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A REVIEW ON OPTIMIZATION OF AIR COOLED CONDENSER

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Abstract —*Air Cooled Condenser is generally used in thermal power plant for condensate hot steam which is coming from turbine at low pressure. The main benefit of Air Cooled Condenser is it reduces the water demand and it do not required water for cooling purpose, it can be installed where water is not available. The Air-Cooled Condenser Mainly Consist of primary condenser tubes, secondary condenser tubes, axial fans, steam header pipe, condensate tank and evaporator etc. Reflux condenser is generally known as Dephlegmator or secondary condenser. The Reflux condenser is less effective as compared to primary condenser because it deals with very less amount of steam i.e. 10 to 15% of total steam. The size of Reflux condenser is increases then system become inefficient and unnecessarily area and cost of the system increases hence the main aim of this review paper is to identify different optimization techniques of Air cooled Condenser and to reduce the size of it. The literature survey is carried out to optimized and enhanced design of Air Cooled Condenser to improve efficiency and reliability of system.*

Keywords-*ACC, Reflux condenser, Limitation of Reflux Condenser, Distribution of steam, Optimized Design.*

I. INTRODUCTION

Steam condenser is a device in which the exhaust steam from steam turbine is condensed by means of cooling water. The main purpose of a steam condenser in turbine is to maintain a low back pressure on the exhaust side of the steam turbine. It condensate the steam below atmospheric pressure. In condenser Latent heat is transferred to cooling fluid flowing through cooling tubes. In 1970's Air cooled condenser were introduced in US power industry. For the environmental safety point of view large number of Air Cooled condenser installed in last 10 to 15 years. For low environmental burdon increased interest in Air Cooled Condenser [1].

In today's era increasing efficiency and decreasing energy consumption is the one of the most important point. In cooling group Air cool Condenser is one of the essential component in cooling group. In today's scenario the international and national standard on energy consumption are always increasing [2].

Finned tube bundle may be sloped at 60° in large Air Cooled Condenser with horizontal in order to reduced land area. Due to this arrangement pressure drop in air side is higher (Figure 1).In Air Cooled finned tube condenser turbine exhaust steam is piped. Steam exhaust pipe has larger diameter and must be minimum pressure losses. Axial flow fans creates cooling air flow on finned tube bundles (Figure 2). In 1970, a 160 MWe plant was commissioned in Spain [3].

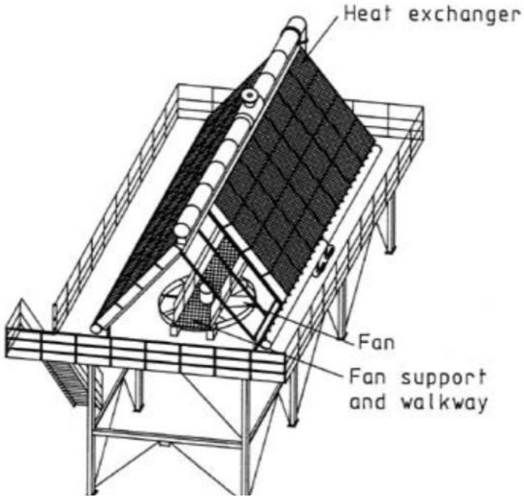

Figure 1: Air Cooled Condensers [3]

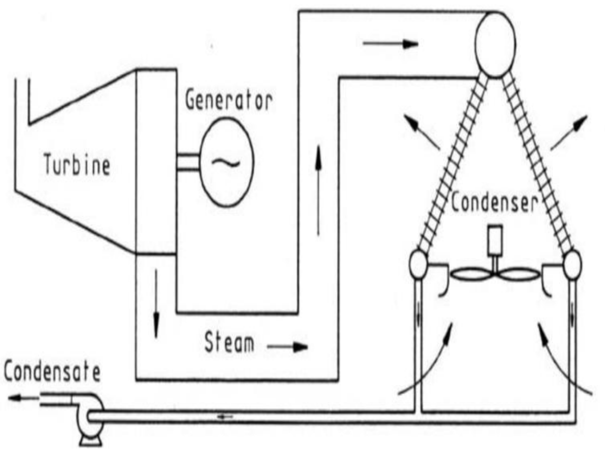

Figure 2: Working of Air Cooled Condensers [3]

II. OBJECTIVE OF LITERATURE REVIEW

The purpose of optimization is to achieve the "best" design relative to a set of prioritized criteria or constraints. These include maximizing factors such as productivity, strength, reliability, longevity, efficiency, and utilization. For increment efficiency of power plant can be obtain by using higher efficient component at low input.
Hence main objective of literature review is to optimize the performance of Reflux condenser and make plant more efficient.

III. LITERATURE REVIEW

Under the literature survey, various types research paper regarding to optimization of Reflux condenser are discussed. The detailed literature of paper is presented below.

