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Module-5
Geothermal energy

SUKRUTH SAGAR
Asst. Professor,
Dept. of Mechanical Engineering,
ATMECE, Mysuru

INTRODUCTION

Geothermal energy originates from earth's interior in the form of heat.

- Volcanoes, geysers, hot springs are visible evidence of the great reservoirs of heat that lies within earth.
- Although the amount of thermal energy within the earth is very large, useful geothermal energy is limited to certain sites only.
- The sites where it is available near the surface and is relatively more concentrated, its extraction and use may be considered feasible.
- These sites are known as geothermal fields.

- The geothermal resource is estimated to be more than 2.11 × 1025 J, which is equivalent to 109 MTOE (million tons of oil equivalent).

- This is a huge amount of energy, enough to supply our energy needs at current rates for 3,50,000 years.

- However, it is a low-grade thermal energy form and its economic recovery is not feasible everywhere on the surface of the earth.

- Practically it is not the size of the resource that limits its use but the availability of technology that can tap the resource in an economic manner.

Types of Geothermal Resources

Four types of geothermal resources:

1. Hydrothermal or Hydro –geothermal energy resources.
   (i) Vapour –dominated (or) dry steam fields
   (ii) Liquid –dominated system or wet steam fields
      (a) The flash steam open system (FSOS)
      (b) The binary cycle system
2. Geo pressured resources.
3. Petro-thermal systems or Hot dry rock (HDR) resources.
4. Magma resources (Molten-rock-chamber systems).

The hydro-thermal convective systems are best resources for geothermal energy exploitation at present . Hot dry rock is also considered.

1. Hydrothermal Resources

- Hydrothermal resources occur when underground water has access to high temperature porous rocks, capped by a layer of solid impervious rock.
- Thus, water is trapped in the underground reservoir and is heated by surrounding rocks.
- Heat is supplied by magma by upward conduction through solid rocks below the reservoir.
- Thus, it forms a underground boiler. Under high pressure, the temperature can reach as high as 350ºC.
- In order to utilize the hydrothermal energy, wells are drilled into the hydrothermal reservoir as shown in the next slide.

