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Efficient Operation for Improving the Performance of Condensers in Thermal Power Plants

*Hong Son Bui, Thanh Hung Bui **

*School of Mechanical Engineering, Hanoi University of Science and Technology, No 1 Đại Cồ Việt, Hai Bà Trưng, Hà Nội, Viet Nam
*Corresponding author. E-mail: son.buihong@hust.edu.vn

A B S T R A C T

In a thermal power plant, the turbine performance increases when the initial parameter (Po, To) of the steam increases or the final parameter (Pk, Tk) of the steam decreases. The temperature of the exhaust steam the turbine is limited by the temperature of the water cooling (circulating water) and is usually about 10 ^{o}C or more higher than the temperature of the cooling water. The cooling water is taken from ponds, lakes, rivers, streams, sea with a temperature of about 18-30 ^{o}C depending on the season and geographical conditions of the plant, meaning that the saturated steam leaving the turbine can only condense at a temperature of about 30^{o}C, corresponding to a pressure at the end of the turbine about 0.05 bar. So that, the research obtained will be contributed to improve the efficient operation of condenser in thermal power plants.

Keywords: Condenser vacuum, steam, turbine, circulating water temperature, energy efficiency.

Introduction

Steam generated from boilers will provide the required heat for processes or be used to spin a turbine's rotor for generating electricity in thermal power plants. After transferring heat in heat exchangers, the exhaust steam from low pressure turbine is condensed into a liquid called condensate (liquid water). One method to improve energy efficiency in a plant is to recover this condensate back to the boiler. When the condensate is recovered, it will reduce the amount of water supplied to the boiler, saving fuel, chemicals and water treatment costs and reducing the amount of wastewater discharged into the environment.

Condenser is also known a important device that have three main types which are described in details in next parts. The saturated steam after the turbine will be condensed into clean water and the clean water will be reused to supply to the boiler system.

In this paper, the condenser will be described in details and discussed to provide solutions for improving the energy efficiency and save a lot of money and protect the environment.

Basic concepts of condensation and condensers

The condenser in the steam turbine thermal diagram plays a very important role in a coal-fired thermal power station (figure 1). It receives the steam coming down from the low pressure turbine to transfer heat from that steam to the circulating water to cool the condenser which is pumped in from the outside environment (usually from a river or the sea).

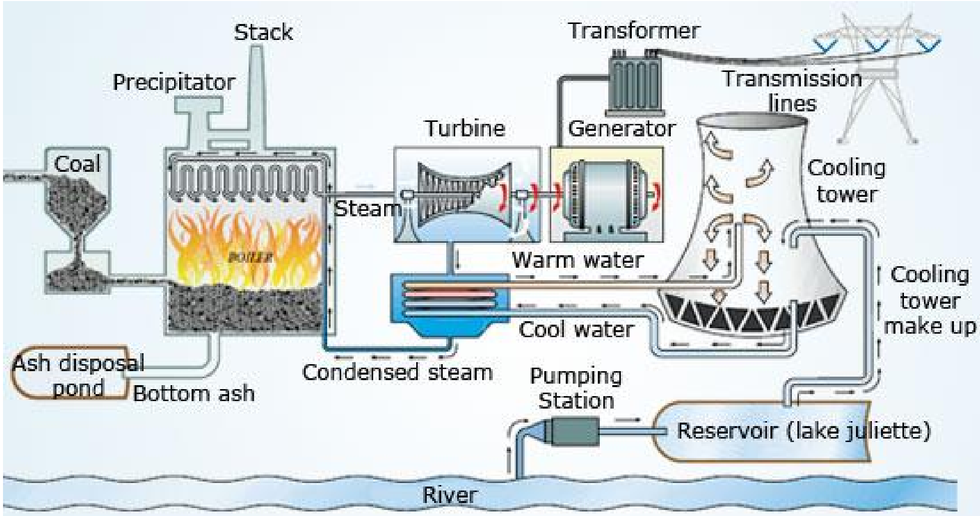

Fig. 1 - A diagram of a coal-fired thermal power station

In the condenser, the saturated steam will release its latent heat of condensation to the cooling water to condense into condensate. The process takes place at a pressure considerably lower than atmospheric pressure and therefre it means a high vacuum. This high vacuum is maintained at a stable value under certain other conditions that are also stable. The pressure in the condenser can be maintained as low as possible in terms of the thermal efficiency of the steam turbine cycle. The strength of the heat exchange in the condenser will determine how low the pressure it can maintain is. This heat transfer process is due to many The decision parameter parameter when the vapor accumulation occurs. One of the main parameter in the practically is the temperature of the circulating water cooling the inlet of the tank (in figure 2).

