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# Thermal Analysis of Hot Wall Condenser for Domestic Refrigerator

**Akash D. Raiyani[1], N. R. Sheth[2], Niraj C. Mehta[3]**

[1]ME Student, Department of Mechanical, GEC Valsad, College campus-396001, India

[2]Department of Mechanical, GEC Valsad, College campus-396001, India

[3]Head of Department, Department of Mechanical Engineering, Noble Engineering College, PARTH VATIKA, Bheshan Road, Junagadh-, India

**Abstract:** ***The Condenser is a heat transferring device. It is used to remove heat from hot refrigerant vapour. Using air cooling method condenser changes the vapour to a liquid. Convection mode of heat transfer plays very important deciding factor transferring heat from condenser tube to atmosphere. This paper presents simulation results of hot-wall condensers that are commonly used in vapour compression cycle based domestic refrigerators. This work is done on the real refrigerator, in present configuration of tube-plate configuration is point contact. Geometrical parameter affect the condenser performance so in this work change in design the condenser by changing the point contact between tube and plate by line contact with wrapping the plate on tube. The analysis is done in ANSYS 14 for existing configuration and result for the temperature distribution is validating by experimentally. After that analysis have been done by increasing the contact angle between tube and plate with same boundary condition. Compare the result of existing configuration and by changing the contact angle for the temperature distribution, heat flux and thermal gradient. From the result with the increase in contact angle heat flux and thermal gradient is increase.***

**Keywords:** about Hot wall condenser, Thermal, Heat transfer, Domestic refrigerator, ANSYS

## 1. Introduction

A domestic refrigerator uses a condenser as a heat exchanger to reject heat to the surroundings. A conventional refrigerator uses a wire-and-tube condenser, which is attached to the back of the refrigerator. However, this condenser is prone to be damaged and dirt tends to accumulate and form a scale layer on the hot surface. This increases the fouling resistance and reduces the heat transfer significantly from the condenser. Due to these factors, a new condenser design, called the ‘‘hot-wall condenser’’ was introduced in recent years to replace the wire-and-tube condenser. The hot-wall condenser, also known as wrapper type condenser, consists of steel tubing (coated with copper), which is installed by direct contact on the inner surface of the outer iron plate of side walls of a refrigerator as shown in Figure 1.

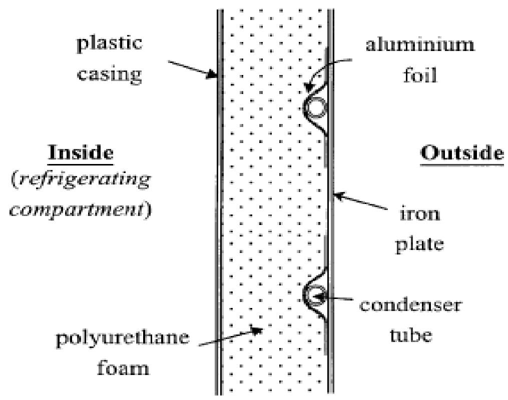


**Figure 1:**.Cross section of a hot-wall condenser on refrigerator’s wall [2]

The adhesive aluminum foil holds the tube in place and acts as a shield to prevent heat transfer into the refrigerating compartment. Since the condenser tubing is installed in a refrigerator wall, which is usually hot, it is called ‘‘hot-wall condenser’’. There are five panels namely the left, right, back, cross rail and base panel. The refrigerant flows from the back panel to the base panel, then to the right-hand side panel and through the cross rail to the left-hand side panel.

Since condensers are relatively inexpensive, they have been widely applied in household refrigerators and freezers – appliances that consume a considerable amount of energy since hundreds of millions are currently in use, and dozens of millions are coming onto the market every year [4].

## 2. Literature review

Alessandro Rebora [1] evaluates the heat transfer rates inside the wall of the hot-wall refrigerator by means of a parametric finite element model; in particular, a chest freezer for domestic applications was considered. A thermodynamic approach was employed to assess the relative heat transfer merits of the apparatus from the point of view both of the thermodynamic performance and of capacity. The sensitivity analysis of the design parameters affecting the performance was developed for fixed working temperatures with reference to the thickness of the metallic plates, the thickness of the insulating foam, the evaporator and condenser tube diameters and pitches, and the thermal contact resistance between the tubes and the plates.