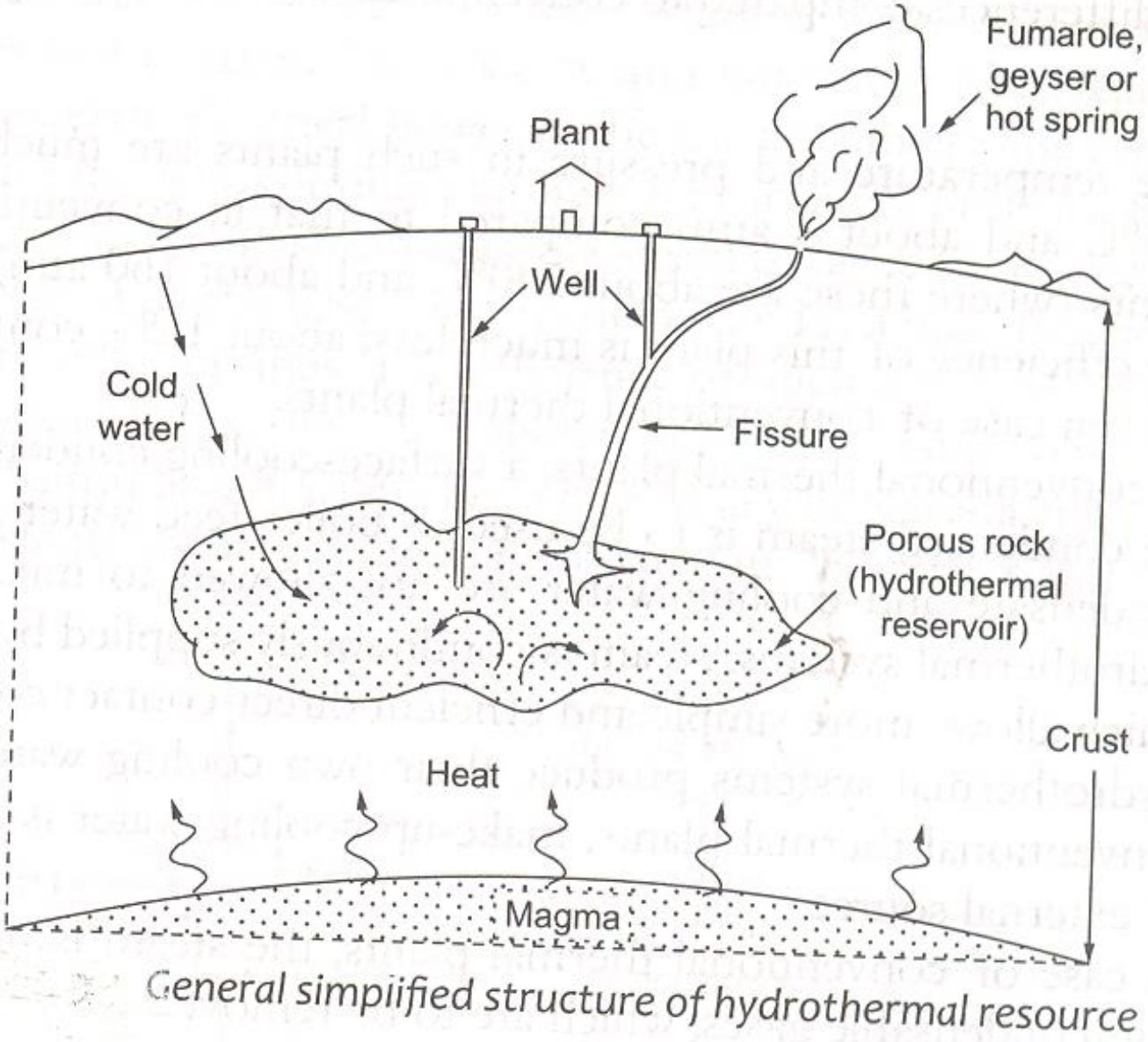


Fig: Hydrothermal Resources

* Magma is the molten or semi-molten natural material from which all igneous rocks are formed. Magma is found beneath the surface of the Earth.

Cont.,

- The hydrothermal resources are located at shallow to moderate depths (from approximately 100 m to 4,500 m).

- Temperatures for hydrothermal reserves range from 90ºC to 350ºC.

- Hydrothermal resources are further subdivided into

(i) vapour dominated (dry steam fields),
(ii) liquid-dominated (wet steam fields), and
(iii) hot water resources.

- Vapour-dominated fields deliver steam with little or no water and liquid-dominated fields produce a mixture of steam and hot water.

(i) Vapour – Dominated (or) Dry Steam Fields

- Dry steam fields occur when the pressure is not much above the atmospheric pressure and the temperature is high.