1. Dong H. Lee, Jin M. Jung, Jong H. Ha, Young I. Cho (2011), "improvement of heat transfer with perforated circular holes in finned tubes of air-cooled heat exchanger", International Communications in Heat and Mass Transfer 39 (2012) 161-166.
This paper investigated impact of perforated circular finned tubes on air side heat transfer performance. For of perforated circular finned tubes results shows that Convective heat transfer coefficient on air side is increased by 3.55% for two hole and 3.31 % for four hole as compared to circular fin tubes. Pressure drop across the tube bundle increases 0.68% for two hole and 2.08% for four hole as compared to circular fin tube. Fin factor for two hole case was 5.19 and fin factor for four hole case was 1.59 .It shows that two hole shows better performance.

2. L.vZ smit and D.G. Kroger (2001), "Flow distribution, pressure drop, flooding and entrainment in an air cooled reflux steam condenser" ,R & D Journal ,2001, 17(3).
In this paper, discussion regarding inlet manifold of dephlegmator (Reflux Condenser) and its effect on performance on Air Cooled Condenser is done. Generally in many Air Cooled Condensers the D-type inlet manifold is used for dephlegmator inlet but it significantly reduced the performance of system. So by using Box-type inlet manifold at the inlet of dephlegmator the overall performance of Air cooled Condenser is increases.

3. John Lawrence, Berg, George Edward Kluppel, Wilson Joseph Oberjohn, Thomas Wayne Strock, "Steam Condensing Module with Integral, Stacked Vent Condenser", United State Patent, Patent number 5653281.
In this patent, impact of integral, stacked vent condenser is discussed. In this invention larger diameter dephlegmator tubes are used. The main objectives of this invention is to reduce the maintenance cost, eliminate accumulation of non-condensable gases, eliminate freezing problem in condenser by stacking vent condenser over main condenser, Locate vent condenser in region such way that where heated air temperature must have above freezing temperature, to prevent accumulation of non-condensable gases inside the dephlegmator, increase inlet design configuration of dephlegmator (Reflux condenser).

4. Xang Cao, Jinfeng Zhao, Xiqing Duan and Yan Jiang (2017), "Optimization of flow in steam pipe and tube bundles in air cooled condenser" in 2nd International conference on Artificial Intelligence and Engineering Applications.
In this paper, an optimized Air-Cooled condenser velocity field of traditional and optimized Air-Cooled condenser tube bundle is optimized and get conclusions is that velocity distribution and uniformity of velocity distribution for traditional water vapor pipe is bad as compared to optimized water vapor pipe. Uniformity of velocity distribution is found better in optimized water vapor pipe. Due to uniform pipe structure in Air Cooled Condenser water vapour capacity increases.

5. Seo Young Kim, Jin Wook Paek, and Byung Ha Kang (2003), "Thermal Performance of Aluminium Foam Heat Sinks by Force Air Cooling", IEEE Transactions on component and Packing Technology Vol 26, No 1.
In this paper, Aluminum foam force cooling technology is used for electronic cooling. Different readings taken for finding heat transfer characteristics by varying pores per inch (PPI) of Aluminium foam: 10, 20, 40 and varying Reynold's number from 2900 > Re >710. It is found that thermal resistance gets reduced and thermal performance of the system is increased by 28%. So, we can use similar Aluminium foam structure for improving thermal performance of Air Cooled Condenser.

6. Werner Honing (2009), " Steam flow distribution in Air Cooled condenser for power Plant Application" Department of Mechanical Engineering, Stellenbosch University.

This paper is related to steam flow distribution in Air Cooled Condenser, for single row condenser result shows that shorter dephlegmator length is required as compared to two row condensers. For wind case forth condenser reject more amount of heat and for night time more amount of heat is rejected in first condenser fan unit. Due to which between the headers pressure get changed.

7. Raimund Witte (2011), "Air Cooled Condenser System and Method for Setting up Such a Condenser Plant", United State Patent Application Publication, Publication number US 2011/0308764 A1.

This patent application is related to excavation and it reduce the wind load on Air Cooled Condenser. Wind speeds at ground level lower than at a particular height and due to excavation, wind wall along the periphery can be lighter weight and small height.

8. Charles Kutcher and Eric Kozubal (2004), "An Analytical Model for Evaluating Enhanced Fin Concept for Air Cooled Condenser", Geothermal Resources Council Transactions, Vol.28.

In this paper, author is discussed is that by using enhanced fin condenser temperature get reduced. The model allows to determine impact of fin spacing, number of tube rows for enhanced concept and fin spacing. By applying for enhancement concept, it showed that there is 1.8 ºC reduction in condenser temperature and net output of power plant increase approximately 4%.

9. Raf de Lausnay (2017), "Turbine Exhaust Duct Design for Air Cooled Condenser", United State Patents, Patent Number -US9850782B2.

In this paper, author invented new steam duct design. Conventionally T-piece duct designed used but it having some disadvantages, after changing T-piece design into inline V turbine exhaust duct and double turbine exhaust duct substantially steam side pressure drop get reduces and it minimizes sub-cooling in the steam cycle, thus overall efficiency of plant get improved.

