls of pipes, heat exchangers, and other equipment. This scaling can reduce the heat transfer efficiency and increase maintenance costs.

- Impurities : Calcium carbonate, silica, and other minerals.

2. Corrosion:

- Effects : Corrosive elements in the geothermal fluid can degrade the materials used in the construction of geothermal power plants, leading to equipment failure and leaks.
- Impurities : Chlorides, sulfides, and other corrosive compounds.

3. Erosion:

- Effects : Suspended solids and abrasive particles in the geothermal fluid can cause erosion of the equipment, including pumps, turbines, and pipes, leading to increased wear and reduced lifespan of the equipment.
- Impurities : Sand, silt, and other particulate matter.

4. Scaling in Reservoir:

- Effects : Precipitation of minerals and salts in the underground reservoir can reduce the permeability of the rock formations, restricting the flow of geothermal fluid and decreasing the

overall productivity of the reservoir.
- Impurities : Silica, calcium carbonate, and other minerals.

5. Biological Growth:
- Effects : Microbial growth in the geothermal fluid can cause biofouling of equipment and pipelines, leading to reduced flow rates and increased maintenance requirements.
- Impurities : Bacteria, algae, and other microorganisms.

6. Environmental Impact:
- Effects : Discharge of geothermal fluid containing impurities into surface water bodies can lead to environmental pollution and harm aquatic ecosystems.
- Impurities : Heavy metals, boron, and other toxic elements.

Mitigation Measures:

1. **Pre-treatment :** Pre-treatment of geothermal fluid by filtration, sedimentation, and chemical treatment can reduce the concentration of impurities before they enter the power plant.

2. **Material Selection :** Using corrosion-resistant materials and coatings for the construction of equipment can minimize the effects of scaling and corrosion.

3. **Scale and Corrosion Inhibitors :** Addition of scale and corrosion inhibitors to the geothermal fluid can prevent the formation of scale deposits and protect the equipment from corrosion.

4. **Monitoring and Maintenance :** Regular monitoring of the geothermal fluid composition and condition of equipment, along with preventive maintenance measures, can help in early detection and mitigation of problems caused by impurities.

4. Explain Geothermal District Heating: An Example of Energy Savings.

Ans: Geothermal district heating is a system that uses the heat from geothermal resources to provide heating and sometimes cooling to multiple buildings or a whole community through a network of underground pipes. This system offers a sustainable and cost-effective solution for space heating and hot water supply, reducing energy consumption and greenhouse gas emissions compared to conventional heating systems. Below is an explanation of geothermal district heating, along with an example showcasing energy savings:

Geothermal District Heating System Components:

1. **Geothermal Wells :**
   - Description : Wells are drilled into the ground to access the geothermal reservoir, which can be a source of hot water or steam.
2. **Heat Exchanger Station :**
   - Description : The geothermal fluid from the wells transfers its heat to a secondary loop containing a non-corrosive fluid (e.g., water or antifreeze) via a heat exchanger.
3. **Distribution Network :**
   - Description : Underground pipes distribute the heated fluid from the heat exchanger station to individual buildings or homes in the district.
4. **Heat Transfer Stations :**
   Each building or home is equipped with a heat transfer station where the heat from the distributed fluid is transferred to the building's heating system (e.g., radiators, underfloor

heating).

5. Cooling System (Optional) :
In some cases, the geothermal system can also be used for cooling by reversing the heat exchange process, extracting heat from the buildings and transferring it back to the ground.

Example of Energy Savings:
Let's consider a hypothetical district with 1,000 homes currently using natural gas boilers for heating. Each home consumes an average of 20,000 kWh of energy per year for heating.

Total Energy Consumption with Natural Gas Boilers:

= 1,000 homes × 20,000 kWh/home
= 20,000,000 kWh

Now, let's compare this with a geothermal district heating system:

1. Geothermal System Efficiency :
Assumption : A geothermal district heating system has an efficiency of 300% (for every 1 kWh of electricity used to operate the system, it produces 3 kWh of heat).

