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# Enhancement of Heat Transfer in Water Heater with Fins

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**Abstract:**
Proper design of water heater will increase the rate of heat transfer so that the water will heat in less time with less energy consumption is the main purpose behind the design of water heater. In order to increase the heat transfer rate and efficiency of the water heater, the finned tube water heater is the one of the best way instead of water heater without fins. The heat transfer coefficient is the most important parameter for successful design. Analysis and modeling of tube with and without fins is very important.

**Keywords:** water heater, heat transfer, heat transfer coefficient, fins.

## I. INDRODUCTION

In recent years, the high cost of energy and material results an increased effort for producing efficient water heaters. The improvement of design techniques is relevant and important for better performance over several engineering applications. Although a number of research works have been performed to investigate the heat transfer and performance of fins, no publications relating to water heating boiler. The rate of heat transfer to water around a pipe can be greatly enhanced by the use of extended fins. The main objective in improving the performance of thermal system is to enhance heat transfer. To increase thermal performance of water heating boiler, it is necessary & effective to employ extended surface, referred to as fins, on the central pipe, to compensate for the low heat transfer coefficient. The prototype finned tube consists of equispaced fins mounted on the outer surface of tube, in order to locally augment heat transfer between the fin base area & the surrounding fluid. As heat conduction through fins is very efficient for metals, it results in high fin surface temperature & an increase of total active area. Presently the conventional water heating boiler used, has central pipe of large diameter or three pipes of small diameter, of 30 liter capacity. It takes 30 minutes to heat the water. Also common heat exchanger geometry consists of finned tube in cross flow, where as many studies have investigated the temperature distribution for single finned tube, few studies have probed the relationships between the temperature distribution & flow behavior. Heat is lost to atmosphere in conventional water heating boiler because no insulation is provided on the circumference of water heating boiler. Fins are widely utilized in many industrial applications such as in heat exchanger industries. For example, fins are used in air cooled finned tube heat exchangers like car radiators and evaporators and condensers of air conditioning units. Fins are also utilized in cooling of electronic components and gas turbine blades. In these applications, fins can have simple design such as spiral fins. In addition, fins can also be arranged in a complex network forming in fin system. This kind of fin assemblies is utilized in application requiring removal of large volumetric heat generation rate, such as cooling of large heat flux electronic devices. Presently the exhaust gases leaving from the central pipe are released in the atmosphere, that heat is lost in atmosphere. In ordinary water heating boiler, heating is required at regular interval of time to maintain the necessary temperature of water.

## II. LITERATURE SURVEY

Heat transfer enhancement is the process of improving the performance of a heat transfer system by increasing the heat transfer coefficient. In the past decades, heat transfer enhancement technology has been developed and widely applied to heating appliances. Modern technology requires more powerful and heat generating components to be utilized. Water heating is often the second largest energy expense, and may account for up to 20 percent of annual household energy costs. There are three ways to reduce hot water expenses: use less hot water, improve the efficiency of your present hot-water heater or purchase a new high efficiency model. A conventional water heater is a fairly simple appliance. It consists of a storage tank and a source of heat. The tank is usually steel and coated with glass or enamel to prevent corrosion. It is covered with insulation and enclosed in a steel jacket. The most common sources of heat are a gas burner or an electric resistance heating element. Both are controlled by a thermostat that responds when hot water is drawn from the tank. Electric water heaters: Most electric models use resistance coils inside the tank. Electric water heaters typically have slower recovery rates that many gas models. They make up for that with larger tanks. Although electric water heaters are generally more expensive to operate than natural gas models, they do have some advantages over gas. Electric units have no flue pipe, so you can put one almost anywhere in your home, for instance, in a closet, or under a sink. The entire tank is surrounded with insulation so less heat is lost when compared to a standard gas model. Insulation should be kept at least three inches from the draft hood and flue. Due to the high demand for lightweight, compact, and economical fins, the optimization of the fin size is of great importance. Therefore, fins should be designed to achieve high heat removal with low material expenditure, with-the ease of manufacturing the fin shape. Other studies have introduced shape modifications by cutting some materials from fins to make cavities, holes, slots, grooves or channels through the fin body to increase the heat transfer area and/or the heat transfer coefficient. her

