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A REVIEW ON OPTIMIZATION OF AIR COOLED CONDENSER SUPERSTRUCTURE

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Abstract —*An air cooled condenser is the setup of machinery and motors which are used in the thermal power plant to condensate hot steam coming out from a turbine. It is an approach to reduce the cooling water demand using direct dry cooling phenomena which require no consumptive water and also reduces a power plant water demand by up to 90%. The ACC support structure consists of wind wall at the top, truss frames, columns, and bottom raft respectively. A typical ACC support structure can be of any height depending upon wind conditions and topographic conditions, which is subjected to concentrated load so generally, it acts like an inverse pendulum. Due to the high sensitivity of this type of structures towards lateral & dynamic loads, it requires meticulous engineering analysis and deliberate sectional design which is optimized too. The aim of this paper is to get an exposure regarding optimized design and various analysis for the support structure. The literature survey is carried out to review various criteria and benchmarks which are needed to be considered to get enhanced and optimized design of ACC support structure to improve its safety and reliability.*

Keywords-*ACC support structure, Earthquake Analysis, Optimized Design, Pylon Design, Wind Analysis*

I. INTRODUCTION

A thermal power plant consists of various components and systems which include

i. Boiler
ii. Prime mover
iii. Condenser
iv. Draught system
v. Pumping system etc.

In thermal power plant water is heated, turns into steam and carried to a steam turbine which spins the turbine and it drives an electrical generator. After passing through the turbine, the condensation process of steam takes place which can be done using wet cooling condensation or dry cooling condensation and recycled to where it was heated. This is known as Rankine cycle.

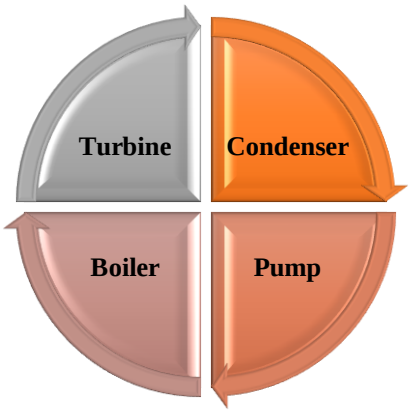

Figure 1. Rankine Cycle

Air cooled condensers (Dry cooling) are the machinery setups placed at a deck type support structure which is built to greater heights provided with long columns. The primary function of ACC is to condensate the steam (low pressure) coming out from a turbine and recycled back to where it was heated at sub-atmospheric pressure. The ACC does not require cooling water as in the case of a water-cooled condenser, so it reduces the burden of having power plant near a cooling water source and also helps in an easy installation at any place. From water scarcity point of view in the power industry, use of Air cooled condenser plays a major prime role to get better efficiency from any individual plant. The direct dry cooling option condenses turbine exhaust steam inside finned tubes, which are externally cooled by ambient air instead of the sea or river water as in once through water-cooled plants.

