ISSN 2229-5518

# Effect of Operational Temperatures in Efficiency of Shell and Tube Heat Exchanger

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**ABSTRACT:** The most common application of Shell and tube heat exchangers are nuclear power plants, surface condensers and hydraulic power packs. The aim of this paper is to study the effect of various operational temperatures for finding out the heat transfer rate at particular temperatures. By using the reference dimensions published in the grab cad, shell and tube heat exchanger is modeled and numerical analysis is done using Autodesk Software Attempts were made to investigate the heat transfer rate by varying the temperatures namely 10o, 20o, 25o& 30o.The results are observed to be that hot outlet temperatures of Shell and tube heat exchangers has given a converged solution for the formulated expression.

**Key Words:** Shell and Tube Heat Exchangers, Heat transfer, Numerical Analysis.

# 1. INTRODUCTION

A shell and tube heat exchanger is a class of heat exchanger designs. It is the most common type of heat exchanger in oil refineries and other large chemical processes, and is suited for higher-pressure applications. As its name implies, this type of heat exchanger consists of a shell (a large pressure vessel) with a bundle of tubes inside it. One fluid runs through the tubes, and another fluid flows over the tubes (through the shell) to transfer heat between the two fluids. The set of tubes is called a tube bundle, and may be composed of several types of tubes: plain, longitudinally finned two fluids, of different starting temperatures, flow through the heat exchanger. One flows through the tubes (the tube side) and the other flows outside the tubes but inside the shell (the shell side). Heat is transferred from one fluid to the other through the tube walls, either from tube side to shell side or vice versa. The fluids can be either liquids or gases on either the shell or the tube side. In order to transfer heat efficiently, a large heat transfer area should be used, leading to the use of many tubes. In this way, waste heat can be put to use. This is an efficient way to conserve energy. Heat exchangers with only one phase (liquid or gas) on each side can be called one-phase or single-phase heat exchangers. Two-phase heat exchangers can be used to heat a liquid to boil it into a gas (vapor), sometimes called boilers, or cool a vapor to condense it into a liquid (called condensers), with the phase change usually occurring on the shell side. Boilers in steam engine locomotives are typically large, usually cylindrically-shaped shell-and-tube heat exchangers. In large power plants with steam-driven turbines, shell-and-tube surface condensers are used to condense the exhaust steam exiting the turbine into condensate water which is recycled back to be turned into steam in the steam generator.

## 1.1 LITERATURE REVIEW

The performance of heat exchanger by the use of helical baffle in place of segmental baffle from the numerical experimental results have discussed by Arjun K.S. and Gopu K.B[1].Vindhya Vasini Prasad Dubey[2] give the heat transfer capabilities of several thermal materials has been compared by assigning different materials to various parts such as tubes, baffles, shell. By using Kern's method Vindhya Vasini Prasad Dubey [3] has been designed the Shell and Tube heat exchanger under various ambient temperatures to see its effect on the performance of the heat exchanger. The overview of Shell and Tube type heat exchanger design by Kern's method have discussed by Uttam H. Patel et al [4].Thermal analysis is done by G.V.Srinivas Rao et al[5] on Shell and Tube heat exchangers with the determination of heat transfer coefficient,friction coefficient, length, area and pressure drop. Dilip S. Patel et al[6] focuses on the various researches on CFD analysis in the field of heat exchanger. The baffle spacing and the tube metallurgy are being changed to obtain the results of Shell and Tube heat exchanger by Durgesh Bhatt and Priyanka M.Javhar[7].