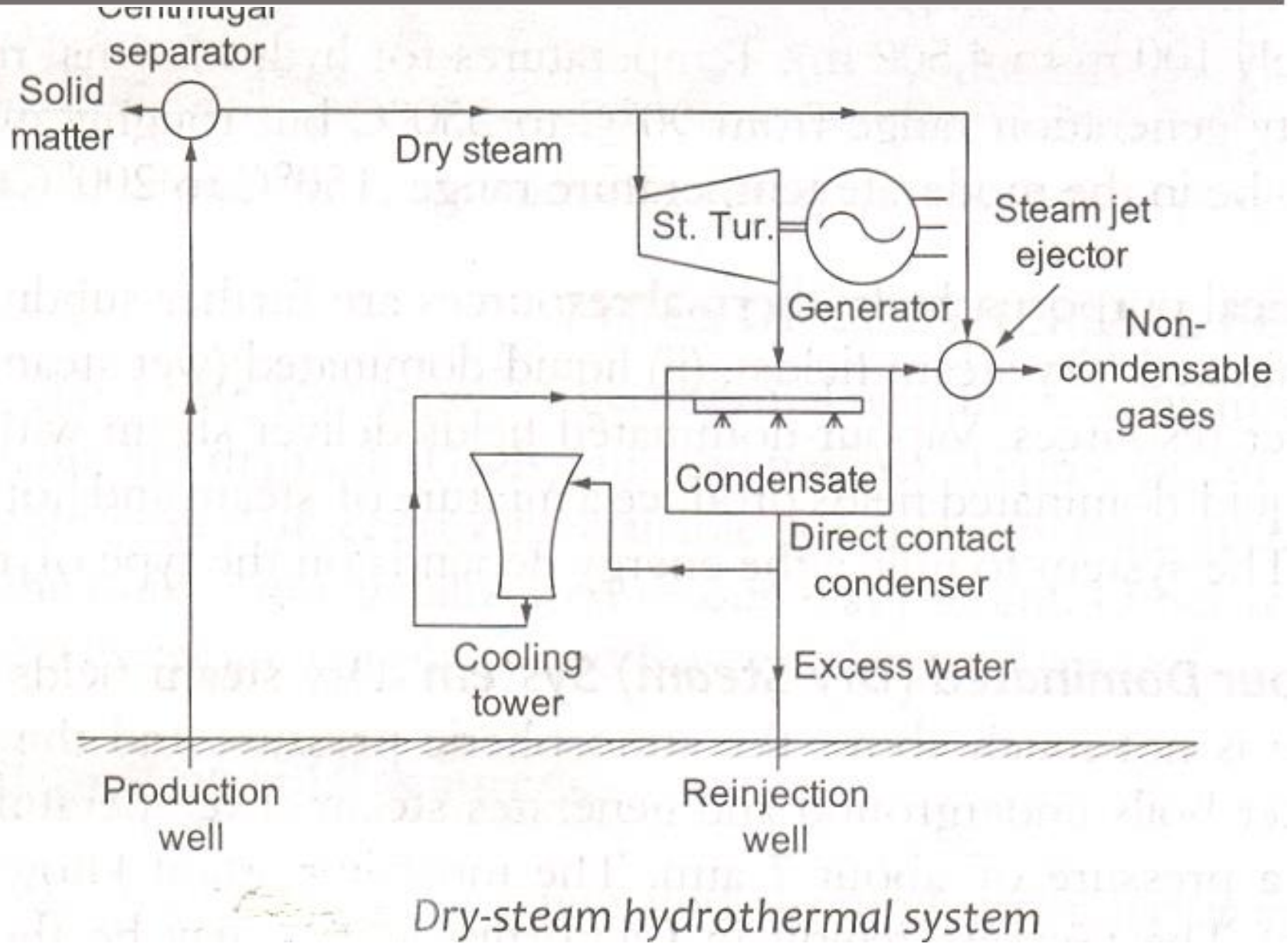
- Water boils underground and generates steam at temperatures of about 165ºC and a pressure of about 7 atmosphere.

- The most important dry steam fields are

(a) The Geysers region in California, which may be the largest,
(b) The Larderello and some smaller areas in Italy, and
(c) Small fields at Matsukawa, Japan.

Geysers

(Centrifugal separator)



Dry-steam hydrothermal system

Cont.,

- Steam is extracted from the well, cleaned in a centrifugal separator to remove solid matter and then piped directly to a turbine.
- The exhaust steam of the turbine is condensed in a direct contact condenser, in which the steam is condensed by direct contact with cooling water.
- The resulting warm water is circulated and cooled in a cooling tower and returned to the condenser.
- The condensation of the steam continuously increases the volume of cooling water. Excess water is re-injected into the ground for disposal.
- The non-condensable gases are removed from the condenser by steam jet ejection.

(ii) Liquid –dominated system or wet steam fields

The flash steam open system (FSOS)