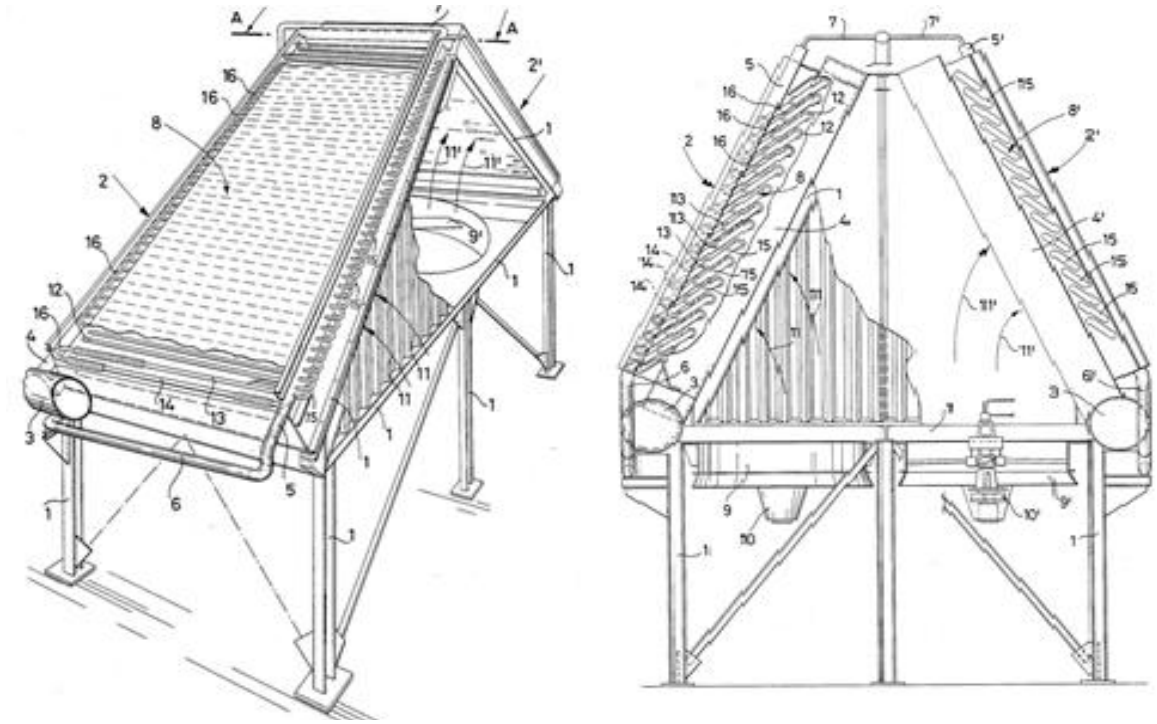

Figure 2. Air-Cooled Condensers (Taken from US Patent-4513813)

II. OBJECTIVE OF LITERATURE REVIEW

Generally, Optimization includes the action of making the best or most effective use of a situation or resource. As the efficiency of thermal power plant lies between 33% to 48%. The increment in efficiency can also be obtained by changing components of the power plant or using same components in a most effective way such that it gives higher output results in an exchange of low inputs.

Hence the main objective of this literature survey is to determine the factors which are responsible for an efficient performance of thermal power station inclusive of optimization application to the components and their designs. Also to get a detailed knowledge and information about air-cooled condensers and its support structure which is required to step ahead in the process of optimization.

III. LITERATURE REVIEW

Under the literature survey, the research paper regarding thermal power station, air cooled condensers, stack like support structure, and also cooling tower (to get exposure about efficiency as compared to ACC) are contemplated.The detailed descriptions of literature paper are presented below.

Hongfang Gu, Zhang Zhe, Haijun Wang, Chen Qi(2015) "A numerical study on the effect of roof windbreak structures in an air-cooled system" Applied Thermal Engineering (Science Direct),
In this paper, the discussion regarding the effect of ambient wind velocity on the heat transfer performance in a direct air-cooled condenser (DACC) is done. Also used Computational Fluid Dynamics (CFD) to numerically simulate and analyzed the effect of roof windbreak system on the DACC in 2×350 MW power station. The results which included vertical length L_1 = 30m, inclined length L_2 = 5m, and inclination angle α = 60 shows the optimal performance of the Direct air cooled condenser.

Xuelei Zhang, Haiping Chen (2015) "Effects of windbreak mesh on thermo-flow characteristics of air-cooled steam condenser under windy conditions" Applied Thermal Engineering (Science Direct),
In this paper, the author considered a windbreak mesh to improve air cooled steam condenser (ACSC) performance under windy conditions. The wind tunnel test is also applied to determine the windbreak mesh loss coefficient. The effects of windbreak mesh are numerically investigated. The author concluded that the windbreak mesh in rectangle-type configuration shows the best performance.

ShuyangCao, JinWang, JinxinCao, LinZhao, XuChen, (2015) "Experimental study of wind pressures acting on a cooling tower exposed to stationary tornado-like vortices" Journal of Wind Engineering and Industrial Aerodynamics (Science Direct)

In this paper, a physical study is carried out for wind pressure acting on a cooling tower exposed to stationary tornado-like vortices. Particular attention is devoted to the differences of pressure distribution and cross-correlation coefficients of pressures in a tornado with that in a conventional boundary-layer-type straight-line wind. The results show that cooling tower exposed to a tornado experiences combined effects of pressure drop accompanying a tornado and aerodynamic flow-structure interaction. Also suggested that tornado-induced wind pressure is significantly different than that in conventional straight line winds, and highlighted the need to study tornado-induced wind loads on structures.

Weifeng He, Dong Han, Chen Yue, Wenhao Pu, Yiping Dai (2015) "Mechanism of the air temperature rise at the forced draught fan inlets in an air-cooled steam condenser" Applied Thermal Engineering (Science Direct)
In this paper, the author investigated the air temperature distribution at the fan inlets. Mechanisms resulting in air temperature rise are discovered and generalized recirculation rate is defined to scale the extent of the temperature rise. This paper resulted that the average temperature rise, as well as the generalized recirculation rate at the inlets of the axial fans, grows with the increase of the wind angle at the wind speed of Vm = 2 m/s, while the corresponding peak value arises at the wind angle of $\beta = 135°$ for other wind speed conditions.

