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# Design configuration of cooling tower using techniques of Computational Fluid Dynamics to improve the effectiveness of cooling tower

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***Abstract**:* The cooling towers are used in various applications and industries involving chemical treatment, air conditioning, textile and water supply systems and comprises of air inlet, the spray zone and fill media. The objective of current research is to investigate the performance of cooling tower with single air inlet design and five air inlet design configuration. The investigations are carried out techniques of Computational Fluid Dynamics in ANSYS CFX software. The temperature plot and mass flow rate of both fluids are evaluated and its observed that water has mass flow rate of .00706 Kg/sec and air mass flow outlet has rate of .2831 Kg/s.

***Key Words:*** *Cooling tower, thermal analysis, CFD*

## 1. INTRODUCTION

The cooling towers are used in various applications and industries involving chemical treatment, air conditioning, textile and water supply systems [1]. The use of cooling tower in cooling of circulating water is shown in figure 1 below. The design of cooling tower can be optimized to achieve higher heat and mass transfer. The cooling tower comprises of air inlet, the spray zone and hot water inlet zone along with fill. The hot water gets cooling when it passes through fill region and the heat of hot water is transferred to air which exits from the top.

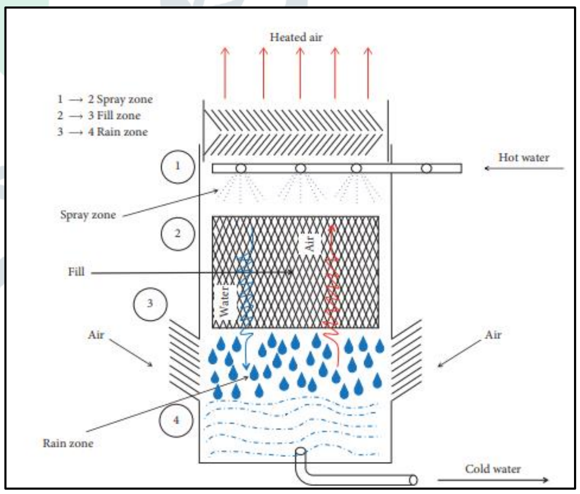


Figure 1: Schematic of a counter flow wet cooling tower [1]

## 2. LITERATURE REVIEW

Gan [2,3] have worked on development of analytical models which considers the mass, momentum, and energy transfer simultaneously. The models are based on "Merkel theory" which can investigate the heat transfer processes of different cooling towers. The author also conducted numerical investigation and corroborated the results with analytical results.

Ronak Shah, Trupti Rathore [4] have conducted experimental investigation of industrial cooling tower to evaluate the its performance parameters under given inlet and outlet conditions. The losses during the process are also taken in to the account. The research findings have shown that the performance of cooling tower increases with increase in air flow rate. However, the performance deteriorated with increase in "water to air mass" ratio.

Plasencia et al [5] developed a new model which is based on "transfer of heat and mass for IEC; few simplifications were incorporated to make this model as user friendly used for analysis of energy as well as adaption of system" [5].

Camargo et al [6] have worked on development of empirical correlation for heat and mass transfer to improve saturation efficiency or effectiveness. These equations determined the value of heat transfer between warm air and wetted media. The research was limited to the study of air exiting from the cooler and not with water stored in the tank.

Pushpa B. S, Vasant Vaze, P. T. Nimbalkar [7] have evaluated performance of cooling tower in thermal power plant by varying "water inlet temperature, air inlet temperature and mass flow rate of water" [7]. The research findings have shown that performance of cooling tower enhances with increase in water inlet temperature and air inlet temperature. The performance of cooling tower decreases with increasing mass flow rate.

## 3. OBJECTIVES

The objective of current research is to investigate the performance of cooling tower with single air inlet design and five air inlet design configuration. The investigations are carried out techniques of Computational Fluid Dynamics in ANSYS CFX software.

## 4. METHODOLOGY

The design of cooling tower is developed in Creo design software and converted in parasolid file format. The cooling tower design is imported in ANSYS design modeller where it is checked for geometric errors. The slice tool and fill tool is used to generated inner features.