# 2. METHODOLOGY

The starting point of any heat transfer calculation is the overall energy balance and the rate equation. Assuming only sensible heat is transferred, we can write the heat duty Q as follows.

$$Q = m \cdot c_p \cdot \Delta T = m_c \cdot c_p \cdot \left(T_{c\,out} - T_{c\,in}\right) = UAF\,\Delta T_{lm} \tag{1.1}$$

$$T_{lm} = \frac{\left(T_{in\,hot} - t_{out\,cold}\right)\left(T_{out\,hot} - t_{in\,cold}\right)}{\ln\left[\dfrac{T_{in\,hot} - t_{out\,cold}}{T_{out\,hot} - t_{in\,cold}}\right]} \tag{1.2}$$

$$Q = f\,(t_{in\,cold}) \tag{1.3}$$

From the above equation we can see that the change in the inlet temperatures are the function of the heat transfer

The new symbol F stands for a correction factor that must be used with the log mean temperature difference for a countercurrent heat exchanger to accommodate the fact that the flow of the two streams here is more complicated than simple countercurrent or concurrent flow. Consider the simplest possible shell-and-tube heat exchanger, called 1-1, which means that there is a single shell "pass" and a single tube "pass." The sketch schematically illustrates this concept in plain view. Note that the contact is not really countercurrent, because the shell fluid flows across the bank of tubes, and there are baffles on the shell side to assure that the fluid does not bypass the tube bank. The entire bundle of tubes (typically in the hundreds) is illustrated by a single line in the sketch. The baffle cuts are aligned vertically to permit dirt particles settling out of the shell side fluid to be washed away.

Heat Transfer Coefficients The evaluation of the overall heat transfer coefficient is an important part of the thermal design and analysis of a heat exchanger. The result can be written for the overall heat transfer coefficient $U_o$based on the outside surface area of the tubes, which is the heat transfer surface.

$$\frac{1}{U_0} = \frac{1}{h_0} + \left(\frac{\Delta r}{k}\right)\left(\frac{A_0}{A_{lm}}\right) + \frac{1}{h_j}\left(\frac{A_0}{A_j}\right) + R_{f,0} + R_{f,j} \tag{1.4}$$

Where

$h_o$ is the heat transfer coefficient for the fluid flowing in the shell

$h_j$ is the heat transfer coefficient for the fluid flowing through the tubes

$A_i$ and $A_o$ are the inside and outside surface areas of a tube.

$A_{lm}$ is their log mean.

The fouling resistances on a unit area basis are $R_{f,0}$ for the shell side,

$R_{fi}$, for the tube side. Accumulated information on fouling resistances can be found in the Standards published by TEMA.

## 3. GEOMETRY

The shell and tube heat exchanger is modeled by using the reference dimensions published in the grab cad since our study is not yet on the model optimization but just prove the heat transfer is affected by the inlet temperatures.

