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An overview on Organic Rankine Cycle (ORC)

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Abstract -*Now a days energy obtain from the non-conventional energy resources is quite easy and less expensive so that we need to convert heat obtain from the resources into mechanical energy. Organic rankine cycle provides systemic and detailed description and the way they are increasingly of interest for cost effective sustainable energy generation. popular applications include cogeneration from biomass and electricity generation from geothermal reservoirs and concentrating solar power installations rankine cycle use water as working fluid but in organic rankine cycle working fluid is organic fluid such as a hydrocarbon having lower boiling temperature. Major application of the organic rankine cycle in geothermal power plants, solar power plants, biomass power plant and waste heat recovery power plants. So that there is an easy transformation of heat into mechanical energy which can be achieve easily.*

Keywords: *Organic, Cogeneration, Hydrocarbon, Heat recovery, adiabatic.*

I. INTRODUCTION

Energy conservation is very important in recent year. The energy extraction from industrial waste heat, solar energy, wind energy, geothermal energy and Biomass energy is more popular now a days. Organic Rankine Cycle is used to convert the heat energy into the electrical energy. The heat source temperature vary from 50 to over 250°C.

1.1.Ordinary Rankine Cycle

Rankine cycle is thermodynamic cycle which convert the heat energy into mechanical work. The heat is supplied externally to a closed loop which usually uses water as the working fluid.

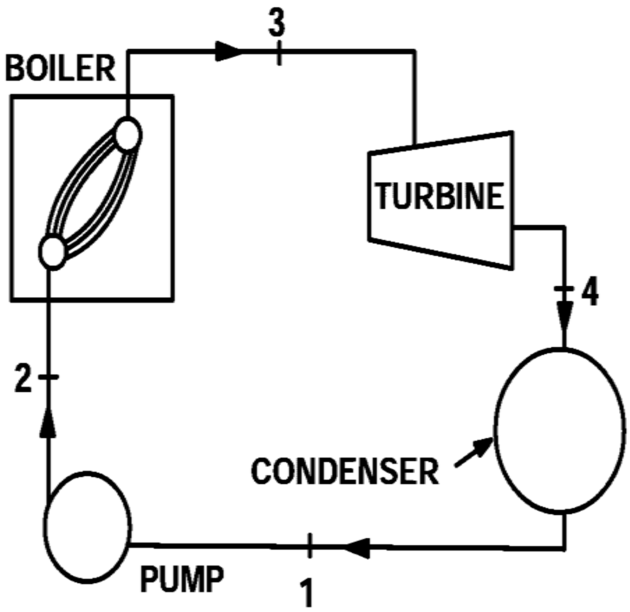

Figure 1. Rankine Vapour power cycle[1]

It consists Boiler, Turbine, Condenser and Pump which used to convert the heat energy into mechanical energy.

1.1.1. Working Processes

- Process 1-2: Water from the condenser at low pressure is pumped into the boiler at high pressure. This process is called reversible adiabatic.

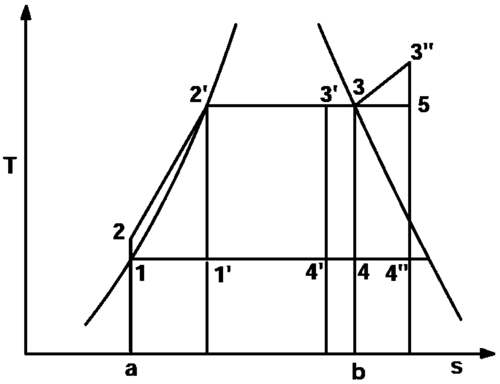

Figure 2.T-S diagram of Rankine cycle [1]

- Process 2-3: Water is converted into steam at constant pressure by theaddition of heat in the boiler.
- Process 3-4: Reversible adiabatic expansion of steam in the steam turbine.
- Process 4-1: Constant pressure heat rejection in the condenser to convert condensate into water.

The steam leaving the boiler may be dry and saturated, wet or superheated. The corresponding T-s diagrams are 1-2-3-4-1, 1-2-3´-4´-1 or 1-2-3″-4″-1. [1]

1.2.Organic Rankine Cycle

The organic Rankine cycle is named for its use of an organic, high molecular mass fluid with a liquid-vapour phase change, or boiling point, occurring at a lower temperature than the water-steam phase change.

1.2.1.Working Processes

- Isobaric evaporation (1-4): Isobaric means that there is no pressure drop in the heat exchanger. The boiler can be divided into three zones: preheating (1-2), evaporation (2-3) and superheated (3-4).
- Isentropic expansion (4-5): An isentropic expansion is adiabatic (the expander does not exchange heat with the environment) and reversible (no friction losses, no pressure drops, no leakage).
- Isobaric condensation (5-6): The heat exchanger can be subdivided into the de-superheating (5-6),the condensation(6-7) and sub-cooling (7-8) zones.
- Isentropic pump (8-1): The pumping cannot be seen on the T-s diagram, since in an isentropic compression on a liquid, $dS=dT=0$.[2]

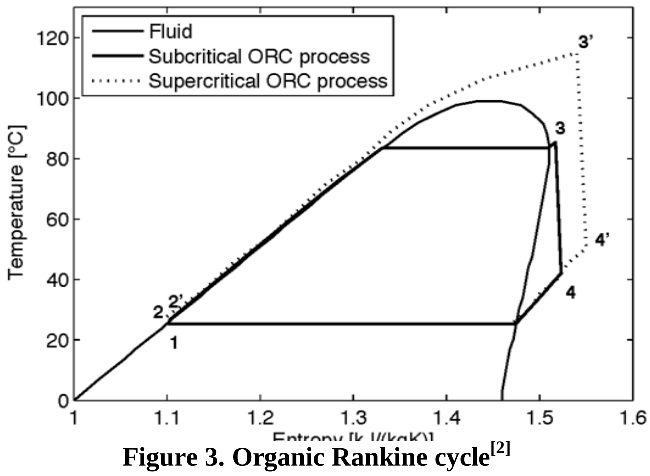

Figure 3. Organic Rankine cycle[2]