**Types of extended surfaces (fins):**
1) Straight Fins
2) Tapered Fins
3) Circular Fins

**Figure.1. Extended Surfaces**

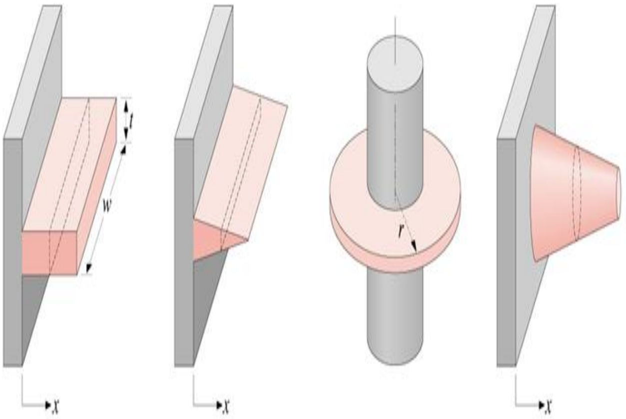


**Figure.2.(A)Straight fin Fig (B).Tapered fin Fig (C).Circular fin Fig (D).Pin fin**
**Figure.II.Types of Extended Surfaces**

## III. METHODOLOGY/REASEARCH PLAN

Computational Fluid Dynamics (CFD) means predicting fluid flows and heat transfer using computational methods. CFD is based on various disciplines of science such as mathematics, computer engineering and physics to provide meaningful modeling of fluid flows. CFD is primarily concerned with numerical solutions of differential equations such as conservation of mass, momentum, and energy in moving and deforming fluids.

**The CFD codes contain essentially three main stages;**

**Pre-processor:**
Pre-processing means creating a representative model of flow problem before numerical solution process. This part also consists of some necessary inputs of the flow problem given by the analyzer and these inputs are transformed to the solver

**Solver:**
There are three different streams of numerical solution techniques. These are finite difference or finite volume method (FVM) which is another special form of finite difference, finite element and spectral methods. The problem under consideration was solved by using FVM solution techniques.

**Post-processor**:
This is the final step in CFD analysis, and it involves the organization and interpretation of the predicted flow data and production of CFD images and animations.

