PERFORMANCE ANALYSIS OF SURFACE CONDENSER IN MINI THERMAL POWER PLANT

Mayank R Pawar[1], Sagar R Chokshi[2], Avesh Khan[3]
[1]Assistant Professor, Mechanical Department, CSPIT, CHARUSAT University, Changa,Gujarat
[2]Assistant Professor, Mechanical Department, CSPIT , CHARUSAT University, Changa,Gujarat
[3]Assistant Professor, Mechanical Department, Parul University ,Vadodara,Gujarat
Email: mayankpawar.me@charusat.ac.in[1], sagarchokshi.me@charusat.ac.in[2],
avesh.mech786@gmail.com[3]

Abstract

The conventional steam power plant working under the rankine cycle and steam condenser as a heat sink and steam boiler as a heat source have the same importance for the power plant operating process. Energy efficiency of any power plant strongly depends on its turbine- condenser system operation mode. Operating the condenser at optimum circulation water flow rate is essentially important to ensure maximum efficiency and minimum operating cost of the plant. To control the condenser variables like cooling water flow rate, condenser pressure, condenser temperature having vital importance on entire plant performance. For the given power plant configuration, cooling water temperature or/and flow rate change generate alterations in the condenser pressure. Those changes have great influence on the energy efficiency of the plant. This paper focuses on the influence of the cooling water temperature and flow rate on the condenser performance..

Index Terms: Cooling water flow rate, Condenser pressure, Steam turbine, Surface condenser.

I. INTRODUCTION

Steam power plant works on the principle of rankine cycle. Carnot cycle is having 100% efficiency and no any other cycle can achieve this efficiency but we can work out or modify current cycles to achieve highest possible efficiency that can be obtained. Carnot cycle has the maximum possible efficiency for the given limits of temperature, it is not suitable in steam power plants.

The steam power plant is one of the most successful systems developed for the conversion of heat energy into mechanical work. It gives 35-38% overall thermal efficiency. Heat energy is released by the combustion of fuel is utilized to vaporize water into steam. The steam thus produced is expanded in steam turbine to obtain useful work or power. The vapour leaving the turbine is normally condensed and pumped back to its initial state constituting a cycle. Thus the working fluid changes from liquid to vapour and back to its original state. This succession of processes is designed as vapour cycle to recognize the state of the working substance during the work output process [1].

Thermal power plants are designed based on required conditions but actually inlet conditions are not as per the designed conditions. In practice, when power plant works, it tends to reduce or increase output power. Due to this condition, designed conditions never achieved. Variations in the power outputs from plant is always matter of disputes. So the parameters for power and heat rate generated for different conditions of condenser pressure, flow rate of water through condenser, temperature difference. This paper deals with the factors and parameters which reduced the efficiency of the condenser and power plant [6].

Basic theory of condenser

Condenser is a heat exchanger wherein steam is condensed either in direct contact with cooling water or indirect contact with cooling water through a heat transfer medium separating them. It creates a low back pressure for the turbine exhaust so as to obtain the maximum possible energy from steam and thus to secure a high efficiency. Even condenser condenses the exhaust steam from the turbine and recover the high quality feed water for reuse in the cycle.

II. LITERATURE REVIEW

Bindu Pillai[5] focuses on various aspects of automation of laboratory based mini-thermal power plant and virtual simulation where automatic plant operation and monitoring is achieved by automatic controllers and indicators placed on the panel displays the status of valves, sensors and actuators used in the automation of the plant. Simulation model provides a good understanding and better visual idea about the real-time performance of lab based mini-thermal power plant, investigates complex operations and displays failure patterns and aids in remote monitoring and control through SCADA.

Milan V. Sanathara[4] focuses on the influence of the cooling water temperature and flow rate on the condenser performance, and thus on the specific heat rate of the coal fired plant and its energy efficiency where reference plant taken is of GSECL-Sikka having capacity of 120 MW situated at Sikka village near Jamnagar district under state of Gujarat, India which is working under turbine-follow mode with an open cycle cooling system. The study revealed that when plant runs at full load, the parameters like condenser pressure, heat rate, fuel consumption and cycle efficiency affected by cooling water flow rate.

Ajeet Singh Sikarwar[3] discusses about thermal power plants which are designed based on required conditions (like a good quality of steam, pressure and temperature of steam etc.), but actually inlet conditions are not as per the designed conditions. In practical situations, there are lots of constraints which tends to reduce or increase output power and heat rate of thermal power plants. Due to these conditions, the designed power and heat rate are never achieved. So the parameters for power and heat rate are generated for different conditions of condenser pressure, flow rate of water through the condenser and temperature difference. This paper deals with the factors or parameters which reduced the efficiency of the condenser.

R K Kapooria[2] in his paper shows a theoretical investigation about thermal analysis and design considerations of a steam condenser has been undertaken where the use of a hybrid steam condenser enables higher efficiency of the steam power plant by lowering condenser steam pressure and increasing the vacuum inside the condenser.

