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Analysis of a Condenser in a Thermal Power Plant for Possible Augmentation in its Heat Transfer Performance

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Abstract: In this paper, a comparative study of Surface Condenser used in a thermal power plant integrated with flower baffles to that of the condenser with segmental baffles and without baffles is done. The heat transfer coefficient on the shell side is calculated analytically and compared graphically with other condenser configurations. Three models of the condenser are designed, one without baffle, second one with segmental baffles and third with flower baffles. Three sector angles 75^0, 90^0 and 115^0 are taken for segmental baffles. In this analysis pressure, velocity, heat transfer rate, and mass flow rates are investigated by ANSYS 14.0 software and comparative analysis also done.
Keywords: Ansys, pressure, velocity, heat transfer rate, and mass flow rate.

I. INTRODUCTION TO CONDENSER

A condenser or evaporator is a heat exchanger, allowing condensation, by means of giving off, or taking in heat respectively. Refrigerant and air will be physically separated, at air conditioner condenser, and evaporator. Therefore, heat transfer occurs by means of conduction.

A. Specifications of Condenser

The length and size of air conditioner condensers and evaporators have to be sized such that,

1) the refrigerant is completely condensed before the condenser's exit, and
2) the refrigerant is completely boiled before the evaporator's exit

Those two, depends mainly on the size of the compressor and refrigerant used.

B. Condenser is required in the Power Plant

The condensers and cooling systems involved in condensing the exhaust steam from a steam turbine and transferring the waste heat away from the power station. The function of the condenser is to condense exhaust steam from the steam turbine by rejecting the heat of vaporization to the cooling water passing through the condenser. The temperature of the condensate determines the pressure in the steam/condensate side of the condenser. This pressure is called the turbine backpressure and is usually a vacuum. Decreasing the condensate temperature will result in a lowering of the turbine backpressure. Note: Within limits, decreasing the turbine backpressure will increase the thermal efficiency of the turbine.

Surface Steam condenser: In surface condensers there is no direct contact between the steam and cooling water and the condensate can be re-used in the boiler: In such condenser even impure water can be used for cooling purpose whereas the cooling water must be pure in jet condensers. Although the capital cost and the space needed is more in surface condensers but it is justified by the saving in running cost and increase in efficiency of plant achieved by using this condenser. Here, cooling water and exhaust steam are separated by a barrier and condensation is done by heat exchanging through this barrier wall. Cooling water is passed through numbers of water tubes and exhaust steam passes over the outer surface of the tube. The heat of steam is absorbed by the water inside the tube through the wall of the tube. Again in some cases, steam is passed through an array of steam tubes, cooling water is sprayed over the steam tube and condensed steam comes out from the outlet of the tubes. Surface steam condensing is slower process than Jet Steam condensing, but the main advantage of surface steam condensing is that, the condensed

C. Baffles

Baffles are used to increase the fluid velocity by diverting the flow across the tube bundle to obtain higher transfer co-efficient. The distance between adjacent baffles is called baffle-spacing. The baffle spacing of 0.2to 1 times of the inside shell diameter is commonly used. Baffles are held in positioned by means of baffle spacers. Closer baffle spacing gives greater transfer co efficient by inducing higher turbulence. The pressure drop is more with closer baffle spacing.

II. LITERATURE SURVEY

A brief review of the work carried by various researchers on condensers is presented following. In the paper by SK. R. S. Mahaboob Ali[5], the Surface Condenser in Dr.NTTPS is modeled and numerically analyzed in SOLIDWORKS Flow Simulation. A comparative study of the condenser integrated with flower baffles to that of the condenser with segmental baffles is done. The effectiveness of the condenser is found to have increased with increasing baffle angles due to the induced turbulence. The heat transfer performance of the condenser with segmental baffles is higher than that of the condenser with flower baffles, but segmental baffles cause large pressure drop. The heat transfer coefficient on the shell side is calculated analytically and compared graphically with other condenser configurations. In the paper by Ajeet Singh Sikarwar[3], deals with the factors or parameters which reduced the efficiency of the condenser and power plant. In the paper by Dhananjay R.Giram[1], a theoretical investigation about thermal analysis and design considerations of a steam condenser has been undertaken. A hybrid steam condenser using a higher surface area to diameter ratio of cooling a water tube has been analyzed. 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. The latent/sensible heat of steam is used to preheat the feed water supply to the boiler. A conceptual technological design aspect of a super vacuum hybrid surface steam condenser has been theoretically analyzed.