Parag Mishra, Manoj Arya. (2015) "A Review of Literature on Air Cooled Steam Condenser (A Heat Exchanger used in Thermal Power Plants)" International Journal of Research in Aeronautical and Mechanical Engineering,
In this paper, the author has discussed basics mode of condensers like Water cooled condensers, Air cooled condensers. The main focus is made on the Air cooled heat exchanger's consumption of auxiliary power. The conclusion of the literature review shows that power savings can be obtained in Air cooled heat exchangers by proper working of fan, pumps, motor, etc.

Parth R. Chhaya, Nizam M. Mistry, Anuj K. Chandiwala(2014) "A Review on Effect of Wind Loading on Natural Draught Hyperbolic Cooling Tower" International Journal of Advance Engineering and Research Development,
In this paper, the author performed the detailed study of two cooling towers of 200m high above ground level with an application of various load effects using software "STAAD-Pro". The conclusion presented that ultimate load bearing capacity of the cooling tower shell under consideration is obtained as 1.925 times that of the design wind pressure that corresponds to the wind velocity of 40.2 m/s (90 mph). The nonlinear behavior is commenced by the formation of horizontal tension cracks in the windward meridian at the 43% height of the cooling tower shell. Free vibration analysis technique may be used in a seismic analysis. The stress state in the cooling tower takes the full range from the tension to the compression domain. With the increase in height, wind vibration coefficients first increase, then decrease, and reach their maximum at the top section.

Devesh Kumar Garg, Dr. Rohit Rajvaidya (2014) "Air Flow Characteristics of an Air Cooled Condenser used in Thermal Power Plant" International Journal of Engineering Inventions,
In this paper, the effect of wind speed on a 5×5 fan air cooled condensers under windy conditions are investigated using computational fluid dynamics. The authors found that the effect of wind speed is varying for different fan deck heights of the air cooled condensers. And also recommended that the wind effect analysis is necessary and helpful in mitigating the adverse effect of winds on thermal power plants.

Madhuraj Naik, S. N. Tande (2016) "Analysis and Design of Steam Turbine Generator Building with R.C.C. Deck" International Journal of Innovative Research in Science, Engineering and Technology,
In this paper, the author presented the detailed procedure for the finite element modeling, static and dynamic analysis of the foundation structure. STAAD.Pro software is used to demonstrate the analysis procedure and design is carried out using Excel spreadsheets as per IS 2974 Part-III (1992).

Harikrishna .T, Penchal Reddy .M, Baskar .K (2012) "Static and Dynamic Analysis of Boiler Supporting Structure Designed Using Concrete Filled Square Steel Tubular Columns and Comparison with Structural Steel Columns" International Journal of Science and Research,
In this paper, the author discussed in view of optimizing the structural steel usage and to develop an efficient structural system, a theoretical attempt is made through the design of such structure using concrete filled square steel tubular (CFST) column. Also done modeling using structural analysis program and analyzed for various conditions such as different seismic zones, wind zones, different load combinations and various section sizes. The comparison between CFST columns and plus-I columns is also done in which CFST columns is more preferred in results.

Manish Baweja, Dr. V.N Bartaria (2013) "A Review on Performance Analysis of Air-Cooled Condenser under Various Atmospheric Conditions" International Journal of Modern Engineering Research,
In this paper, the authors concluded that the performances of air cooled condenser decrease with increase in ambient temperatures and high wind conditions. To reduce the effect of wind, wind-walls are used which helps in increasing fan speed. Changing the shading of ACC, Shape of finned tubes from circular to flat and adjusting their inclination also helps to increase heat transfer rate and reduce the high ambient temperature due to solar radiation.

IV. CONCLUSION

An optimized design with satisfactory project requirements is always advantageous from the economical point of view for any plant or any industry. From all the literature reviews shown in this paper, we obtained following conclusion i.e.

1. The height of fan deck is one of the most important factors that need to be selected with respect to wind conditions in order to have the maximum air cooled condenser efficiency.
2. The increment in fan deck height is not always favorable.
3. The earthquake analysis shows effective results which prove its importance to design the structure.
4. The sectional geometry of pylons of support structure should be in such a way that it requires only reasonable material consumption.
5. For pylons of the support structure, the use of concrete-filled steel tubular columns shows a great response and precise results from safety and reliability point of view.

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