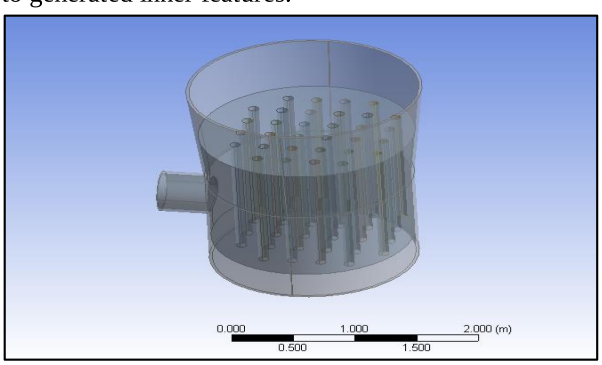


Figure 2: Imported cooling tower design in ANSYS design modeler

The cooling tower design is discretized using tetrahedral element type which has 4 nodes with 3 DOF/node. The adaptive type size function is used with slow transition and medium relevance center. The meshed model has 465601 elements and 294035 nodes.

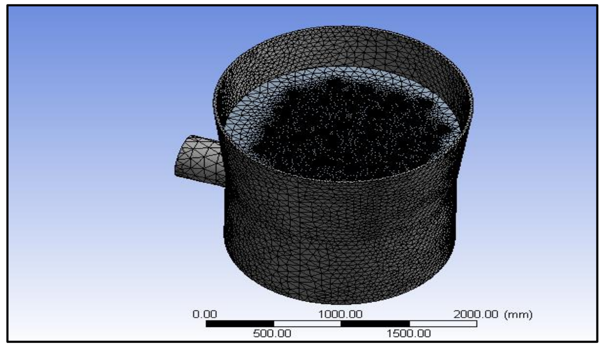


Figure 3: Discretized model of cooling tower

The domain definition is defined with solid and fluid domain. The reference pressure is set to 1atm and turbulence model is defined to k-omega turbulence model.

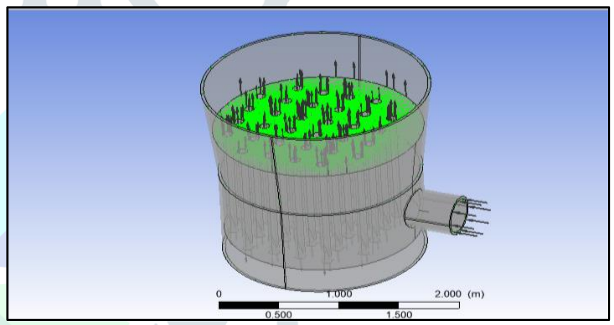


Figure 4: Domain definition

The air inlet boundary condition is defined with mass flow rate of .0404Kg/s and static temperature is set to 300K. The air inlet boundary condition is shown in figure 5 below.

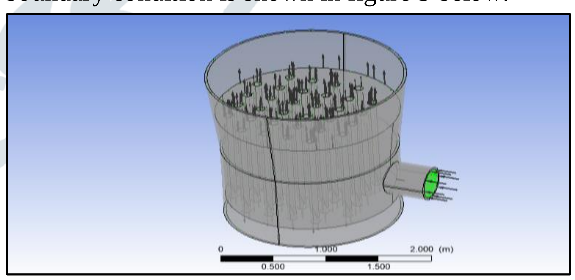


Figure 5: Air in boundary condition

The water inlet boundary condition is defined with .055Kg/s with temperature of 329K. The flow direction is set normal to boundary condition and turbulence intensity is set to 5%.

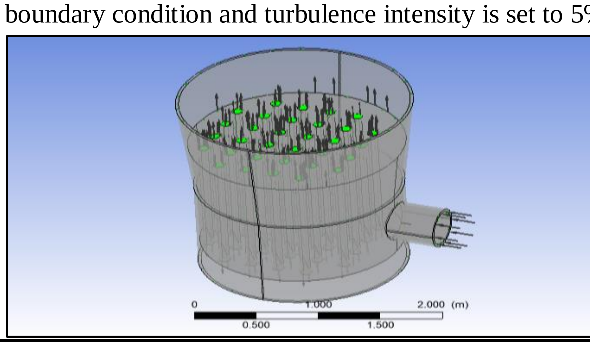

Figure 6: Water in boundary condition

The solver definition is defined with number of iterations set to 100 and RMS residual values set to .0001. The convergence of mass, momentum and energy is achieved at the solution stage.