II.TYPES OF ORGANIC RANKINE CYCLE

- Subcritical organic rankine cycle: The evaporation and condensation pressure are lower than the critical pressure and evaporation temperature is lower than the critical temperature.
- Trans-critical organic rankine cycle**:**The evaporation pressure is higher than the critical pressure and condensation pressure is lower.
- Supercritical organic rankine cycle**:** The evaporator and condenser pressures are higher than the critical pressure.[3]

III. SELECTION OF WORKING FLUID

Following factors are used to select the working fluid:

1. Thermodynamic properties:

Following properties are considered the Thermodynamic properties:

- Condensing pressure is higher than the atmospheric pressure.
- The working fluid should be thermally and chemically stable.
- Large enthalpy variation in the turbine leads to high net work output.
- High heat capacity of the liquid leads to better energy recovery from the heat source and decrease the mass flow rate of the working fluid.
- Higher convective heat coefficient and high thermal conductivity increases the heat transfer process between the heat source, heat sink and working fluid.[3]

2. Heat transfer properties:

Heat transfer properties are very important parameter. High heat capacity allow better temperature profile and improves efficiencies.Other factor are also affect the heat transfer properties such as material selection, flow rate, piping design, thermal conductivity, specific heat and viscosity.[3].

3. Chemical trends:

- Increasing carbon generally increases the molecular weight and the boiling point.
- Increasing sulphur generally increases toxicity and decreases stability.
- Increasing nitrogen generally makes the compound more reactive. This can be lead to toxicity and instability issues.
- Increasing fluorine attached to carbon increases global warming potential.
- Increasing bromine increases ozone depletion potential.
- Increasing chlorine improves lubricant miscibility and toxicity.[3]

4. Environmental data and Safety data:

Environmental data includes global warming potential and ozone depilation potential. Safety data includes lower flammability level.

5. The effect of normal boiling point on evaporator and condenser pressure:

Figure shows demonstrates the influence of normal boiling point on evaporator and condenser pressure. Higher normal boiling point gives a lower evaporator and condenser pressure at certain temperature. The pressure in both evaporator and condenser temperature to 298K, the evaporator lower than the atmospheric pressure. To increase the pressure in both evaporator and condenser we can increase the temperature. In Organic Rankine cycle due to the very low temperature problems are occur in the cycle. [3]

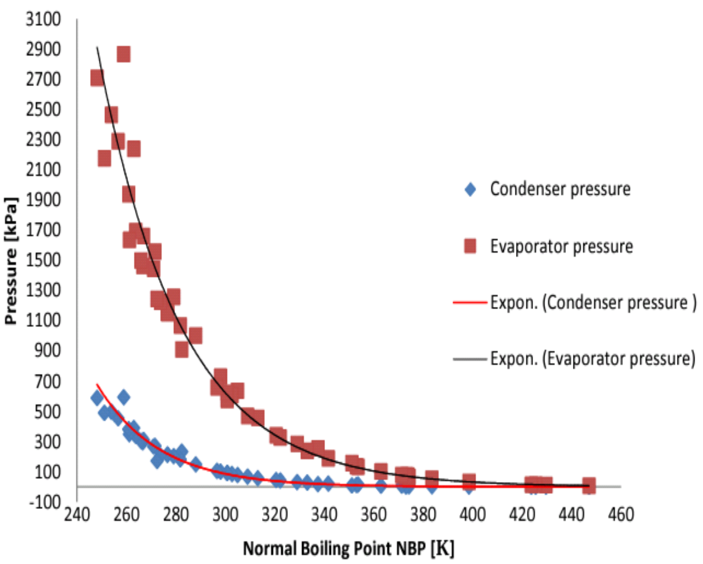

Figure 4. Influence of normal boiling point on evaporator and condenser pressure [3]

IV. APPLICATIONS

- Waste heat recovery:
  In this process the heat is obtain from the waste heat which comes from the many industrial applications. The economics of waste heat recovery don't justify when the temperature of the wasted heat is very low.
- Solar thermal power:
  In this power plant the power is obtain from the parabolic dish and solar tower and many other technologies. Parabolic tower can work at temperature range of 300˚C-400˚C.In this power plant the organic Rankine cycle work atlower temperature range. The cost of the organic rankine cycle is very low compare to the steam cycles.
- Geothermal power plants:
  The geothermal power has the potential to supply renewable electricity to large number of communities. This source of energy is clean and renewable.
  Dry steam power plants, flash steam power plants and binary cycle power plants are three different technologies used to extract power in geothermal power plants.
- Biomass power plants:
  Biomass is easily available, clean and eco-friendly. Biomass fuels exist in many forms wood wastes, Biogas from organic materials such as farm waste or waste water sludge and black liquor which is a by-product of the pulping process.

V. CONCLUSION

Organic rankine cycle is very useful to obtain the power from the various power plants. This cycle is modification of clausius rankine cycle. This technology is suitable for water heat recovery and power production from solar thermal heat and also to production of electricity from biomass and geothermal heat. This cycle has various advantages which can be used in many different application. This process is highly efficient and easy to operate with economical cost of revenue is high.

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