III. EXPERIMENTAL SET UP

The test rig consists of a steam turbine coupled to an alternator both mounted on a suitable base plate. The boiler is oil fired. Steam from the boiler passes through a flow meter and to the turbine. Suitable taps are provided to sample this steam and determine its quality and to measure its pressure and temperature. A main valve is used to control the flow rate from the boiler. The output shaft of the turbine is coupled to the alternator. A panel mounted tachometer is provided to measure the turbine speed. A set of electrical bulbs and water rheostat are used to utilize the electrical power produced by the alternator. Exhaust steam from the turbine is led out to a condenser using the exhaust valves. Separate centrifugal pump is provided to circulate the cooling water through the condenser. An evacuating pump is used to remove the condensate from the condenser. The setup is manually operated with a power generation capacity of 5 KVA, alternator rotating at 3000 rpm producing maximum of 3 kw of which 1 kw is used to illuminate the bulbs and rest is by passed to the rheostat for heating water in the tank. The used steam is passed through the condenser and converted to water. The fuel (diesel) consumption is 40 ltr/hr and the boiler efficiency is 28%.

During the installation the manually operated valves of the existing set up are replaced by the motorized valves. Globe valve is located at the outlet pipe of the boiler. It is actuated only when the temperature of steam reaches 170°C and pressure of steam reaches 5 bar. All other manually operated valves are replaced by automatic ball valves. Electric solenoid actuator is used to actuate valves.

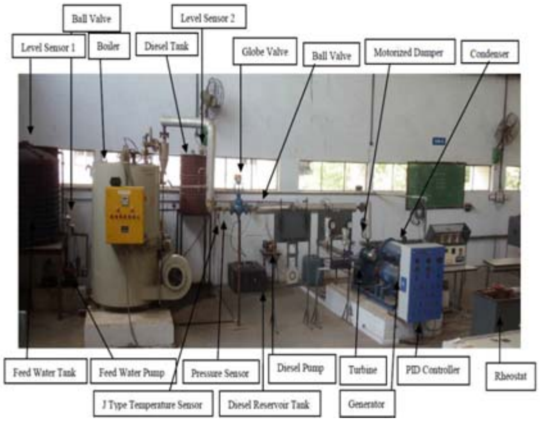

Fig.1 Different components of steam power plant

Surface condenser

In thermal power plants, the primary purpose of a surface condenser is to condense the exhaust steam from a steam turbine to obtain maximum efficiency and also to convert the turbine exhaust steam into pure water so that it may be reused in the steam generator or boiler as boiler feed water.

The steam turbine itself is a device to convert the heat in steam to mechanical power. The difference between the heat of steam per unit mass at the inlet to the turbine and the heat of steam per unit mass at the outlet from the turbine represents the heat which is converted to mechanical power. Therefore, more conversion of heat per kilogram of steam to mechanical power in the turbine, the better is its efficiency. By condensing the exhaust steam of a turbine at a pressure below atmospheric pressure, the steam pressure drop between the inlet and exhaust of the turbine is increased, which increases the amount of heat available for conversion to mechanical power. Most of the heat liberated due to condensation of the exhaust steam is carried away by the cooling medium used by surface condenser

Fig.2 Automation power circuit

Fig.3 Surface Condenser system.

IV. Result and discussion

The carnot cycle is the most efficient cycle for any given source and sink temperature of a heat engine. The efficiency of the carnot cycle can be increased if the higher temperature in the cycle is increased but the upper temperature is limited by constructional material consideration. So it can be increased also by decreasing the lower temperature. The lower temperature is limited by the temperature of cooling water supplied to the condenser. Here, figure 4 shows that as cooling water flow rate is increased, the condensate exit temperature decreases and even cooling water temperature decreases in figure 5 due to increase in cooling water flow rate where cooling water inlet temperature is maintained constant. Reference to the carnot cycle efficiency confirms that the lower value of condensate temperature will result in higher efficiency. It is necessary to keep the temperature of the condenser cooling water below the saturation temperature of the low pressure of steam which is entering the condenser for the condensation of steam.

Figure 6 shows that the increase in cooling water flow rate decreases the condenser pressure and vaccum is obtained inside the condenser by providing higher flow rate of cooling water from the condenser tubes. Lowering the condensing pressure will result in a greater expansion ratio in the turbine meaning that more work will be done in the turbine, leading also to a more efficient power plant. This decrease in the pressure as shown in figure 7 will increase the plant output and efficiency. It is therefore essential to keep the condenser pressure as low as possible.

Figure 8 shows the effects of condenser pressure on the cycle performance. The efficiency decreases with an increase in the condenser pressure parameters. Decreasing the cycle condenser pressure and temperature will result to higher power output, resulting in higher work output of the turbine. Even the turbine outlet enthalpy is a function of condenser pressure. Decreasing the turbine outlet enthalpy causes the turbine output work to increase. Therefore in order to increase the turbine work, condenser pressure should be reduced.

V. Conclusion

In this paper, study on varying the different parameters of the condenser like as condenser pressure, cooling water flow rate, condensate temperature, cooling water exit temperature is done and its effect on net power output of the turbine is measured. Effect of cooling water flow rate changes the cooling water exit temperature, condensate exit temperature. It eventually changes the condenser pressure and condenser pressure is the main parameter for increasing the power output of the turbine. Even by maintaining the vaccum inside the condenser, the efficiency of the plant can be increased as greater the vaccum in the system, greater will be the enthalpy drop of the system. So, more work will be available per kg of steam condensed. Even the non –condensate can be removed from the condensate- steam circuit by maintaining a vaccum in the condenser. So the same condensate can be used as boiler feed water.

