

A CRITICAL REVIEW ON OPERATING CONDITION FOR THE PERFORMANCE OF AIR COOLED CONDENSER USED IN THERMAL POWER PLANT

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Abstract: One of the most significant systems which play a crucial role in power plant for power production is the cooling systems. Conventional power plants used cooling medium in condenser is river water or sea water. But water resource is limited throughout the world. So, the alternative option for the cooling medium was air, so air used as a cooling medium. The performance of the ACCs was affected by the various parameter. So, in this work we have to studied various parameter like Ambient Temperature, Exhaust steam flow rate, Ambient wind direction and speed, Air-cooled platform height location of the main building and terrain condition, hot air recirculation, fan speed etc., and conclude that Turbine Back Pressure is widely affect on the performance on the ACCs. This review concentrates on the Turbine back pressure. Which was widely affected on the efficiency of the plant

Keywords: Air Cooled Condenser, Backpressure, Wind condition, Wind break mesh, Diffuser orifice plate

INTRODUCTION

US power industry had first introduced Air cooled condenser in 1970's. Population growth and energy intensity has put increasing strain on growing demand for water for residential use, power generation, industry and agriculture. Hence in last 15 to 20 years brought an increased interest in use of Air Cooled condensers and number of installation of the same had been greatly increased. But there is difference in the efficiency of using ACCs as compared to water cooling condensers. It is found that ACCs performance and overall power output are greatly depends on different design and operation condition. The various operating and design conditions has been taken into account to minimizing the performance of the ACCs. According to the Survey, the present population of over 1,200 million, the per capita water availability is around 1.170 m³ /person/year. This translates to **1170 liters/person/per year or less than 3 liters per day per person**. The urban area consumption is in upwards of 100-150 liters per day. This shows that the scarcity of the water. There is penalty of using ACCs by 5 to 10% in overall power plant efficiency and this is on greater side under high ambient temperatures and windy conditions. The degradation in the performance of ACC is mainly due to hot air recirculation, inlet flow distortion, phenomenon of diffusion and reverse irrigation

The basic principle of ACC is similar to radiator, which is used in the automobile. In order to cool the water from a car's engine, it flows through the tubes of a radiator, where air coming through the front of the car, aided by the cooling fan, reduces the temperature of the coolant. Detail construction of direct air-cooled condenser used in a thermal power plant is shown in fig.1.

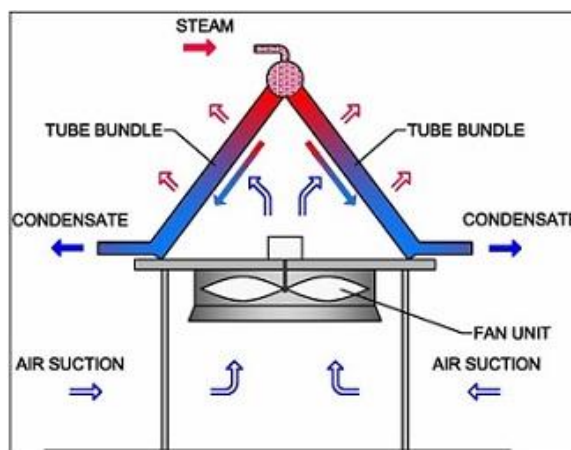


Fig.1 Forced draft Air Cooled Condenser

In the ACC, air is forced through by the draught fan past the finned tube (heat exchange bundle) cooling and condensing the high-temperature process fluid. This air-cooled condenser unit consists of three basic parts of finned tube bundles, fan and frame as well as auxiliary parts such as steam duct, condensate tank, window-shades, maintenance platform, and a ladder.

The following are the important advantages of air-cooled Condensers:

- No problem arising from thermal and chemical pollution of cooling fluids
- Flexibility for any plant location and plot plan arrangement because equipment requiring cooling need not be near a supply of cooling water.
- Reduction of maintenance costs
- Easy installation
- Air was used instead of water as a cooling medium in condenser.so it reduced the consumption of water.
- Dry cooling system minimize the water usage requirement.
- Water is corrosive fluid which requires a chemical treatment to control the scaling leading to a reduction in the heat transfer rate.
- Air Cooled condenser make it possible to build a power plant in location without adequate cooling water resources.
- Maintenance may be reduced due to elimination of water fouling characteristics.

LITERATURE REVIEW

Salta and Kroger [1], experimentally studied the effects of the height and distance of fan platforms on the volumetric effectiveness of a single fan or multiple fans, finding that the effectiveness increases with increasing the platform height, and the inlet flow distortions occur in the periphery fans.

