# Comparison heat transfer between finn solar water heater pipe and normal solar water heater pipe using cfd

**Siwan E. Perangin-angin and HimsarAmbarita**

Sustainable Energy Research Centre, Universitas Sumatera Utara, Jl. Almamater Kampus USU, Medan 20155, Indonesia

edi_siwan@yahoo.com

**Abstract**. The development in the world of energy conversion has been progressing especially in the field of applying renewable energy resources related to the Sun. The application is not only in the world of industry but includes the smallest part or household. One application of solar energy resources is solar water heater. Solar water heater is a tool that utilizes heat from the collector to heat water flowing in tubes that are expected to increase the fluid exit temperature. In this study an increase in the efficiency of solar water heater is done by increasing the surface area of the pipe by adding fins on the side of the pipe which are expected to increase the temperature of the fluid out of the pipe that is plain or does not have fins. With the simulation method using CFD software obtained an increase in pipe exit temperature by 0.9%. this shows that in a part of a double-finned pipe, it does not significantly affect the increase in fluid exit temperature.

## 1. Introduction

One application of solar energy sources as an alternative energy source is currently using Solar Water Heater [4]. In general, the majority of the water supply system in the world still uses electricity as an energy source. With the increasing limited fossil energy sources, the study of Solar Water Heaters is increasing [7]. And from the results of the study shows a very promising prospect, in the future. This need is in line with the needs of urban people who make Hot Water for one of their daily needs. The use of water heaters accounts for 13-17% of housing energy consumption in America [6]. Especially in developing countries, including Indonesia, which has the potential for solar radiation which is quite long every year. And this potential is very promising for the development of Solar Water Heaters in Indonesia.

The working principle of Solar Water Heater is almost the same as the working principle of Solar Cookers or even Solar Collectors in general [1]. Where utilizing solar energy to heat the collector, heat is present in the collector, heat transfer occurs by convection and radiation [1]. This heat transfer process is used to heat water flowing in a tube at a certain speed [7]. There are several types of solar collectors, including flat plates, evacuated tubes, and parabolic troughs. collectors (FPC) and evacuated tube (ETC) collectors [3] are collectors that are most widely used by the general public for household water heater applications. The factor that affects the performance of the Solar Water Heater plate is the absorber plate [2]. In general, the type of absorber plate used for solar water heater is a type of flat plate because it is simpler and easier to obtain.

The efficiency of the Solar Water Heater has a higher efficiency than conventional water heaters. Usually conventional water heaters use electrical energy to turn on the heater which will produce heat and the heat is transferred to the water to be heated. And this requires a fee that we pay every month. In contrast to solar water heater using the energy of the Sun which is not required as a source of energy because of its availability from the Sun. this factor is what makes the use of solar water heater more and more.

In the present, research on solar water heater continues. How to increase the efficiency of the solar water heater even higher. From the results of previous studies there are several methods to improve the efficiency of a Solar water heater. First, by increasing the number of pipes and increasing the absorption area of the pipe [7]. With the increase in heat absorption area in the pipe, it is expected to increase the rate of heat transfer from the pipe to the fluid so that the exit temperature of the fluid gets higher. From this basis research is carried out on how to improve the efficiency of solar water heater by adding absorption areas of the pipe by adding fins to the pipe.

The Experimental Test and Simulation test are alternatives to see the extent of the effectiveness of a solar water heater design. From the development of increasingly developing technology, simulation is becoming a method that is increasingly being used compared to the experimental method. For simulation tests can use CFD software [5] which is useful for predicting the results of fluid flow temperature out of the solar water heater pipe. So that we can compare the performance of each solar water heater design without having to make it on a real scale that requires a lot of costs.

## 2. Method

This study refers to experimental data from previous studies. The data that has been presented is then processed with the help of other CFD devices. This study compared 2 different solar water heater pipe designs with a length of 1 meter, pipe diameter 1.75 cm and pipe thickness of 0.03 cm. for the dimensions of the fin has a thickness of 0.1cm and is 2.5 cm thick and 2 m long. Fluid flow velocity variations are 0.395 m/s, 0.5 m/s and 0.6 m/s