The operation conditions is ,for the current turbine thermal power plant, satisfied with the actual operation conditions for different information inputs. That impact is leading to any way to adjust the best to the current economic - technical indicators of the unit.

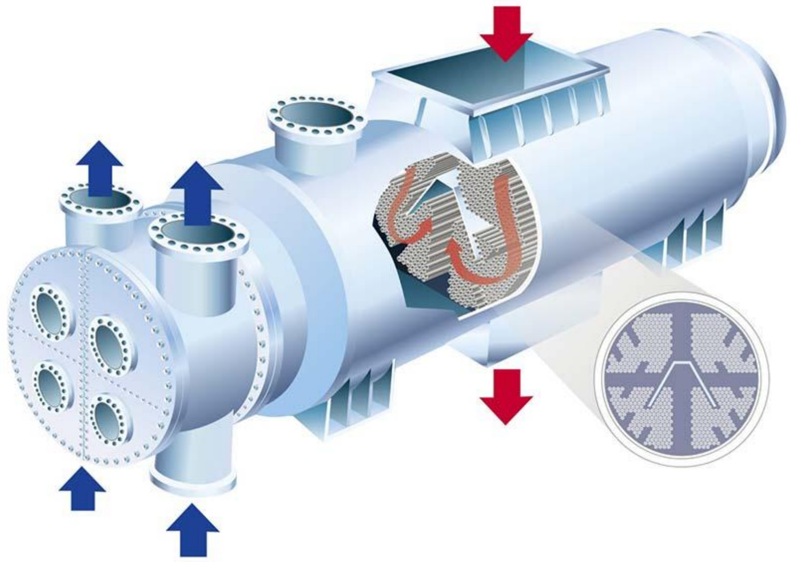

Fig. 2 - Diagram of a condenser

Classification and detailed structure of condenser

During the condensation process, the vapor, after completing the heat exchange task, carrying heat from performing mechanical work in the steam turbine. It will be entering the condenser at high pressure and high temperature conditions. Here, it transfers heat to the cooling water system by using cold water or a air as in figure 3.

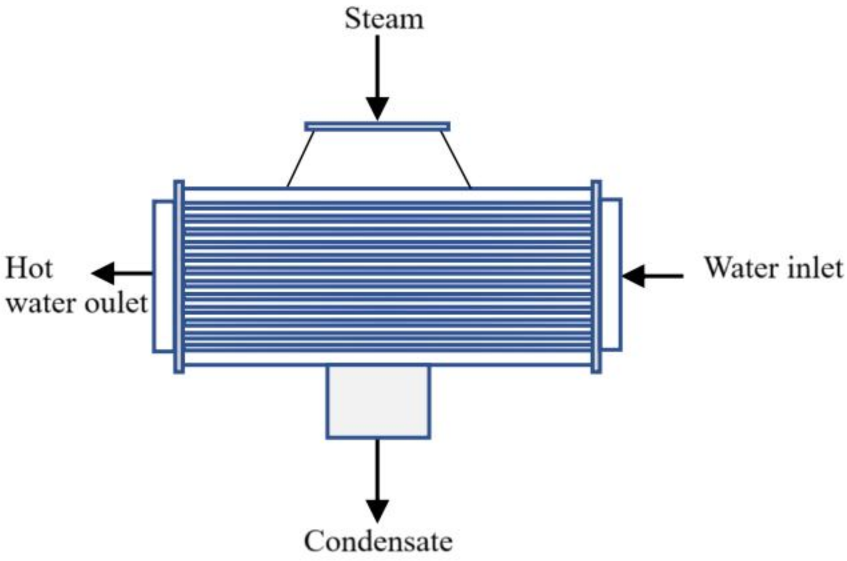

Fig. 3 - Schematic diagram of the condenser

In terms of operating principle, condensers work based on the basic law of thermodynamics: heat always transfer from places with high temperature to places with low temperature. Inside each condenser there are thousands of small heat exchange tubes inside designed to pass through baffles and two flanges at its both ends. In fact, there can be mainly the following types:

1. ***Air-cooled Condenser:*** This type of condenser usually consists of copper or aluminum tubes tightly attached to aluminum or aluminum alloy fins to increase the heat exchange surface area. One or more axial or centrifugal fans are arranged so that forced air flows through the tube array to carry heat away from the environment. Its operating principle is in a high-pressure vapor state enters the tubes, transferring heat to the outside through forced air circulation. The air takes heat from the tube surface and fins, causing the refrigerant to condense into liquid. The entire process only uses the air environment as a heat carrier.
2. ***Evaporative-type Condenser:*** This device combines the characteristics of both water and air cooled condensers. Including: Heat exchange tube; Forced fan; Water spray system on the tube surface; Circulating water tank; Drip shield to prevent water loss to the environment;

In this device, the water is sprayed evenly on the heat exchange tube. When forced air circulation passes through, part of the water will evaporate, carrying heat to the outside. The water evaporation process consumes a large amount of latent heat, effectively cooling the tube. This is a cooling mechanism using both air convection and water evaporation.