Lei Chen et al. [2], studied the performance of the Horizontal ACCs and conclude that the off-axis flows and reverse flows in the upwind condenser cells result in the poor aerodynamic characteristics of axial flow fans, deteriorated thermos flow performances of ACCs and increased turbine back pressure of power generating units. They proposed vertically arranged of ACCs and conclude that the thermo-flow performances are greatly improved due to weakened inlet flow distortions and minimize the reverse flows and also the wind direction improves the performance of the axial flow fan and reduces the turbine back pressure at any wind speed

Xiaoze Du et al [3], develop the ANN back pressure prediction model for the direct air-cooled power generating unit. This ANN model implemented in the MATLAB programmed and conclude that the environmental wind condition is one of the most important factors that influence the operating performances of the direct air-cooled power generating unit.

Jizhen Liu et al, [4], numerically studied the parameter which affect the turbine back pressure. They conclude that the back pressure was decreased by the increases the fan speed but by increased the fan speed the net power output decreased because of the fan consumed more power.by mathematical modelling they optimize the fan speed and turbine back pressure for particular case of power plant.

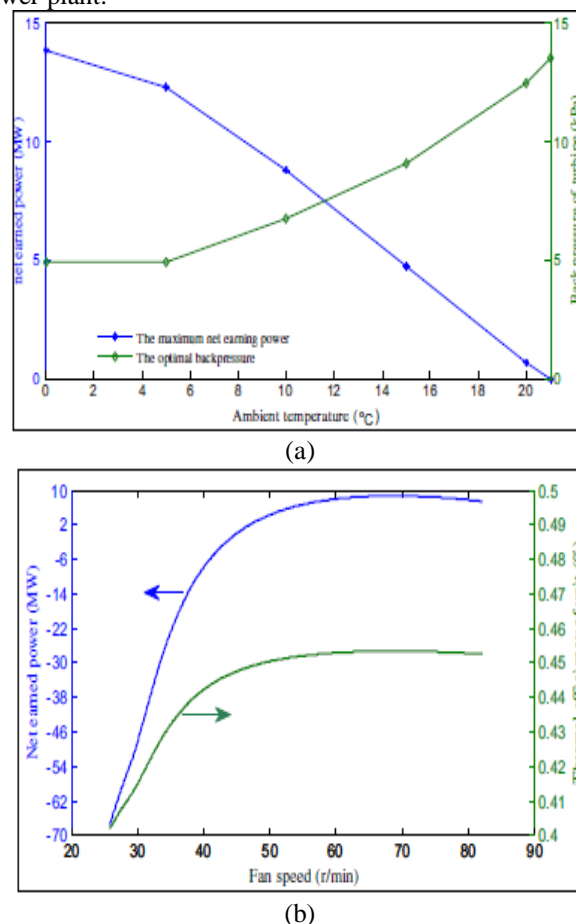


Fig.2 (a) Optimal backpressure in different ambient temperature (b) Net earned power of a unit with a change of fan speed [4]

Fig 2(a) showed that, with increased in the ambient temperature the turbine back pressure increased and the net earned power produced by the plant decreased. Similarly, fig.2(b) shows the net earned power and the thermal efficiency change with the increase in fan speed.

L.J. Yang et al [5], Studied the effect of wind speed on the flow rate of fan and heat transfer rate and fan inlet air temperature. They found out that high ambient winds speed can cause lowered air flow rates and increased inlet air temperatures thus lead to poor thermal performances of the ACC. The performance of the upwind side module has lower heat transfer performance then the downstream side module of ACCs because of the exhaust plume recirculation and the heat release from the boiler and turbine houses also result in the high inlet air temperatures of the condenser cells near the main buildings. They investigated that the performance of the system was decreased not only due to wind effect but also due to plume recirculation. plume recirculation increased the fan inlet air temperature and due to this heat transfer rate decreased.

X.F Gao et al [6], studied that the environmental wind can cause a large flow rate reduction in the axial fans mainly near the windward side of the air-cooled platform due to cross-flow effects, resulting in a heat transfer reduction. This leads to an increase of turbine back pressure, and occasional turbine trips occur under extremely gusty conditions. And they proposed a new method to remove the strong wind effect by adding deflecting plates under the air-cooled platform, it forms a uniform air mass flow rate in the axial fans by leading enough cooling air to the fans in the upwind region. They Numerically studied the thermal-flow characteristics and heat transfer performance of the ACSC with deflectors and found that the improved ACSC with deflector improved in both the cooling air mass flow rate and the heat rejection rate compared with the conventional ACSC. They also change the inclination angle of deflector plate, and conclude that the optimum value of inclination angle for the arrangement of the deflector is 45°.

J. A. van Rooyen,D. G. Kröger [7], found that the reduction in fan performance is the main reason for the poor performance of the ACSC while recirculation of hot plume air only reduces performance by a small amount.