**Steps Used in CFD Analysis:**

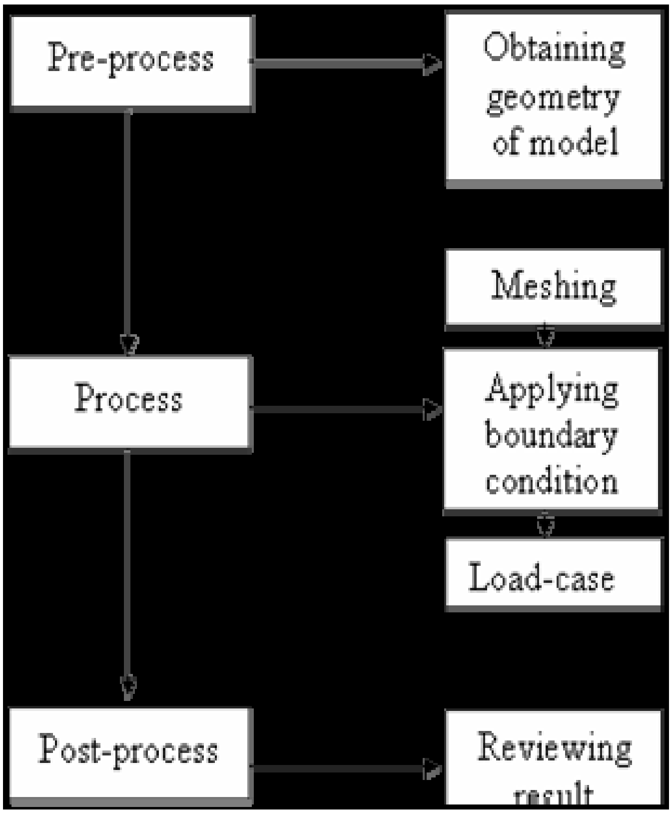



**Figure.3.Typical CFD procedures by commercial software**

## IV. EXPERIMENTAL INVESTIGATION

**1.Experimental Setup**

1. Circular Tube with Trapezoidal Fins

2. Electric Heater

3. Thermocouple

4. Digital Indicator

5. Dimmer Stat

6. Shell

7. Upper and Lower Lids

**Figure.4. Tube with Trapezoidal Fins**

## 2. Software simulation

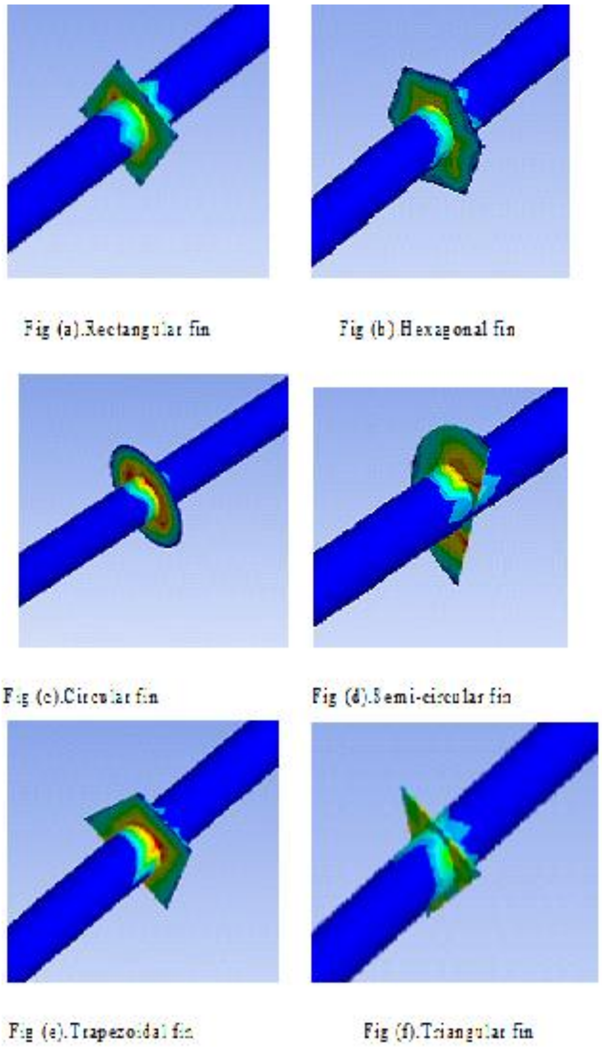



**Figure.5. Different types of fins**

## 3.NUMERICAL CALCULATIONS-

**Calculation for Effectiveness of Fins:**

The following data available for the rectangular fins:

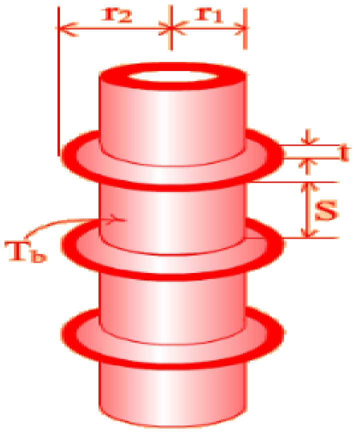



**Figure.6.3 Circular Fins Mounted on Aluminum Cylinder**

Where,

Q - constant amount of heat supplied (11 W),
L - length of pipe (50 mm).
$L_1$ - length of fin (15mm).
t – thickness of fin (3mm).
h - convective heat transfer coefficient of water ($128.45\ W/m^2K$).
$r_2$– radius of fins (32 mm).
n – number of fins (3).
S – space between the two fin (12.5 mm).