Bansal and Chin [2] developed a simulation model for the hot-wall condenser for the refrigerant R134a in FORTRAN90 language. This study paper presents the experimental and modeling results of hot-wall condensers that are commonly used in domestic vapour compression based refrigerators. Experiments were carried out on a real refrigerator using R134a as the refrigerant to obtain the condenser capacity, pressure loss and degree of sub cooling at different operating conditions. A simulation model was developed to analyses the heat transfer characteristics of the condenser.

J.K. Gupta and M. Ram Gopal [3] was developed a mathematical model of hot-wall condensers that are commonly used in domestic refrigerators is presented. The model predicts the heat transfer characteristics of condenser and the effects of various design and operating parameters on condenser tube length and capacity. In this model condenser tube is divided into elemental units, with each element consisting of adhesive aluminum tape, refrigerant tube and outer metal sheet. The heat transfer characteristics of the condensers are then analyzed by considering the heat transfer through the tube wall, aluminum tape and the outer sheet. Variations in inner heat transfer coefficient and pressure drop are considered depending on temperature, fluid phase, type of flow and orientation of tube. In this study shows the aluminum tape used to stick the condensing tube to the outer sheet plays a significant role in heat transfer from condenser to environment.

Vinícius Brandani Labigalini and André Luiz Seixlack [4] develops a mathematical model of hot-wall condensers, commonly used in domestic refrigerators. The model predicts the heat transfer characteristics of the condenser and the geometric and operating parameters affecting the condenser tube length and capacity. The condenser tube of this model is divided into elemental units consisting of control volume, which contains the refrigeration fluid, the wall of the tube, and a bi-dimensional plate in contact with the atmospheric air. The heat transfer characteristics of the condensers are analyzed by considering the conduction heat transfer between the tube and the wall.

## 3. Analysis Of Hot Wall Condenser

### 3.1 Detail of Analysis

The wall is act as a fin. The wall is made of steel and it is provided for increase in contact area in convective heat transfer. By the using of fins the contact area of tube to air is increased therefore the heat transfers rate increase.

### 3.2 Preprocessing Detail

- Element type- PLANE 55 2-D Thermal Solid
- Analysis Type- Thermal
- Thermal Conductivity= 50 watt/m°C
- Density= 7.85 $Kg/m^3$
- Specific Heat= 450 J/Kg.K

### 3.3 Boundary Conditions for Natural Convection

Conduction and convection will occurred in tube plate configuration during heat transfer. Heat transfer process starts when hot refrigerant is passing from the tube. And heat is dissipated from the hot refrigerant to the atmosphere by conduction between wall and tube and by convection from the wall to the atmosphere. All the analysis has been done with the same boundary condition. By the taking data for boundary condition.

- Temperature of the refrigerant inside the tube = $43^0$C
- Film coefficient = 7.892 $W/m^2K$
- Bulk temperature = 34 $^0$C

## 4. Analysis of Existing Tube plate Configuration

### 4.1 Temperature distribution

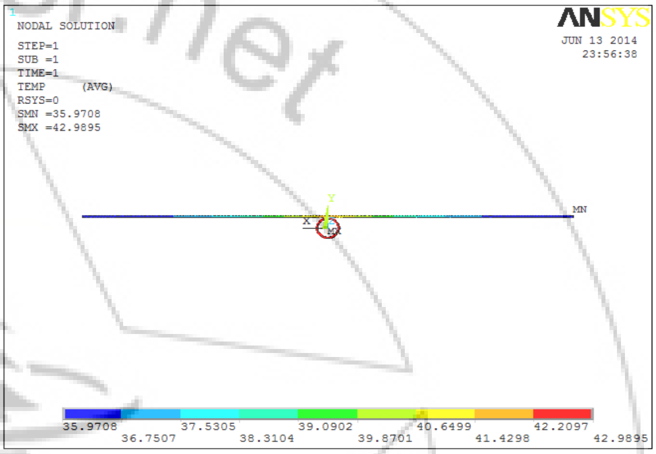


**Figure 2:** Temperature distribution of the present tube wall configuration.

The maximum temperature is $43^0$C which is inside the condenser tube and minimum temperature is 36 $^0$C is wall temperature is experimentally validated by multi thermometer as shown in **Figure 3** and **4**