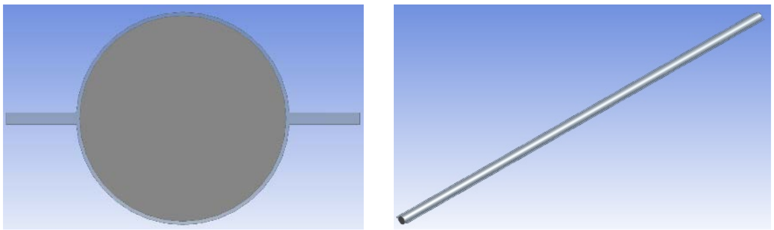


**Figure 1.** Finned pipe geometry

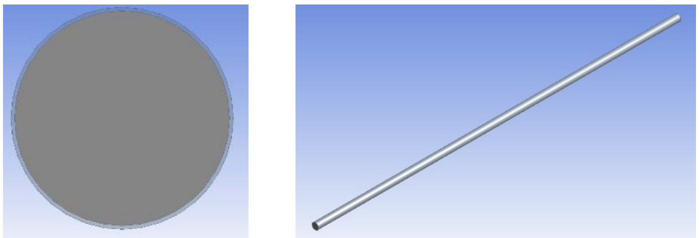
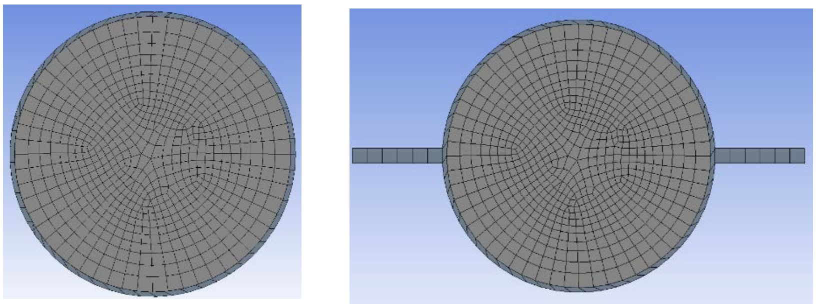


**Figure 2.** Plain pipe geometry

The boundary conditions entered are obtained from the previous data experiment. The pipe is considered to get convection heat transfer of 176.48 w / $m^2$-K, Collector Temperature $65^0$C and pipe inlet flow velocity 0.395 m/s.



(a) (b)

**Figure 3.** Meshing (a) for plain pipes, (b) finned pipes

2.1. Simulation

3 D simulation in Steady State conditions, for turbulent flow, the turbulence model is the standard k-ε. The field of speed and pressure in the collector is determined using the law of conservation of mass and momentum. For laminar flow, the continuity equation is defined by:

$$\rho\left(\frac{\partial u_x}{\partial x}+\frac{\partial u_y}{\partial y}+\frac{\partial u_z}{\partial z}\right)=0$$

The momentum equation is:

$$x-component\colon u_x\frac{\partial u_x}{\partial x}+u_y\frac{\partial u_y}{\partial y}+u_{yz}\frac{\partial u_x}{\partial z}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\frac{\mu}{\rho}\left(\frac{\partial^2 u_x}{\partial x^2}+\frac{\partial^2 u_x}{\partial y^2}\frac{\partial^2 u_x}{\partial z^2}\right)$$

$$y-component\colon u_x\frac{\partial u_y}{\partial x}+u_y\frac{\partial u_y}{\partial y}+u_{yz}\frac{\partial u_y}{\partial z}=g_y\beta(T-T_\infty)+\frac{\mu}{\rho}\left(\frac{\partial^2 u_y}{\partial x^2}+\frac{\partial^2 u_y}{\partial y^2}\frac{\partial^2 u_y}{\partial y^2}\right)$$

$$z-component\colon u_x\frac{\partial u_x}{\partial x}+u_y\frac{\partial u_y}{\partial y}+u_{yz}\frac{\partial u_z}{\partial z}=-\frac{1}{\rho}\frac{\partial p}{\partial z}+\frac{\mu}{\rho}\left(\frac{\partial^2 u_z}{\partial x^2}+\frac{\partial^2 u_z}{\partial y^2}\frac{\partial^2 u_z}{\partial z^2}\right)$$

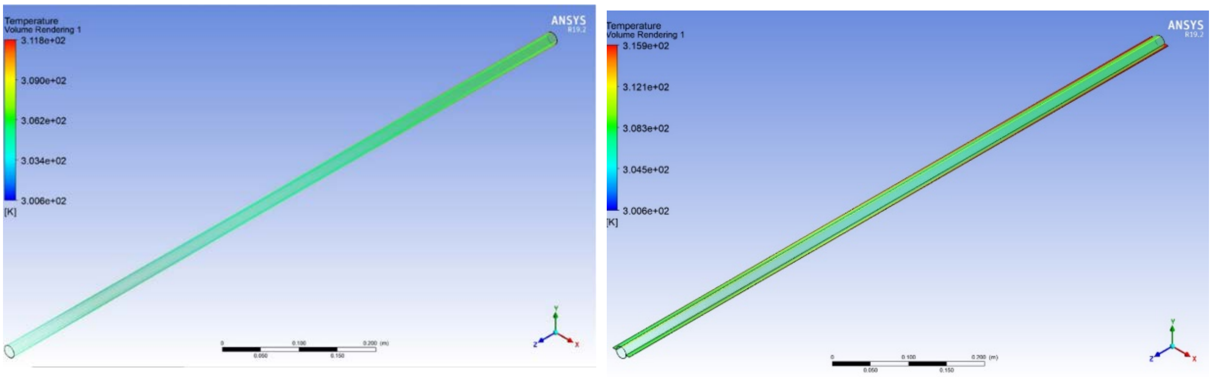
This model is suitable for turbulence flow studies and is already commonly used for a variety of practical engineering flows because of reasonable accuracy for various turbulent flows. The standard equation k-ε is defined as

$$\frac{\partial}{\partial x_i}(\rho k u_i)=\frac{\partial}{\partial x_i}\left[\left(\mu+\frac{\mu_t}{\sigma_k}\right)\frac{\partial k}{\partial x_j}\right]+G_k+G_b-\rho\varepsilon-Y_M$$

$$\frac{\partial}{\partial x_i}(\rho\varepsilon u_i)=\frac{\partial}{\partial x_i}\left[\left(\mu+\frac{\mu_t}{\sigma_k}\right)\frac{\partial k}{\partial x_j}\right]+C_{1\varepsilon}\frac{\varepsilon}{k}(G_k)-C_{2\varepsilon}\rho\frac{\epsilon^2}{k}$$