3. Water-cooled Condenser: are one of the most popular types of exchanger due to the flexibility the designer and wỏking conditions for a wide range of pressures and temperatures.

Double-tube/Coaxial condenser: *Two copper or steel tubes are inserted into each other in a spiral or straight form. The refrigerant flows in the inner tube, the cooling water flows in the outer tube or vice versa.*

- Advantages: Compact design, easy to manufacture, suitable for small capacity systems.

- Disadvantages: Difficult to clean, limited efficiency due to small heat transfer area.

Plate heat exchanger condenser: *Constructed from corrugated metal plates pressed together to form separate channels for the medium and water to pass through alternately.*

– Advantages: High heat transfer efficiency due to high flow rate and turbulent flow, compact design.

– Disadvantages: Difficult to handle scale, easy to clog if the water is not filtered carefully, less durable than shell & tube.

Operating principle: Cooling water flows continuously through pipes or channels, carrying heat from the condensed medium out. Water is often circulated and cooled again through a cooling tower system.

Shell & Tube condenser: *The type of condenser is a shell and tube. The most common type in industry. The refrigerant passes through the space inside the shell, while the cooling water flows in the heat exchange tubes inside. Baffles are arranged to increase the distance traveled and create turbulence, helping to improve heat transfer efficiency.*

- Advantages: High durability, easy to disassemble and maintain, suitable for large capacity.

- Disadvantages: Large size, need a good water treatment system to avoid scale.

In reality, the shell and tube condenser is common in industry and in the thermal power plant. So we will focus on studying this type of condenser.Shell and tube condenser designs can vary depending on the material used and the shape of the tube. Some tubes are designed to be straight or bent in a U-tube as in the figure 4.

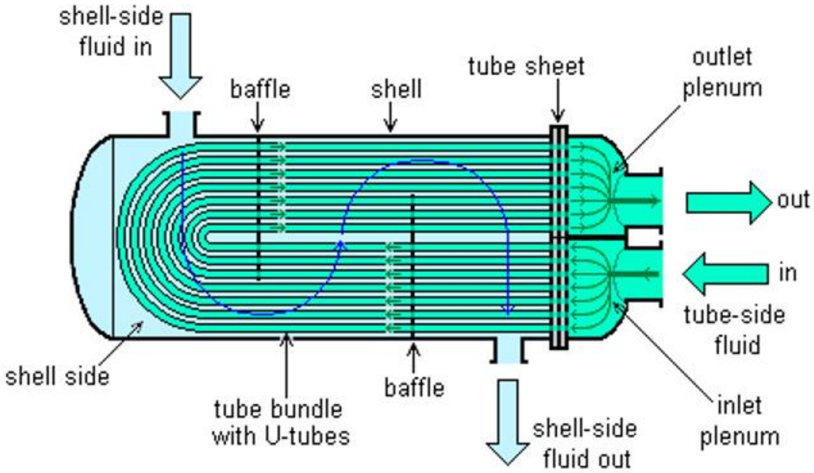

Fig. 4 a- Schematic diagram of U-tube heat exchange

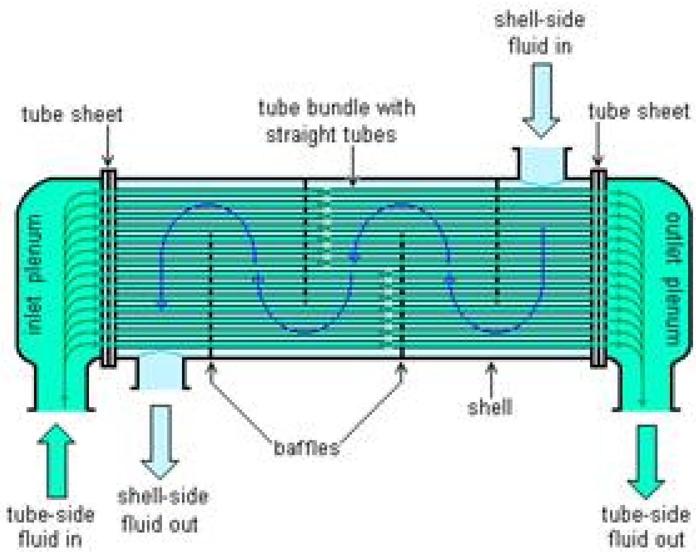

Fig. 4b- Schematic diagram of *straight*-tube heat exchanger (one pass tube side)