10. Najla El Gharbi, Abdel hamid Kheiri, Momammed El Ganaoui, Ryan Blanchard, "Numerical optimization of heat exchangers with circular and non-circular shapes", Case Studies in Thermal Engineering 6 (2015)194–203.

The main aim of this work was to know fluid flow and heat transfer for different arrangement tube bundle such as ellipsoidal, wing and circular shaped. Study carried out for longitudinal section of cross flow for various shapes. The internal diameter of tube is 21.7 mm with uniformed spaced and centres separated by distance 21.7mm. It observed that pressure decreases with increasing Reynold's number. Further observed that circular tubes having more pressure loss as compared to wing and elliptical shaped tubes, because wake region is smaller in non-circular tubes.

11. Juan Wen, Dawei Tang, Zhicheng Wang, Jing Zhang, Yanjun Li, "Large eddy simulation of flow and heat transfer of the flat finned tube in direct air-cooled condensers", Applied Thermal Engineering 61 (2013) 75-85.

Flat tube heat exchanger having higher heat transfer coefficient and lower pressure drop at air side as compared to circular tube heat exchanger. Wake up region is larger for circular tubes heat exchanger as compared to flat tube heat exchanger, so vibration and noise level is less for flat tube. In this paper Large Eddy Simulation (LES) model for flat finned tube is based on 3D calculations. When flow moves then various unsteady effect like vortex shedding, shear layer instability and separation induced around flat tubes. So conclusion of paper result is 3D Large Eddy Simulation (LES) method gives better result for Air Cooled Condenser designing.

12. Ankur Kumar, Jyeshtharaj B. Joshi, Arun K. Nayak, Pallippattu K. Vijayan, "3D CFD simulations of air cooled condenser-III: Thermal–hydraulic characteristics and design optimization under forced convection conditions", International Journal of Heat and Mass Transfer 93 (2016) 1227–1247.

This paper is related to the variation of fin parameter and its impact on fin efficiency. Observations showed that if in fin spacing increases then heat transfer coefficient also increases but pressure drop decreases about 60% to 80%. Result showed that for fin spacing (2 mm) heat transfer coefficient is minimum for all fin heights. It conclude that pressure drop get decrease and heat transfer coefficient get increased by increasing fin spacing for different fin diameters. While designing Air Cooled Condenser fin spacing should be larger. By increase in fin height the efficiency of fin get decreases, the main reason behind is that if fin height get increased then heat transfer due to conduction get decreases which lowers the average fin temperature. Hence it conclude that optimal parameters for fin spacing are fin height to be 5mm and 3mm to 5mm for better performance of Air Cooled Condenser.

13. Lijun Yang, Hui Tan, Xiaoze Du, Yongping Yang, "Thermal- flow characteristics of the new wave-finned flat tube bundles in air-cooled condensers", International Journal of Thermal Sciences 53 (2012) 166-174.
This paper is related to new wave finned flat tube which rotated perpendicular to avoid fouling problem. For orthogonal and oblique tubes heat flow rate and pressure drop compared and result shows that oblique finned tube having lower heat transfer rate than orthogonal finned tube. To increase pressure drop orthogonal finned tube almost twice that of oblique cut finned tube. Friction factor increases with decrease in fin pitch at lower Reynold's number because due to fin pitch broadens equivalent hydraulic diameter increases. Relation of friction factor and hydraulic diameter is inversely proportional. By increase in fin pitch Nusselt number significantly increased. For high Reynold's number friction factor remains unchanged with increasing fin height. By increase in Fin pitch Nusselt number also increases.

IV. CONCLUSION

For the economical point of view optimized design is always advantageous for any industry or any plant. From all literature reviews from this paper we can conclude that-

1. Performance of system is increases by using perforated circular holes in finned tubes
2. Using Box-type inlet manifold at the inlet of dephlegmator the overall performance of Air cooled Condenser is increases.
3. Using larger diameter of reflux condenser tubes (dephlegmator) and oblique cut inlet the performance of Air cooled Condenser get improved.
4. Due to uniform pipe structure in Air Cooled Condenser water vapour capacity increases and steam flow velocity become uniform.
5. After using Aluminum foam structure, the thermal performance of system is increased by 28%.
6. Single row Air Cooled Condenser required shorter dephlegmator length as compared to two row Air Cooled Condenser.
7. Excavation reduces the wind load on Air Cooled Condenser.
8. By using enhanced fin condenser temperature get reduced.
9. V turbine exhaust duct and double turbine exhaust improves the overall performance of plant.
10. Circular tubes having more pressure loss as compared to wing and elliptical shaped tubes, because wake region is smaller in non-circular tubes.
11. 3D Large Eddy Simulation (LES) method gives better result for Air Cooled Condenser designing.
12. Optimal parameters for fin spacing are fin height to be 5mm and 3mm to 5mm for better performance of Air Cooled Condenser.
13. For orthogonal and oblique tubes heat flow rate and pressure drop compared and result shows that oblique finned tube having lower heat transfer rate than orthogonal finned tube.

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