III. CFD ANALYSIS OF CONDENSER

CFD analysis is performed on all condenser models for liquid water. The comparison to determine better model by evaluating heat transfer coefficient and heat transfer rate.

Boundary conditions

Inlet temperatures(T)	303K,353 K
Inlet pressure(P)	101325 Pa
Inlet velocity(V)	1.4412 m/s

A. *Segmental baffles - 75^0*

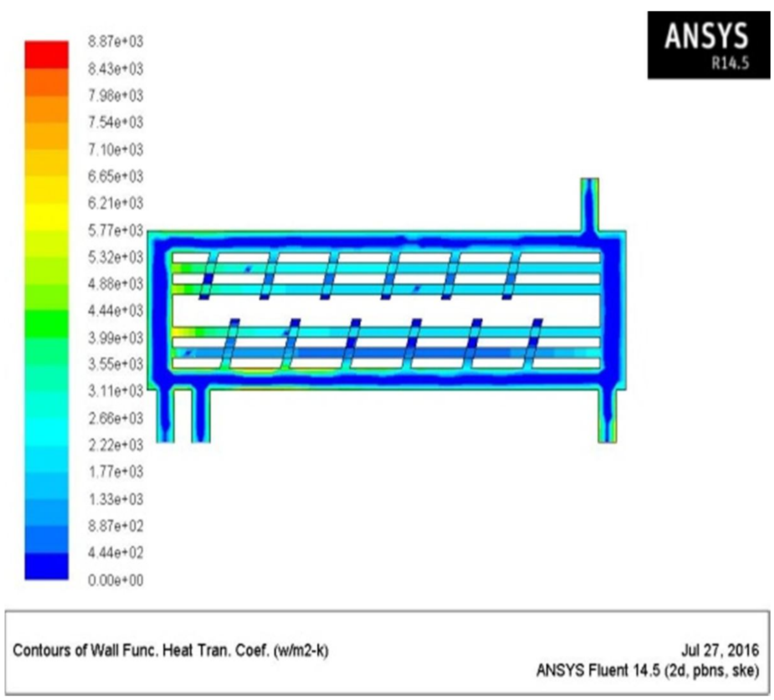

Fig 1: Heat transfer coefficient

B. Segmental baffles - 90^0

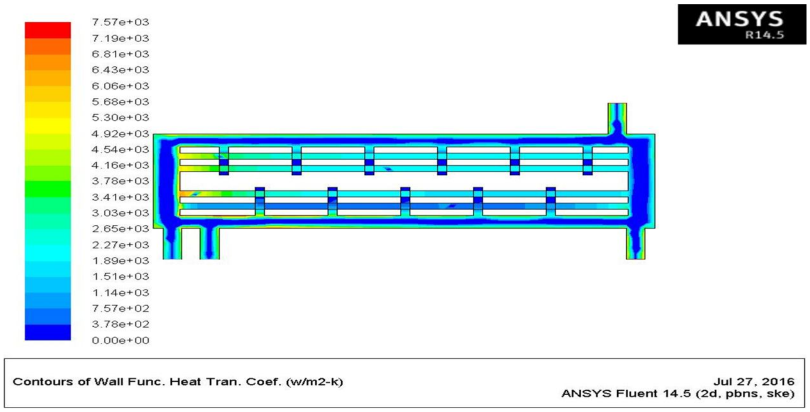

Fig 2: Heat transfer coefficient

C. Segmental baffles - 115^0

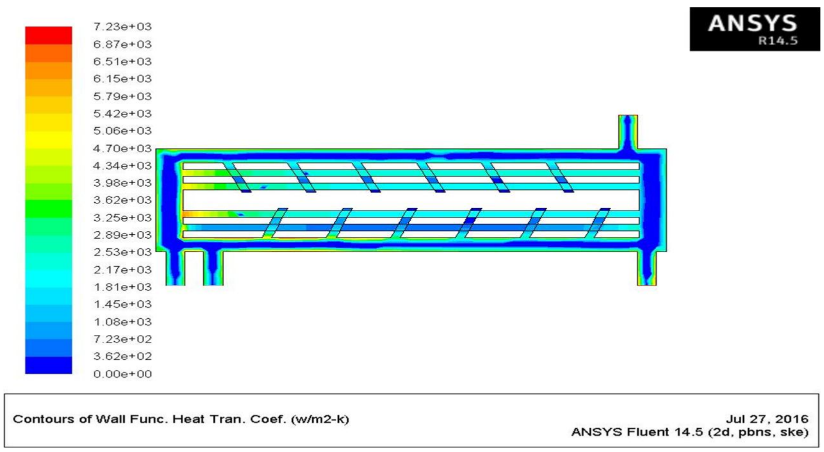

Fig 3: Heat transfer coefficient

D. Flower baffles

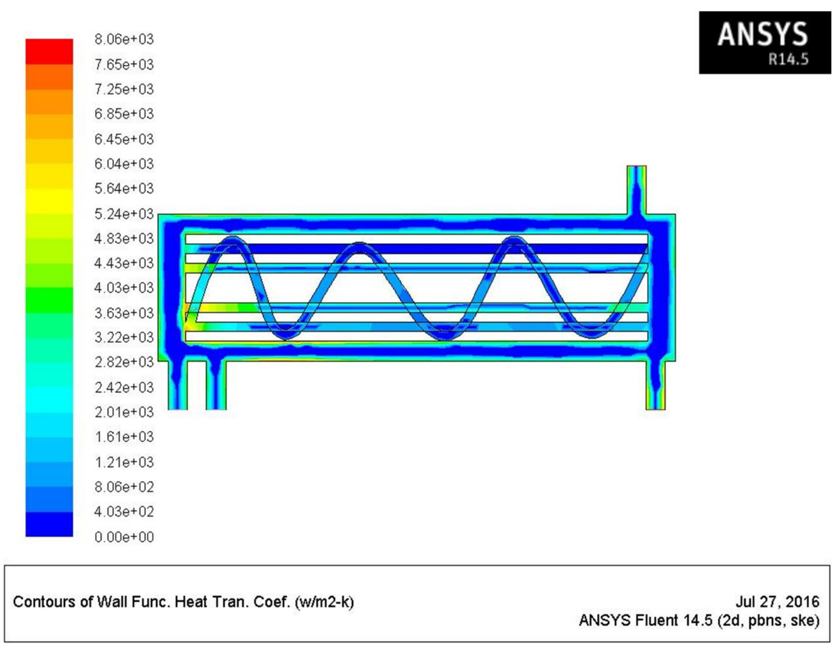