**Figure 3:** Temperature inside the tube

**Figure 4:** Temperature measurement of wall

### 4.2 Heat flux

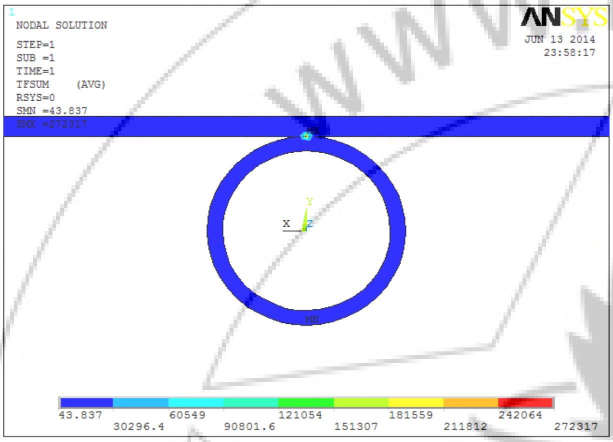


**Figure 5:** Heat flux of the existing tube plate configuration

The result of heat flux is almost same through-out whole tube plate configuration. The value of average heat flux is 43 $W/m^2$ which is within the range of 42.5 to 68.5 $W/m^2$ as per reference paper[2]

### 4.3 Thermal gradient

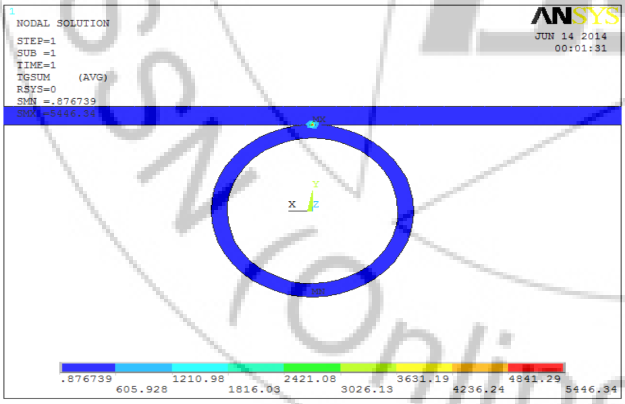


**Figure6:** Thermal gradient of the existing tube plate configuration

## 5. Analysis of Tube plate Configuration with contact angle 90°

### 5.1 Temperature distribution

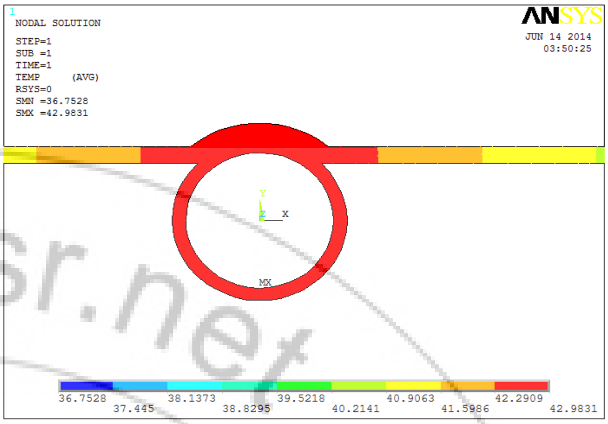


**Figure 7** Temperature distribution of the 90 degree contact angle

### 5.2 Heat flux

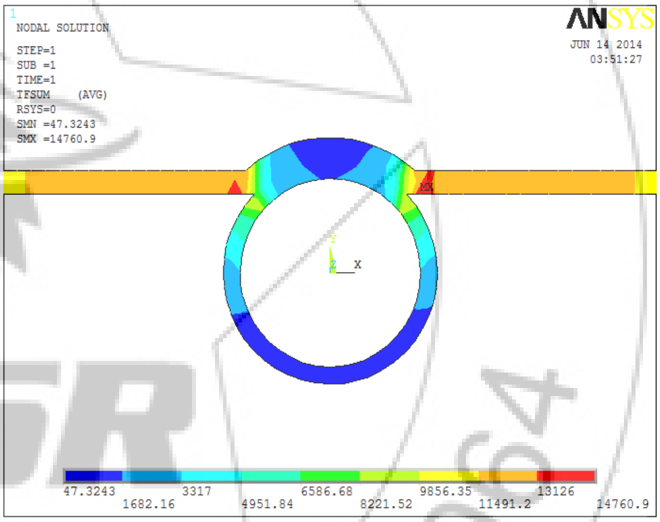


**Figure 8** Heat flux of the 90 degree contact angle

### 5.3 Thermal gradient

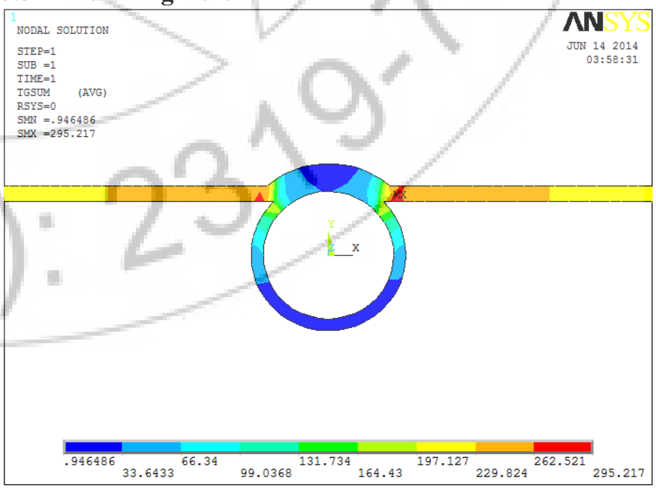


**Figure 9** Thermal gradient of the 90 degree contact angle

## 6. Analysis of Tube plate Configuration with contact angle 180°

### 6.1 Temperature distribution

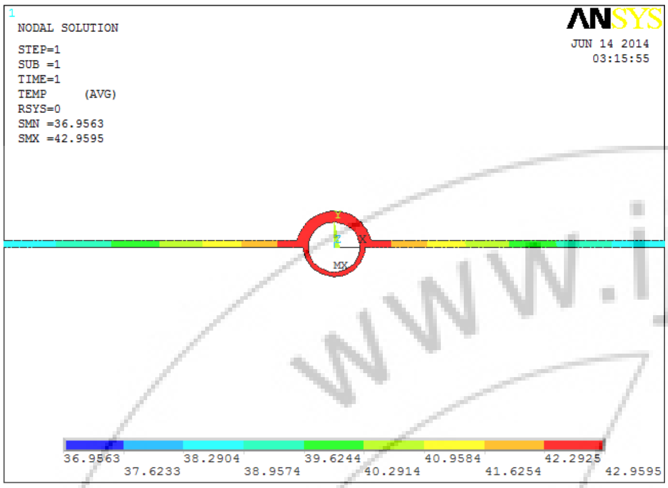


**Figure 10** Temperature distribution of the 180 degree contact angle

### 6.2 Heat flux

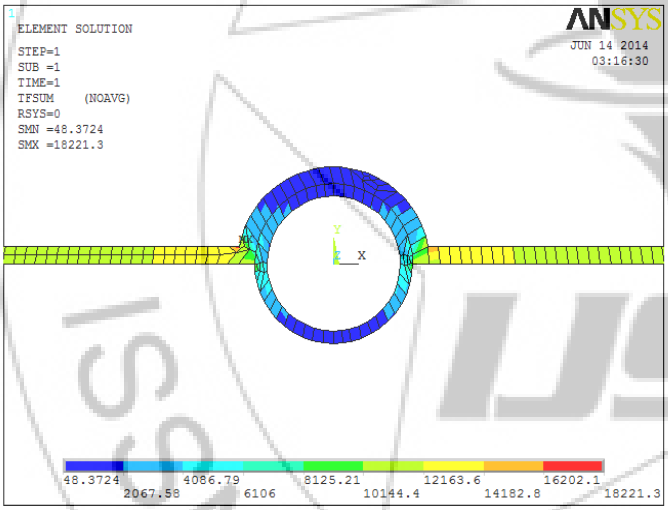