Weifeng He et al [8], numerically investigated that air temperature rise of air at the fan inlet of ACSC system corresponding to the different wind condition like wind speed and wind direction. They consider five wind speed and five wind direction angles for numerically investigation as shown in fig.3, to understand the mechanism of air inlet temperature of ACSC system. Fig.3 shows that the air temperature rises at fan inlet with different wind speed and wind angle and conclude that the average temperature rises at inlet of the axial fan increased until wind angle $\beta=135^\circ$ and wind speed 8 m/s and then decreases

Zhang and Chen [9], numerically and experimentally investigated the effect of wind speed on the performance of ACSC system by using wind break mesh and concluded that the performance of system increased under windy condition. Various types of wind break mesh configuration like grid-type, cross-type and rectangle type are used and concluded that the rectangle type wind break mesh is more efficient to improve the performance of periphery fan.

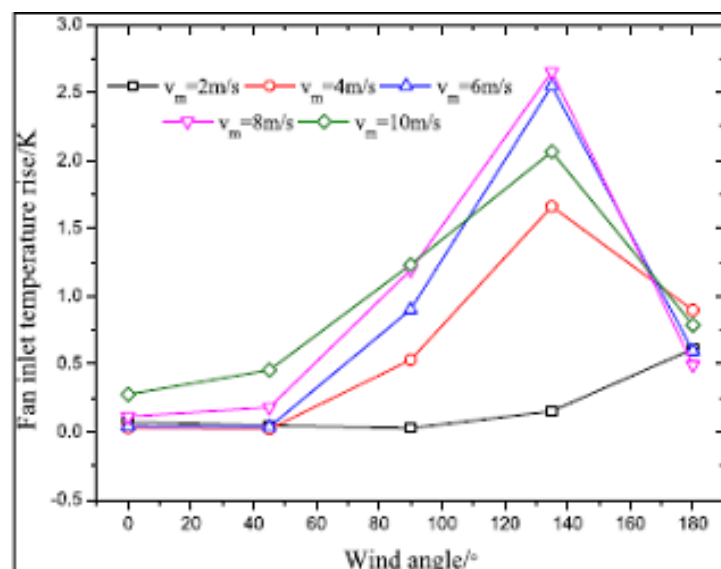


Fig.3 Average temperature distribution of the fan inlets with the wind angle at different wind speeds. [8]

Fig.4 showed that the performance of the ASCs increased under unfavorable windy condition by implementing the different windbreak mesh configuration. Among them the rectangular type mesh configuration was most affected configuration on the performance of the ACCs.

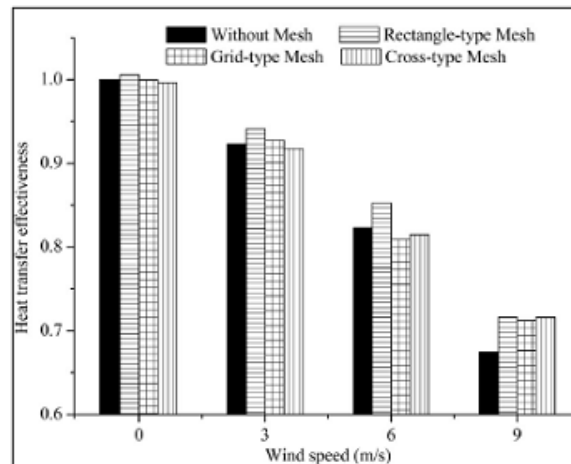


Fig.4 Heat transfer effectiveness of the whole ACSC in different windbreak mesh configurations

Zhang and Wu [10], studied that, due to high velocity just below the fan, the volumetric efficiency of fan decreased and they suggested a new configuration like orifice plate which put under the ACSC platform. By using diffuser orifice plate the velocity head converts to the pressure head, which reduced the negative pressure region under the ACSC platform and improved the volumetric efficiency of the fan.

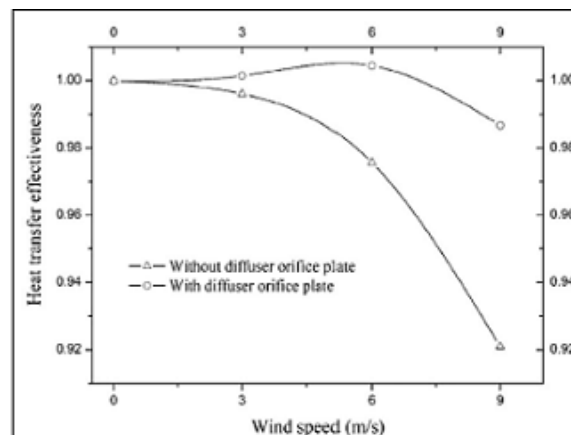


Fig.5 Heat transfer effectiveness at Column 4 under windy conditions.