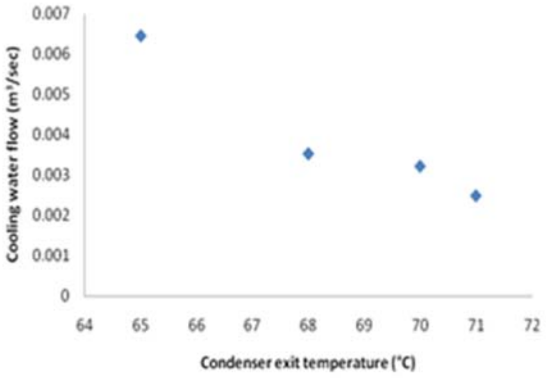

Fig.5 Cooling water flow Vs. Condenser exit temperature

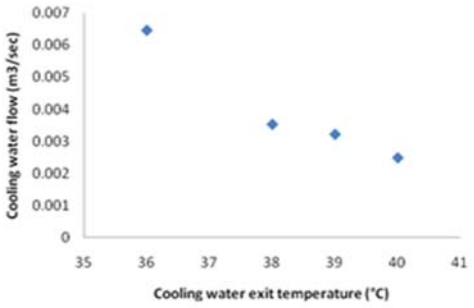

Fig.7 Cooling water exit temperature Vs. Cooling water flow

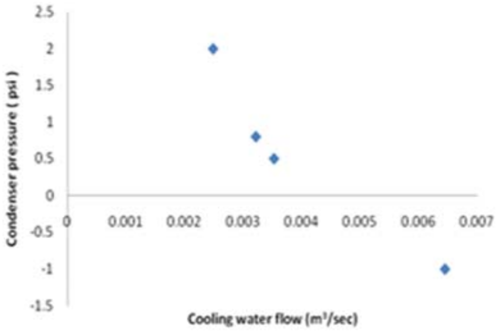

Fig.6Cooling water flow Vs. Condenser pressure

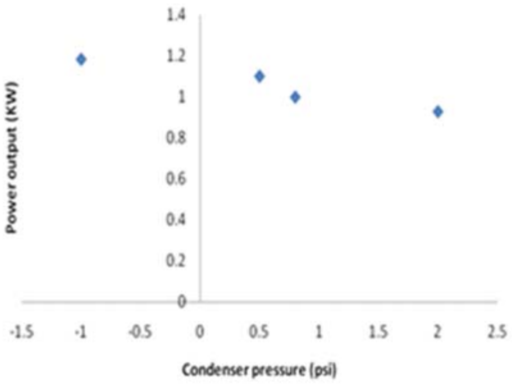

Fig.4 Condenser pressure Vs.Power output

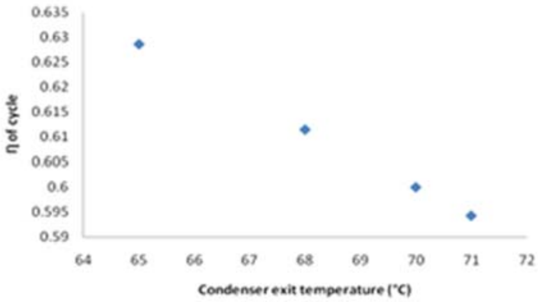

Fig.8 Condenser exit temperature Vs. Cycle efficiency

REFERENCES

[1]Steam and Gas Turbine Plant by R.Yadav, Central Publishing House, New Delhi.

[2]Technological investigations and efficiency analysis of a steam heat exchange condenser: conceptual design of a hybrid steam condenser. R K Kapooria, S Kumar, K S Kasana Journal of Energy in Southern Africa • Vol 19 No 3 • August 2008.

[3]Performance Analysis of Surface Condenser under Various Operating Parameters. Ajeet Singh Sikarwar1, Devendra Dandotiya2, Surendra Kumar Agrawal3. International Journal of Engineering Research and Applications (IJERA) Vol. 3, Issue 4, Jul-Aug 2013, pp. 416-421.

[4]Parametric Analysis Of Surface Condenser For 120 MW Thermal Power Plant. Milan V. Sanathara, Ritesh P. Oza , Rakesh S. Gupta. International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 3, March – 2013.

[5]Automation & Virtual Simulation of Laboratory Based Mini Thermal Power Plant. Bindu Pillai, Dhara Trivedi, Vishal Mehta & Nilim Patel. International Journal of Mechanical and Production Engineering Research and Development (IJMPERD) Vol. 3, Issue 4, Oct 2013, 69-76.

[6]Parametric analysis of surface condenser for thermal power plant. Vikram Haldkar, Abhay kumar Sharma, R.K.Ranjan and V.K.Bajpai. International Journal of thermal technologies, ISSN 2277-4414, Vol.3, No.4 (December 2013).