In the case of **no fins**, heat transfer from the tube per unit length is determined from Newton's law of cooling,

$A_{no\ fin} = \pi D_2 L = \pi (0.034)*(0.05) = 0.00534\ m^2$

$Q_{no\ fin} = h A_{no\ fin} (T_2 - T_3)$

$Q_{no\ fin} = 128.45*0.00534 (331.743-315.32)$

$= 11.26$ W

**Fin case-**

$A_{fin} = 3*2\pi (r_2^2 - r_1^2) + 3*2\pi r_2 t$

$A_{fin} = 3*2\pi (0.032^2 - 0.017^2) + 3*(2\pi\ 0.032*0.003)$

$A_{fin} = 0.01566\ m^2$

$Q_{fin} = \eta_{fin} Q_{fin\ max} = \eta_{fin} hA_{fin} (T_2 - T_3)$

$= 0.93*128.45*0.01566*(331.743 - 315.32)$

$= 30.73$ W

The space (S) between the two fins is 12.5 mm,

Heat transfer from the unfinned portion of the tube is,

$A_{unfin} = \pi D_2 *2*(S+ S_1)$

$= \pi (0.032) *2* (0.0125+0.008) = 0.0041217\ m^2$

$Q_{unfin} = h A_{unfin} (T_2 - T_3)$

$= 128.45*0.0041217*(331.743 - 315.32)$

$Q_{unfin} = 8.695$ W

There are 3 fins in 50 mm length of the tube, the total heat transfer from the finned tube becomes,

$Q_{total\ fin} = (Q_{fin} + Q_{unfin})$

$= (30.73+ 8.695)$

$= 37.227$ W

Therefore, the effectiveness ($\varepsilon$) of fins

$$\varepsilon = \frac{Q_{total\ fin}}{Q_{no\ fin}} = \frac{39.425}{11.26}$$

$\varepsilon = 3.501$

When, 1. $\varepsilon < 1$, no need of fins.

2. $\varepsilon = 1$, no change in heat transfer rate if fins are mounted.

3. $\varepsilon > 1$, need of fins. But in practically it should be greater than 2.