Fig 4: Heat transfer coefficient

E. Without baffles

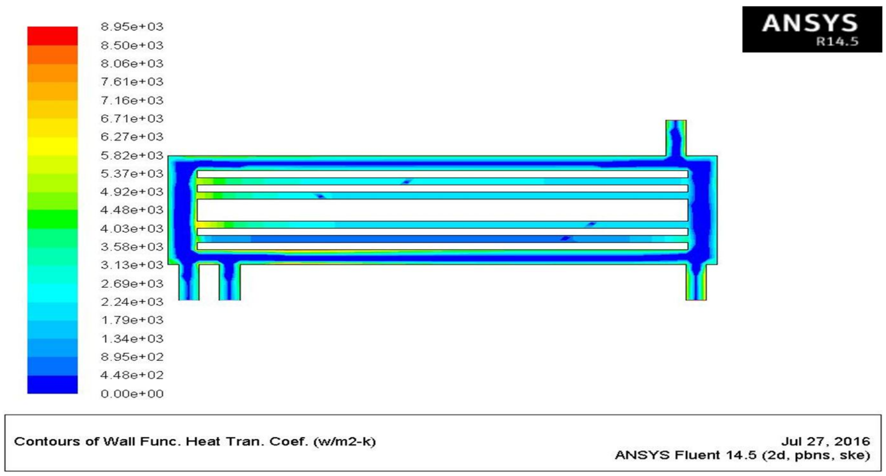

Fig 5: Heat transfer co-efficient

IV. RESULTS & DISCUSSIONS

Table 1: CFD analysis results

Models		Pressure (Pa)	Velocity (m/s)	Temperature (K)	Heat transfer co-efficient (W/m^2-K)	Heat transfer rate (W)	Mass flow rate (Kg/s)
Segmental Baffles	75^0angle	3.50e+03	1.77e+00	3.53e+02	8.87e+03	33478.625	0.1014
	90^0angle	3.48e+03	1.80e+00	3.53e+02	7.57e+03	21432.188	0.1381
	115^0angle	3.49e+03	1.76e+00	3.53e+02	7.23e+03	21031.063	0.1160
Flower baffles		3.39e+03	1.82e+00	3.53e+02	8.06e+03	36290.75	0.3664
Without baffles		3.43e+03	1.70e+00	3.53e+02	8.95e+03	7414.75	0.4255