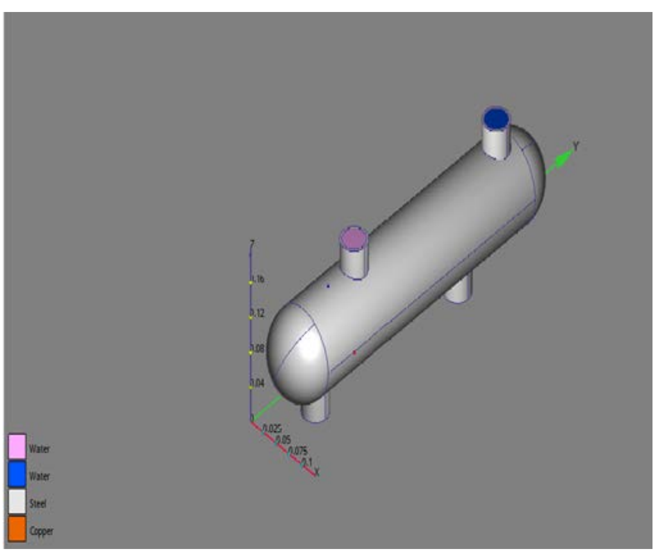


**Figure 1.** Actual Model of the Simulation with the Materials applied**.**

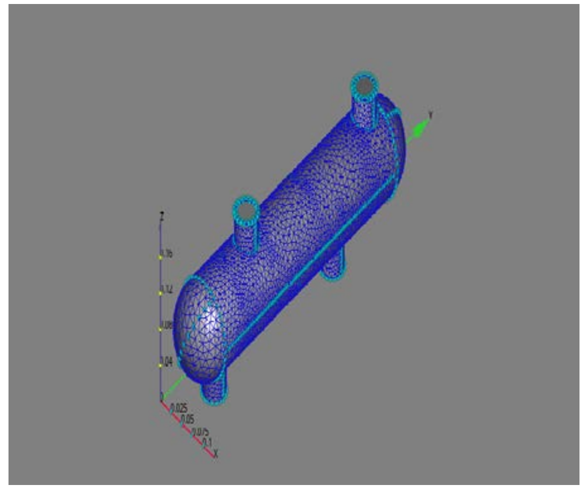

**Figure 2.** Mesh Model of Shell and Tube Heat Exchanger.

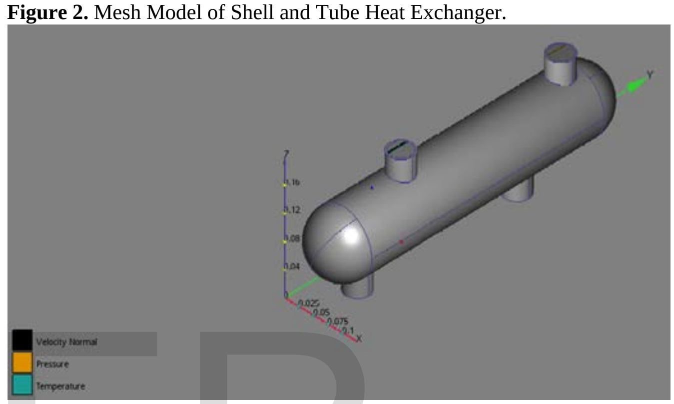


**Figure 3.**Inlet and Outlet Flows of Shell and Tube Heat Exchanger.

## 4. RESULTS AND DISCUSSIONS

The results obtained by the numerical analysis is as follows For 30 temp.