## V. RESULTS AND DISCUSSION

Shape of fin- To find best shape fin software analysis is done-

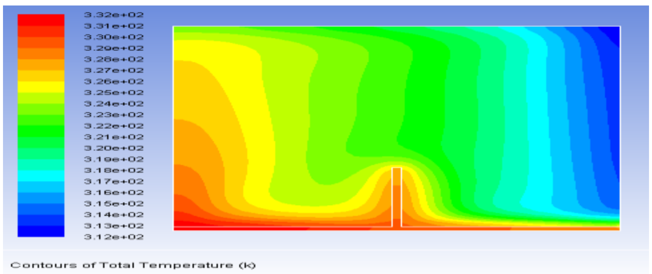



**Figure.7. Contours of Total Temperature For Tube With Single Rectagular Fin**

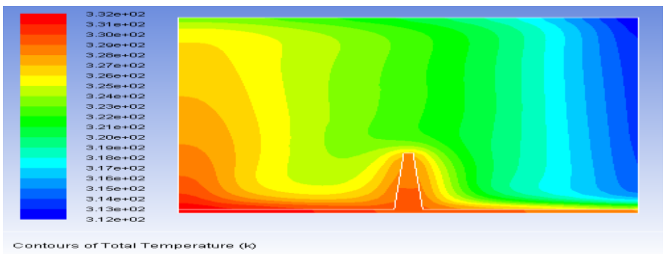


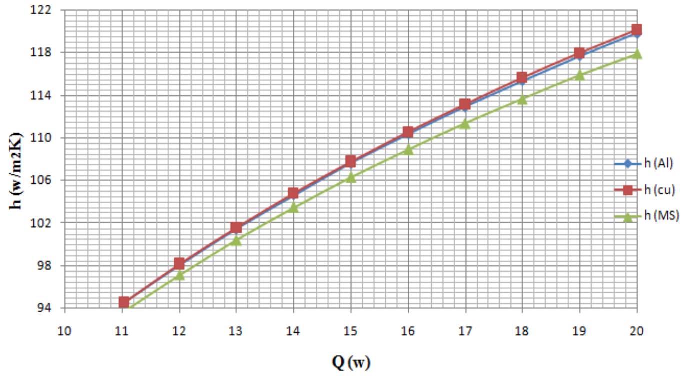

**Figure.8. Contours of Total Temperature For Tube With Single Trapezoidal Fin**

Comparision of Rectangular and Trapezoidal Fins

| Sr.No. | Shape of fin | Temperature (K) | | Total heat transfer rate (w) | Surface heat transfer coefficient (w/ m$^2$K) |
|---|---|---|---|---|---|
| | | Max. | Min. | | |
| 1 | Rectangular fin | 331.93 | 312.11 | 11.04 | 108.26 |
| 2 | Trapezoidal fin | 331.67 | 312.12 | 11.04 | 106.0231 |

Above table shows that the trapezoidal fins are more effective than the other fins.

Experimental comparison between Different materials




Above Graph shows relationship between the surface heat transfer coefficient and heat transfer rate. Red curve indicates the variation of surface heat transfer coefficient with respect to heat transfer rate for copper. Similarly blue curve for aluminium and green curve for mild steel. The value for surface heat transfer coefficient is less for mild steel as compare to aluminium and copper. Aluminium and copper have nearly same surface heat transfer coefficient for the lower value of the heat transfer rate but as the heat transfer rate increases the slightly variation in surface heat transfer coefficient occur which is shown in the graph.

## VI. CONCLUSION

In this study we are doing **Numerical Calculation** for heat transfer in water heater with fins, doing **Software Analysis** and **CFD** on the same model to find out optimum material for fin, number of fins required in given length and optimum shape of fin. Fins are provided to dissipation of heat which is developed in heater we are expecting 5-10 % increase in dissipation.

## VII. REFERENCES


[1]. A. E. Bergles, Handbook of Heat Transfer, McGraw-Hill, New York, NY, USA, 3rd edition, 1998.

[2]. J. K. Hagge and G. H. Junkhan, “Experimental study of a method of mechanical augmentation of convective heat transfer in air,” Tech. Rep. HTL3, ISU-ERI-Ames-74158, Iowa State University, Amsterdam, The Netherlands, 1975. View at Google Scholar

[3]. Nada S.A. 2007 Natural convection heat transfer in horizontal and vertical closed narrow enclosures with heated rectangular finned base plate International Journal of Heat and Mass Transfer **50** 667-679

[4]. A. A. Mohamad, “Heat transfer enhancements in heat exchangers fitted with porous media. Part I: constant wall temperature,” International Journal of Thermal Sciences, vol. 42, no. 4, pp. 385–395, 2003. View at Publisher · View at Google Scholar · View at Scopus

[5]. W. M. Kays, “Pin-fin heat-exchanger surfaces,” Journal of Heat Transfer, vol. 77, pp. 471–483, 1955. View at Google Scholar

[6]. A.D. Kraus, A. Aziz, J.R. Welty **Extended Surface Heat Transfer** John Wiley, New York (2002)

[7]. Ismail Farhad Md., Reza M.O., Zobaer M.A. and ali Mohammad 2013 Numerical investigation of turbulent heat convection from solid and longitudinal perforated rectangular fins 5th BSME Conference on thermal engineering.

[8]. Harlow, F. H. (2004). *"Fluid dynamics in Group T-3 Los Alamos National Laboratory:(LA-UR-03-3852)"*. *Journal of Computational Physics*. Elsevier. **195** (2): 414–433. *Bibcode*: *2004JCoPh.195..414H*. *oi*:*10.1016/j.jcp.2003.09.031*.

[9]. *ANSYS Fluent 17.0 Introduces New User Interface > ENGINEERING.com"*. ENGINEERING.com. February 5, 2016. *Retrieved June 16, 2017*.