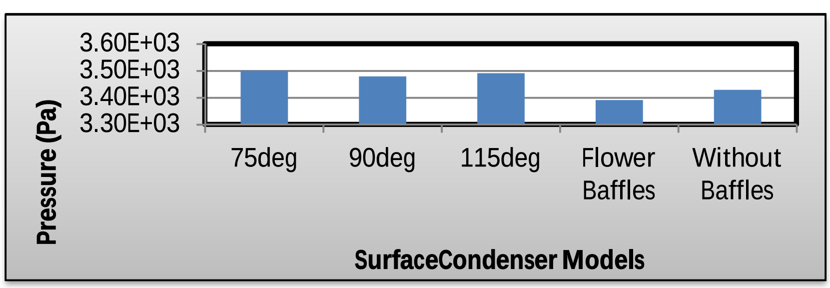

Fig 6: comparison of pressure values for all models

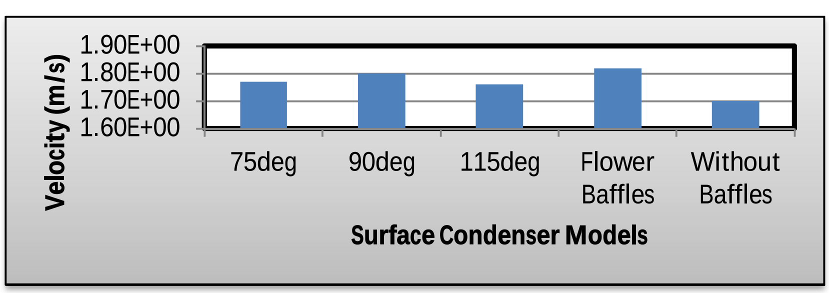

Fig 7: Comparison of velocity values for all models

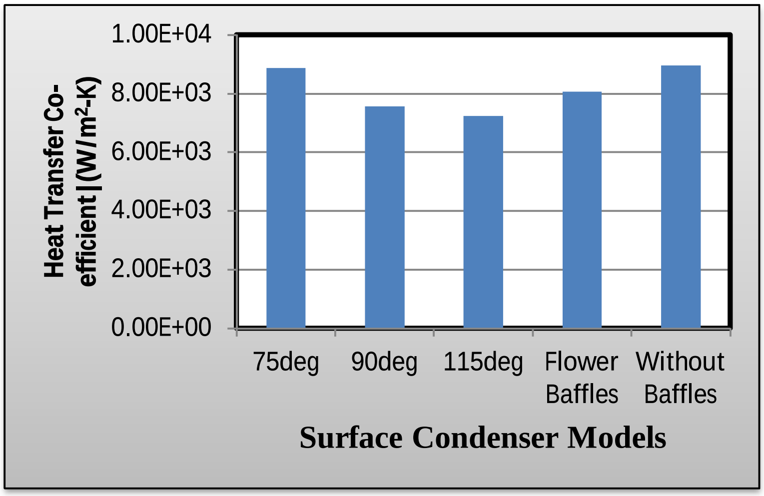

Fig 8: Comparison of heat transfer coefficient values for all models

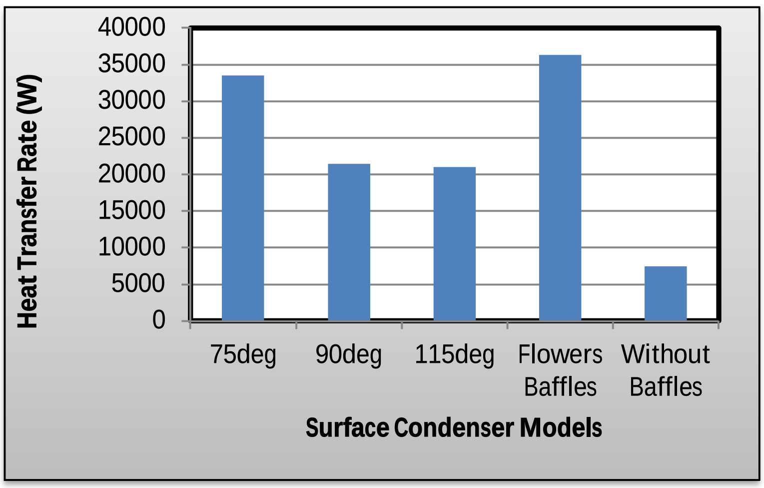

Fig 9: Comparison of heat transfer rate values for all models

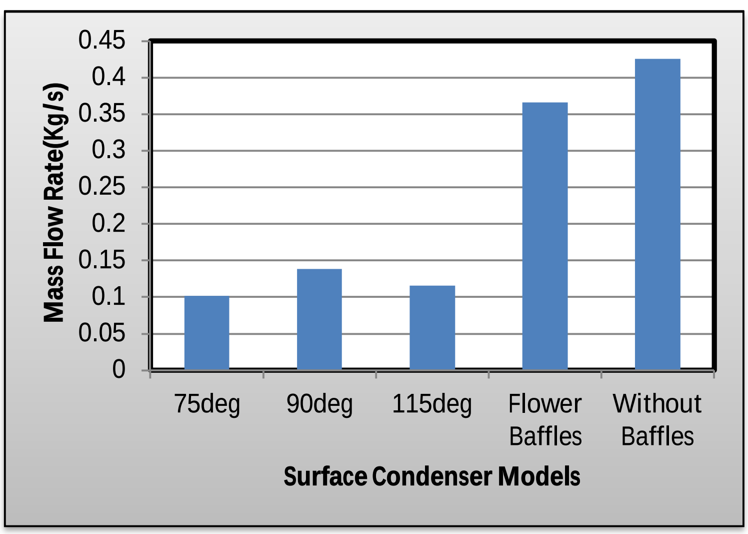

Fig 10: Comparison of mass flow rate values for all models

By observing the analysis results, the overall heat transfer coefficient with varying angle is identified and is found that with increasing sector angle, the overall heat transfer coefficient decreases. The heat transfer coefficient is more for segmental baffles with 75^0 than flower baffles but less when compared with that of without baffles. The heat transfer rate of the condenser with flower baffles is higher than that of the condenser with segmental baffles and without baffles. Segmental baffles also cause large pressure drop and flower baffles cause less pressure drop.

V. CONCLUSION

The overall heat transfer coefficient with varying angle is identified and is found that with increasing sector angle, the overall heat transfer coefficient decreases. The heat transfer coefficient is more for segmental baffles with 75^0 than flower baffles but less when compared with that of without baffles. The heat transfer rate of the condenser with flower baffles is higher than that of the condenser with segmental baffles and without baffles. Segmental baffles also cause large pressure drop and flower baffles cause less pressure drop.

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