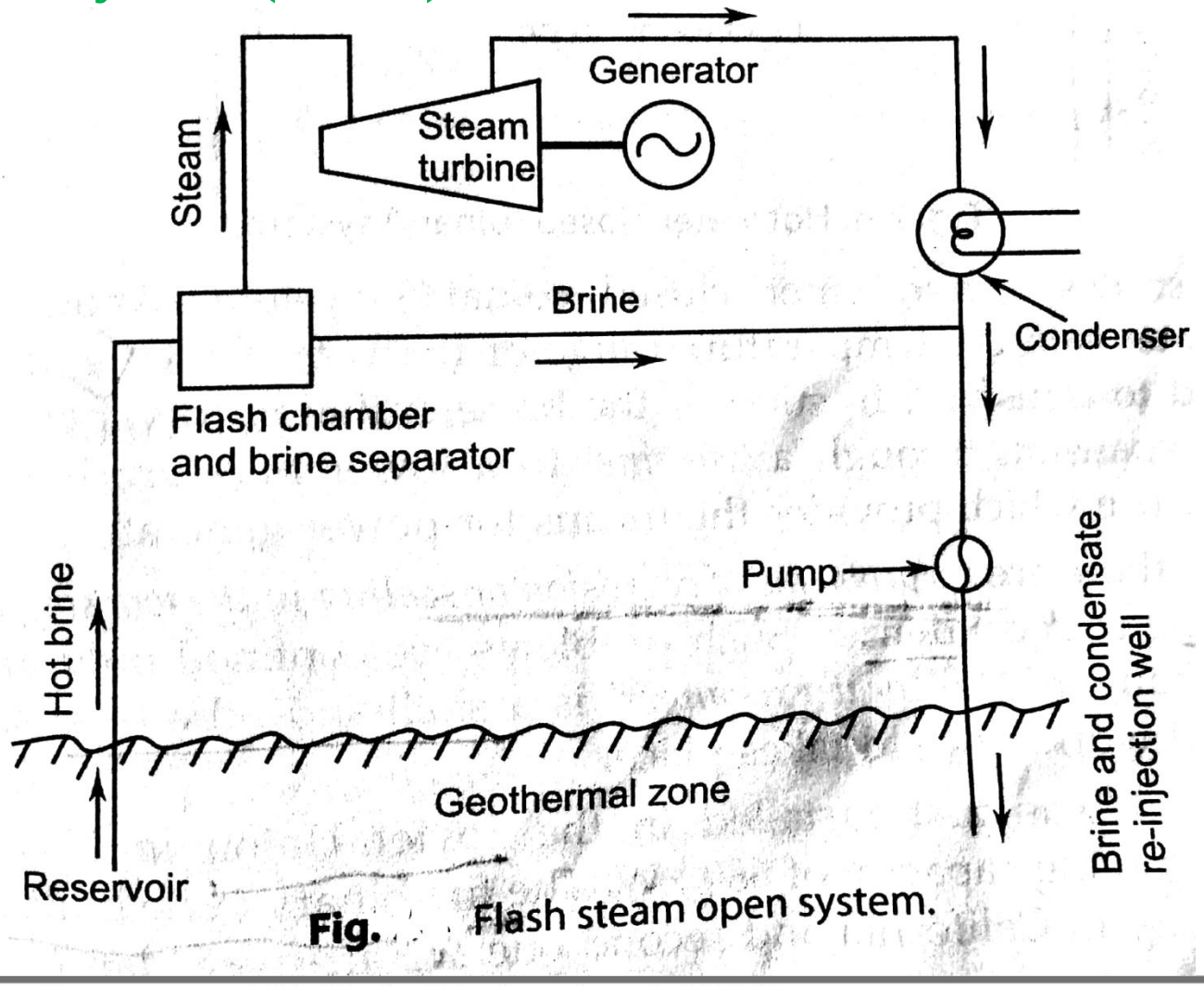


Fig. Flash steam open system.

Cont.,

- Hot brine from the reservoir reaches the well head at lower pressure by throttling process.

- This low quality mixture is then throttled in flash separator which improves the quality of mixture.

- Now steam is separated as a dry saturated steam and supplied to the stem turbine, which produces electricity power through a generator.

- The power generation from such system can be made more economical by associating chemical industry with power plant to make use of brine and gases effluent.