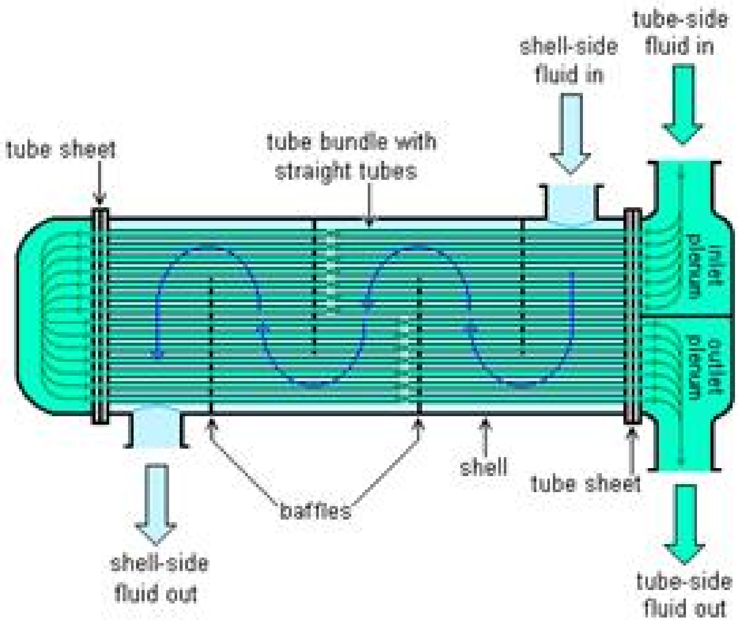

Fig. 4c- Schematic diagram of *straight*-tube heat exchanger (two pass tube side)

Inside each condenser there are thousands of small heat exchange tubes inside designed to pass through baffles and two flanges at both ends. Thermal cycle theory and practical operation in thermal power plants have clearly demonstrated that even a small change in heat transfer conditions in the condenser has a great impact on the overall efficiency of the power generation process with the new steam parameters at the turbine inlet (To, Po). The turbine exhaust pipe is connected to the condenser, the vacuum in the condenser is created by the condensation of steam into water and by special devices such as ejectors or vacuum pumps. These devices will continuously suck air out of the condenser.

The steam goes down and surrounds the outer surface of the copper tube, releasing heat to the cooling water in the copper tube and condensing into water. The water moves from bottom to top in the opposite direction of the steam flow. After releasing heat to the cooling water, the steam is condensed and falls down to the tank at the bottom of the condenser and is pumped away by a condensate pump. In this case, while the cooling water in the copper tube system is called circulating water which is taken from rivers and lakes and supplied by a circulation pump.

Some suggestions to increase the efficiency of condensers in thermal power plants:

- The condenser must be tightly sealed, if not, the outside air will enter for reducing the vacuum, which means increasing the pressure at the end of the turbine and can suddenly reduce the heat transfer capacity on the cooling tube surfaces, reducing the turbine capacity and performance. On the other hand, the copper tubes in the condenser must also be tightly sealed to avoid leakage of circulating water into the condensate, reducing the quality of the condensate.
- To ensure a deep vacuum, people find ways to reduce the resistance of the condenser to the steam and organize the continuous extraction of air from the condenser.

Conclusion

The article presents the research and application of thermal power plant cooling water systems in Vietnam, the development of heat exchange capacity of the heat exchanger must be enhanced by using new materials and then implemented into the practice of the plants in the coming time.

This study includes the consideration of the impact of various factors on the performance of the condenser of a thermal power plant, including cooling water temperature, steam, heat transfer system, condenser designe parameters and heat transfer rate.

This study has highlighted the influence of studying these parameters on the performance of the condenser, emphasizing the importance of considering these factors in the performance of the power plant.

After examining the equipment and heat exchange system, the article has built a results of capacity, heat exchange area, number of equipment and number of heat exchange surface are a very useful basis for manufacturing equipment and heat exchange systems in industrial production and daily life.

The research results play a very important role in the design and manufacture of heat exchange equipment and systems in production and daily life, especially in cases where both hot and cold sources are technological parameters of production processes. This is also a very useful energy saving solution in industrial production and daily life.

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