The hot air recirculation has a very large impact on the heat rejection rate of the ACSC due to the existence of the main factory building in the windward side of the ACSC. Because of it large eddies with low pressure between the factory building and the ACSC are generated and due to this a strong hot air plume inlet to the fan.

Liu et al. [11], Numerically investigated the increased of hot air recirculation under different wind speed and wind direction and they give suggestion that to increasing the wind wall height and accelerating the rotational speed of the fans near the edge of the ACC platform for reducing the effect of hot air recirculation on the performances of ACC system. They consider three wind speeds according to meteorological data in recent several years that the velocity magnitude is 4, 8, and 25 m/s are selected, against eight different angles of the wind direction.

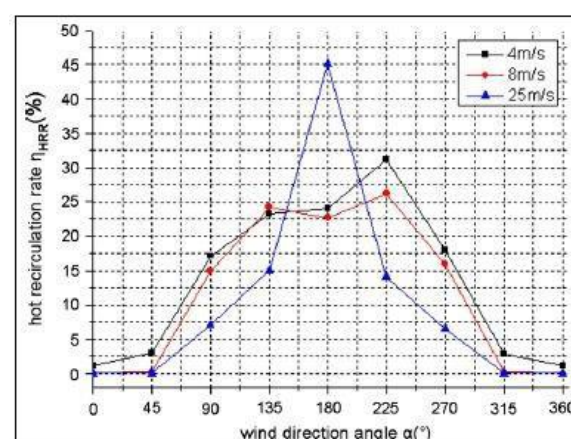


Fig.6 Hot recirculation rate varies with the wind directions [11]

Fig.6 shows how the HRR varies with the wind direction angle. It is found that under different wind speeds, the three curves of the HRR are similar, i.e., when the wind comes from the side of the boiler and turbine building, the HRR is quite high, and the edge fan-inlet of four sides at the bottom of the ACC platform will suffer from the effect of the hot air. The most unfavorable wind directions occur within $\alpha = 180^\circ \pm 90^\circ$ (Westerly wind). When the wind direction between $\alpha = 0-90^\circ$ or $270-360^\circ$, the HAR is very weak and is almost undetectable. In these cases, the HRR is quite low, and the wind effects on the HAR of the ACC system can be neglected. When wind direction angle $\alpha = 0-135^\circ$ or $225-360^\circ$, the HRR of the ACC system gradually reduces with the increase of the wind speed. when the wind blows normal to the boiler house ($\alpha = 180^\circ$), the HAR of the ACC system are more sensitive to the wind speeds, and the intensive wind will lead to the increases of the HAR.

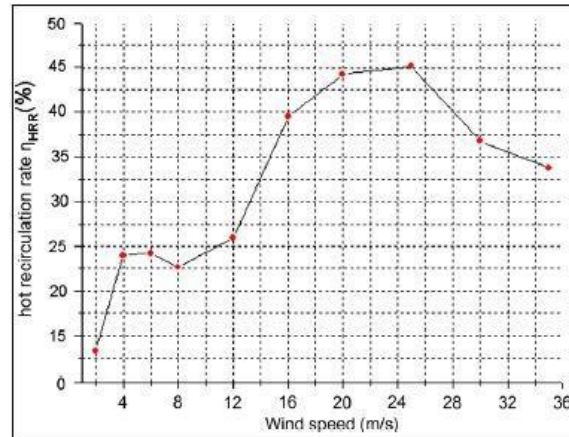


Fig.7 The variation of the HRR with the increases of the wind speed. [11]

Variation of HRR with wind speed also numerically investigated by Liu et al. [11]. Fig.7 shows HRR increases with the increases of the wind speed upto 25 m/s and the peak value of the HRR arises at wind speed of 25 m/s. When the wind speed exceeds 25 m/s, the increasing wind speed will result in the reduction of the HAR of the ACC system.

CONCLUSIONS

The primary focus of this study is to evaluate the performance of Air-cooled condenser under various conditions. The performances of air-cooled condenser decrease with increase in ambient temperatures and high wind conditions.

- By implementing the deflector plate, it improved the heat transfer rate and increased the mass flow rate in the fan and also decreased the flow distortion at the inlet of the fan.
- By implementing the windbreak mesh arranged below the ACSC platform and outside the ACSC steel supporting structure, it improves the volumetric effectiveness of all fans of the ACSC system under windy conditions.
- By using the diffuser orifice plate below the module, it improves the volumetric efficiency of the fan and increased the heat transfer rate.
- Providing the wind break wall around the periphery of the ACC module, it decreased the hot air recirculation rate and increased the performance of the periphery fan.

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