(iii) Hot water resources

The binary cycle system

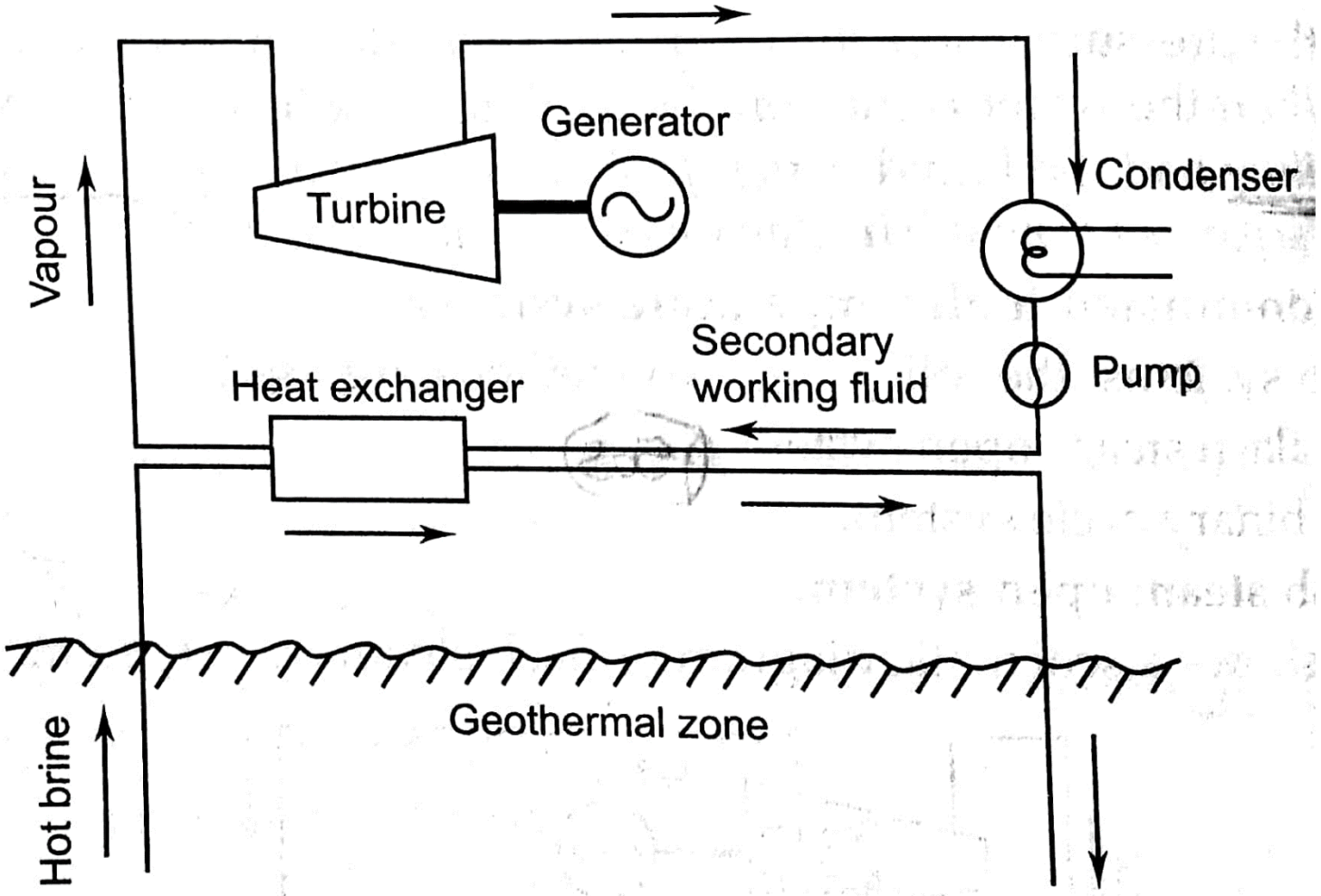


Fig. Hot water closed (binary) system.

Cont.,

- The binary cycle concept isolates the steam turbine from corrosive or non corrosive materials and to accommodate higher concentration of non condensable gases.

- This is basically a Rankine cycle with an organic working fluid.

- In this system is a heat exchanger is used to transfer a fraction of the brine enthalpy to vaporize the secondary working fluid.

- In this system there are no problems of corrosion or scaling in the working cycle components , such as the turbine and condenser.

- The heat exchanger is a shell – and –tube types so that no contact between brine and working fluid takes place.

2. Geo Pressured Resources

- The geo pressured resources contain moderate temperature brines (160˚C) containing dissolved methane.
- These are trapped under high pressure (nearly 1000 bar) in a deep sedimentary formation sealed between impermeable layers or shale and clay at depths of 2 to 10 km.
- At geo pressured, dissolved methane gas is usually 1.9-3.8 meter cube per cubic meter of water.
- Methane gas is separated from brine by simple and economical gravity separation technique and burning of CH_4 also produces energy.