## 4. RESULTS AND DISCUSSION

The temperature plot of across outer face of cooling tower is shown in figure 7 below. The maximum temperature obtained from the analysis is 329K. The temperature at the air inlet is 300K.

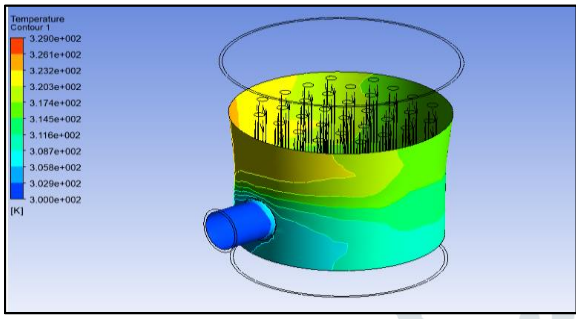


Figure 7: Temperature plot at the outer face

The temperature distribution across water domain is shown in figure 8 below. The water at the inlet is higher with magnitude of 329K and reduces towards the exit of the water domain as shown by dark blue colour.

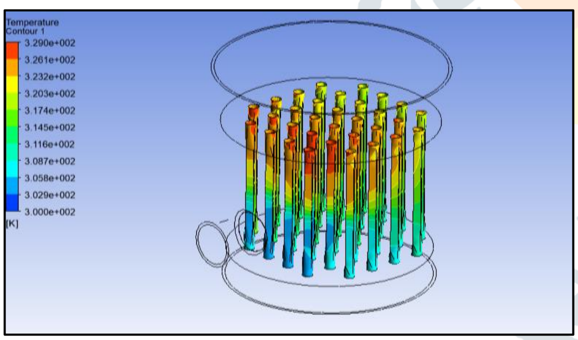


Figure 8: Temperature plot for water domain

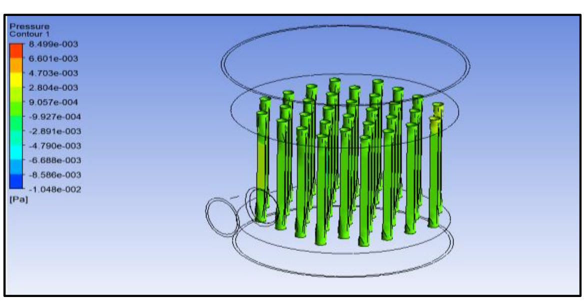


Figure 9: Pressure plot for water domain

The pressure distribution plot across water domain is shown in figure 9 above which shows almost uniform pressure with magnitude of nearly 8.49Pa. The pressure is higher at the mid-section of the water domain with magnitude of nearly 9.05Pa.

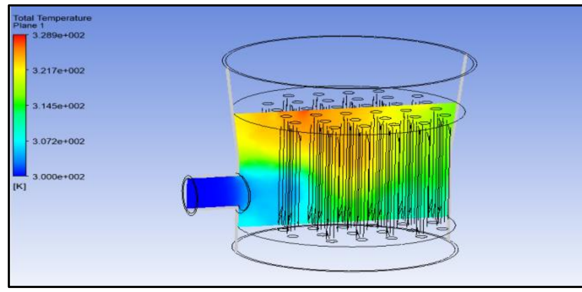


Figure 10: Temperature plot for air domain

The temperature plot across lateral plane is shown in figure 10 above. The plot shows low temperature at the bottom region where the temperature is nearly 307.2K. The temperature of air increases towards the water inlet region with magnitude of nearly 328.9K which is shown in red color. The temperature at the other regions has magnitude of nearly 321K.

## 5. CONCLUSION

The numerical investigation was conducted on single fuel inlet design of cooling tower using techniques of Computational Fluid Dynamics. The k-omega turbulence model provided reasonably good fluid flow predictions inside cooling tower. The temperature plot and mass flow rate of both fluids are evaluated and its observed that water has mass flow rate of .00706 Kg/sec and air mass flow outlet has rate of .2831 Kg/s.

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