**Figure 11** Heat flux of the 180 degree contact angle

### 6.3 Thermal gradient

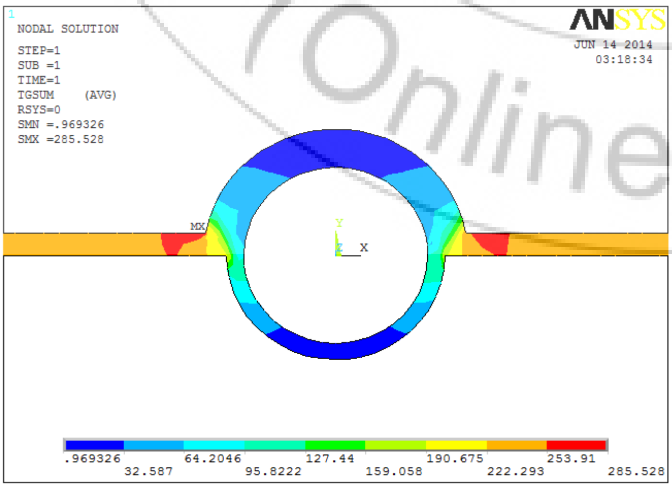


**Figure 12:** Thermal gradient of the 180 degree contact angle

## 7. Comparison of the Analysis Result

**Table 1:** Comparison of the existing tube wall configuration, contact angle 90 degree and contact angle 180 degree

| | | *Existing Configuration* | *90 Degree Contact Angle* | *180 Degree Contact Angle* |
|---|---|---|---|---|
| Temperature | min | 35.97 | 36.75 | 36.95 |
| | max | 42.98 | 42.98 | 42.95 |
| Heat flux | min | 43.83 | 47.32 | 48.37 |
| | max | 272317 | 14760.9 | 18221.3 |
| Thermal gradient | min | 0.8767 | 0.9494 | 0.9693 |
| | max | 5446.34 | 295.217 | 285.528 |

## 8. Conclusion

Geometrical parameter affects the heat transfer characteristic of the condenser. So the thermal analysis has been done in the ANSYS 14 for the present configuration and with contact angle 90 degree and 180 degree. From the analysis result of the ANSYS I have found out that if we increase the contact angle between tube and wall heat flux is increase and also thermal gradient is increase.

## 9. Future Scope

The same analysis can be done with better meshing using hyper mesh kind of software. Optimum contact angle can be found out by using Genetic Algorithm kind of advanced method. More number of cases can be studied. Experimental investigation can be done for further research work.

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## Author Profile

**Prof. Niraj C Mehta** has more than 7 years of experience in the field of Teaching, Research & Industry. He has published more than 10 Research Papers and Review Papers in the area of Heat Transfer, Computational Fluid Dynamics, Finite Element Method, Turbo Machinery, Automation, etc. in International referred Journals and presented/published in

International Conferences/Proceedings. He is a Reviewer and Editor of international referred journals in the field of Mechanical Engineering, Thermal Engineering, Computer Aided Manufacturing, etc. He is actively involved in Consultancy, Research and Testing in the area of Mechanical Engineering. His research interests include Computational Heat Transfer, Engineering Optimization, Finite Difference Method, etc. He has guided many PG Dissertations and UG Projects.

**Akasd D. Raiyani** received the B. E. degree in Mechanical Engineering from Government Engineering College, Surat in 2011. During 2012 he will work with Tube product corporate.