Three sources of energy are available

(i) Thermal
(ii) Mechanical-as pressure
(iii) Chemical-as pressure

3. Petro-thermal systems or Hot dry rock (HDR) Resources

- These systems are composed of hot dry rock(HDR) but no underground water.

- They represent by far the largest geothermal resources available.

- The recovery of heat from HDR involves drilling deep into hot rocks, then cracking it to form cavity or fractures.

- This can be achieved by
  (i)Using high explosives at the bottom of the man-made well
  (ii) Using nuclear explosion
  (iii) By hydraulic fracturing
- The thermal energy of the HDR is extracted by pumping water or fluid through a well at the lower part of the fractured rock and withdrawn by another well at a distance.

4. Magma resources (Molten-rock-chamber systems)

- At some of places, especially in the vicinity of relatively recent volcanic activity, molten or partially molten rock (i.e magma) occur at a moderate depth (less than 5 km).

- The very high temperature above 650°C and the large volume make magma a substantial geothermal resources.

- This resource has not been used yet due to the reason that the existing technology does not allow recovery of heat from these resources (Magma technology requires special manufacturing technology).

ADVANTAGES

(i) It is reliable and cheap source of energy.

(ii) It is available 24 hours per day.

(iii) It is the least polluting as compared to another conventional energy sources.

(iv) It is amenable for multiple uses from a single resource.

(v) Its availability is not dependent on weather.

(vi) It has inherent storage feature and hence no extra storage facility is required.
(vii) Geothermal plants require little land area.
(viii) Feasibility of modular approach represents a lot of opportunities for the development of relatively quick and cost-effective geothermal projects.

DISADVANTAGES

(i) Low overall power production efficiency (about 15 % as compared to 35 % for fossil fuel plants).

(ii) Drilling operation leads to noise pollution.

(iii) Large areas are needed for exploitation of geothermal energy.

(iv) The withdrawal of large amounts of steam or water from a hydro-thermal reservoir may result in surface subsidence or settlement.

APPLICATIONS

- Generation of electric power.
- Space heating for buildings.
- Industrial process heat.
- Crop drying.
- Plastic manufacture.
- Paper manufacture.
- Mushroom culture.
- Timber seasoning.
- Production of salt from sea.
- Sewage heat treatment.
- Greenhouse cultivation using discharge from a geothermal field.

Geothermal Energy in India

- A systematic collaborative, research, development and demonstration progamme has been undertaken with different organizations, viz,
  - IIT Delhi,
  - National Aeronautic Limited Bangalore,
  - Geological Survey of India,
  - National Geophysical Research Institute (NGRI) Hyderabad,
  - Oil and Natural Gas Corporation, etc.

- As a result of various resource assessment studies/surveys, nearly 350 potential hot springs, distributed in seven geothermal provinces, have been identified throughout the country.
- These springs surface temperatures range from 37 to 90ºC.
- Most of them are low-temperature hot water resources and can best be utilized for direct thermal applications.

Geothermal Energy in India continued…

- Only some of them can be considered suitable for electrical power generation.
- The potential for power generation at these sites has been estimated to be around 10,000MW.
- The use of geothermal energy has already been demonstrated in the country for small-scale power generation and thermal applications.
- Small direct heat pilot plants have been installed at Puga and Chumathang (in Ladakh Jammu and Kashmir) and Manikaran (Himachala Pradesh)
- The seven geothermal provinces include
  The Himalayas: Sohana
  West coast: Cambay
  Sonata: Godavari and Mahanadi

THANK YOU

1. Estimates of Geothermal Power ,Geothermal stations in the world
2. Flux on a plane surface, latitude
3. declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle,
4. expressions for the angle between the incident beam and the normal to a plane surface (No derivation) local apparent time
5. apparent motion of sun, day length
6. Solar air collector, Solar distillation,
7. Solar Photovoltaic Systems: Introduction
8. Characteristics and classification, Solar cell:Module,