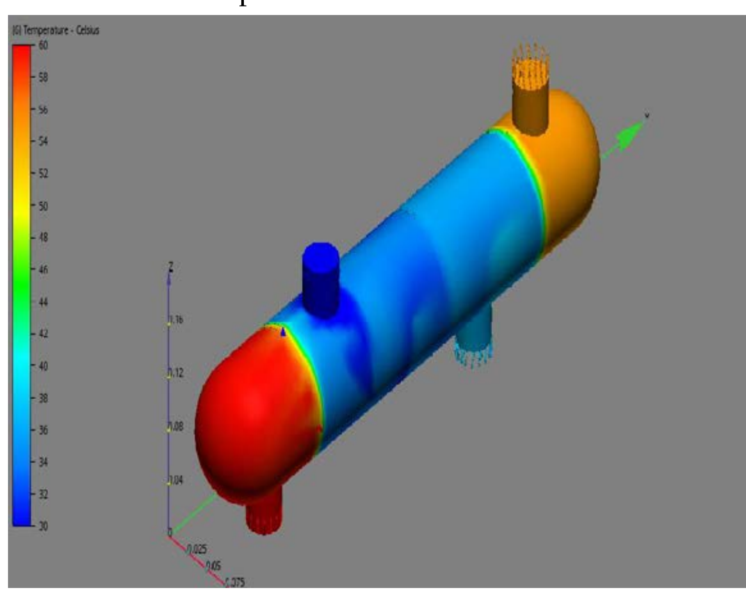


**Figure 4.** Showing the distribution of temperatures of fluids under Operational cold water of 30 degree.

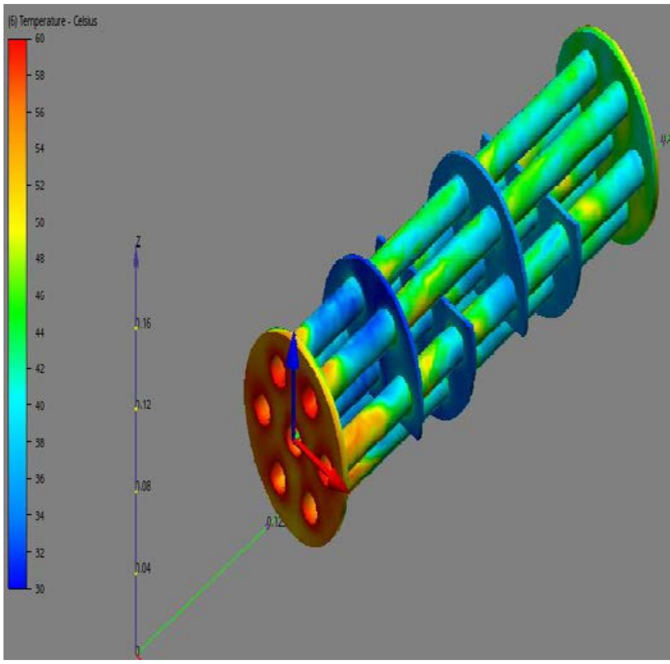

**Figure 5.** Showing the temperatures of the baffle plates and inner tubes.

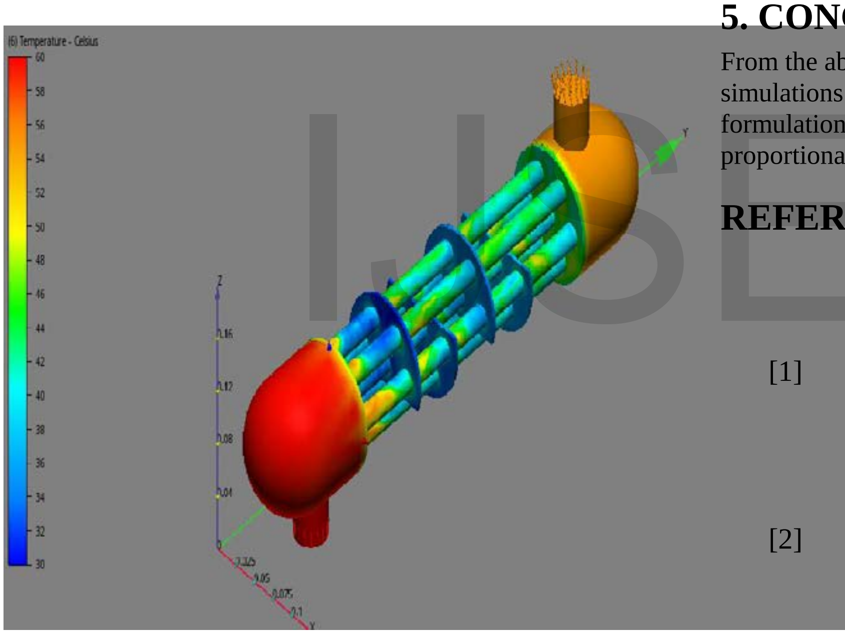

**Figure 6.** Showing the hot water temperatures.

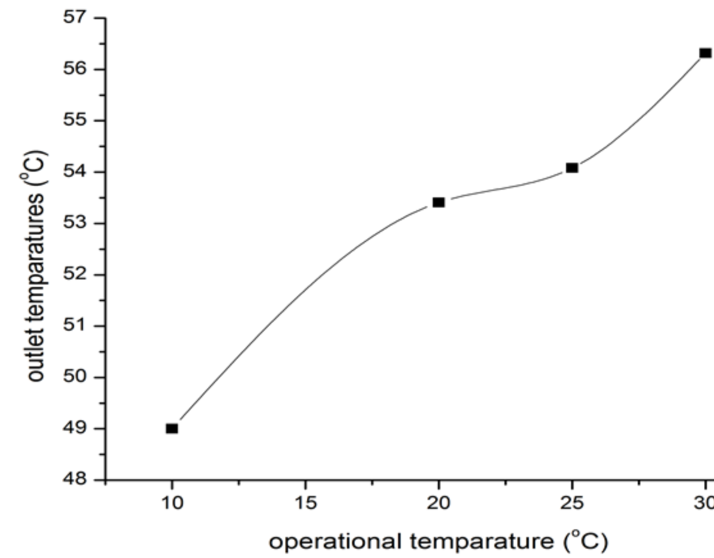


**Figure 7**. Plot between operational temperature and outlet temperature.

## 5. CONCLUSION

From the above observations it is found to be the numerical simulations have given arguable solutions according to the formulation of effect of heat transfer which is directly proportional to the function of cold water inlets.

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