2. Electricity Consumption for Geothermal System :
Calculation : 20,000,000 kWh ÷ 3
= 6,666,667 kWh

3. Energy Savings :
Calculation : 20,000,000 kWh - 6,666,667 kWh
= 13,333,333 kWh

By switching from natural gas boilers to a geothermal district heating system, the district can save approximately 13,333,333 kWh of energy per year. This not only reduces energy consumption but also results in significant cost savings and a reduction in greenhouse gas emissions.

Additional Benefits:

1. Cost Savings : Geothermal district heating systems can provide long-term cost savings due to lower operating costs and stable energy prices compared to fossil fuels.

2. Environmental Benefits : By utilizing renewable geothermal energy, these systems reduce greenhouse gas emissions and contribute to climate change mitigation.

3. Reliability and Resilience: Geothermal energy is a reliable and consistent energy source, reducing dependency on imported fuels and enhancing energy security.

5. **Discuss the Environmental Benefit and environmental Effects of Geothermal power plant.**

Ans: Geothermal power plants are known for their environmental benefits as a renewable and clean energy source, but they can also have some environmental effects that need to be managed carefully. Below is a discussion of the environmental benefits and effects of geothermal power plants:

Environmental Benefits of Geothermal Power Plants:

1. **Low Greenhouse Gas Emissions :**
Geothermal power plants produce very low amounts of greenhouse gas emissions compared to fossil fuel-based power plants. The emissions are mainly from the extraction and processing of geothermal fluid and are significantly lower than those from coal, oil, and natural gas combustion.
2. **Renewable Energy Source :**
Geothermal energy is a renewable resource, as the heat from the Earth's interior is continuously replenished. It provides a reliable and sustainable energy source for power generation without depleting finite resources.
3. **Reduced Air Pollution :**
Geothermal power plants do not produce air pollutants such as sulfur dioxide, nitrogen oxides, and particulate matter, which contribute to air pollution, acid rain, and respiratory diseases.
4. **Land Use Efficiency :**
Geothermal power plants have a small land footprint compared to other renewable energy sources like solar and wind power. Once the geothermal wells are drilled, the land above can be used for other purposes such as agriculture or conservation.
5. **Stable and Predictable Output :**
Geothermal energy provides a stable and predictable output, which can help in grid stability and reliability, reducing the need for backup power sources and energy storage systems.

Environmental Effects of Geothermal Power Plants:

1. **Land Disruption :**
The construction and operation of geothermal power plants can disrupt the local ecosystem and land use, especially during the drilling and exploration phase.

2. **Water Use and Discharge :**
Geothermal power plants require water for the extraction and cooling processes. The extraction of geothermal fluid can reduce the water level in the underground reservoir, affecting local water resources. Additionally, the discharge of geothermal fluid containing impurities can pollute surface water bodies if not managed properly.

3. **Induced Seismicity :**
The injection of water into deep underground reservoirs for enhanced geothermal systems (EGS) can induce seismic activity, leading to earthquakes. Although the seismic events are usually small and not felt at the surface, they can pose risks to infrastructure and public safety.

4. **Noise and Visual Impact :**
The operation of geothermal power plants can produce noise and visual impact, especially during the construction and drilling phase, which can affect the local community and wildlife.

Mitigation Measures:

1. **Water Management :**
Implementing water recycling and treatment systems to minimize water use and discharge, and managing the geothermal fluid to prevent pollution of water bodies.

2. **Seismic Monitoring and Regulation :**
Conducting continuous seismic monitoring and implementing regulations and protocols to minimize induced seismicity and ensure public safety.

3. **Environmental Impact Assessment :**
Conducting comprehensive environmental impact assessments before the construction and operation of geothermal power plants to identify potential environmental risks and implement mitigation measures.

4. **Community Engagement :**
Engaging with local communities and stakeholders to address their concerns, ensure transparency, and promote the sustainable development of geothermal energy projects.