## 3. Result

### 3.1. Temperature Distribution




(a)(b)

**Figure 4.** (a) Plain pipe temperature distribution contour, (b) Finn pipe temperature distribution contour

From the picture above, you can see a color change contour that shows changes in temperature changes that are increasing. There was an increase in exit temperature from finned pipes of 0.264 $^{0}$C

**Table 1.** Water Temperature

| Pipe type | T in ($^{0}$K) | T out ($^{0}$K) |
|---|---|---|
| Fin | 27.499994 | 28.664715 |
| Plain/Normal | 27.499994 | 28.400834 |

3.2. Graph of comparison of mean temperature along fin and plain pipes with variations in velocity of fluid flow

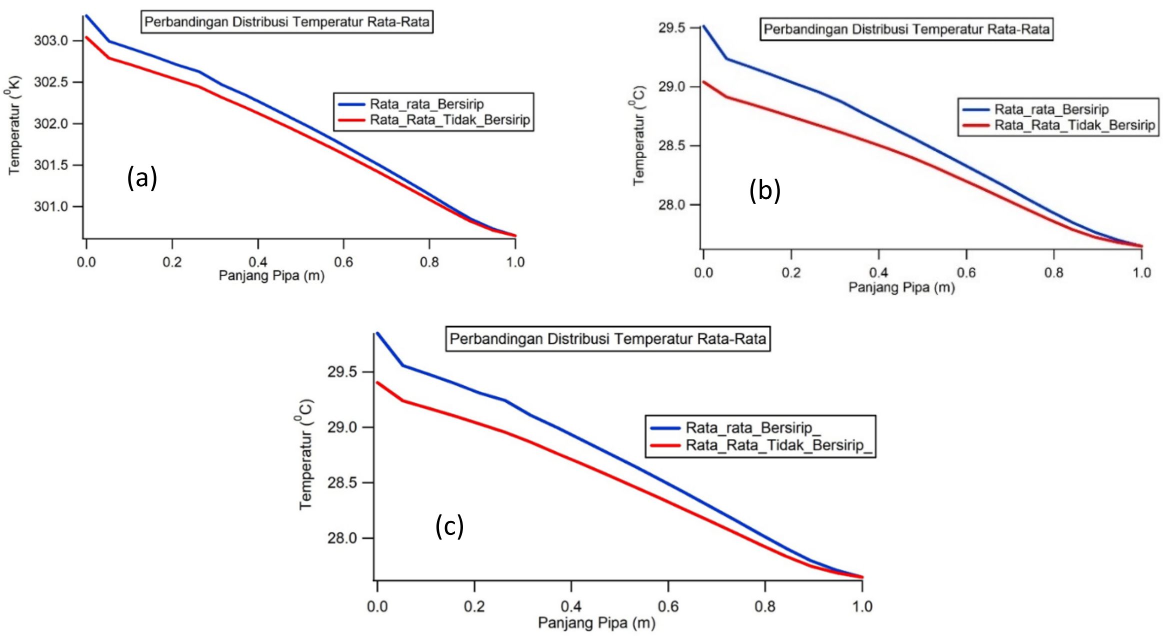


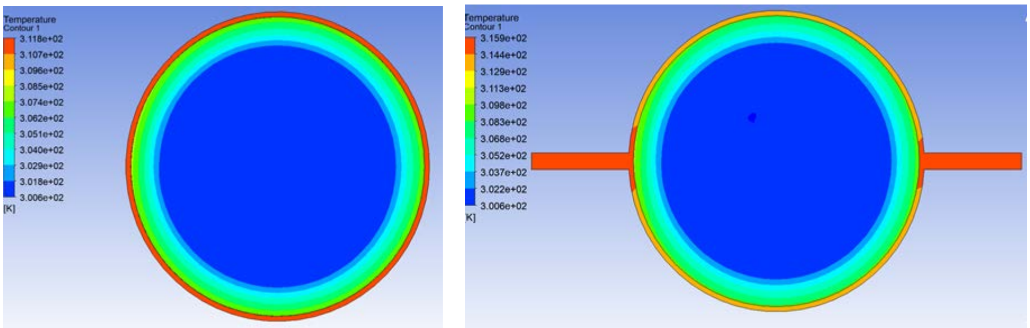

**Figure 5.** Graph of comparison of speed temperature 0.395 m/s (a), speed of 0.5 m/s (b), Speed of 0.6 m/s (c)

From the graph above, shows the trend of increasing temperature in finned pipes at each speed variation made.

### 3.3. Comparison of temperature contour at each intersection

The cutting points taken are 0.2 m, 0.4 m and 0.6 m from the pipe outlet point

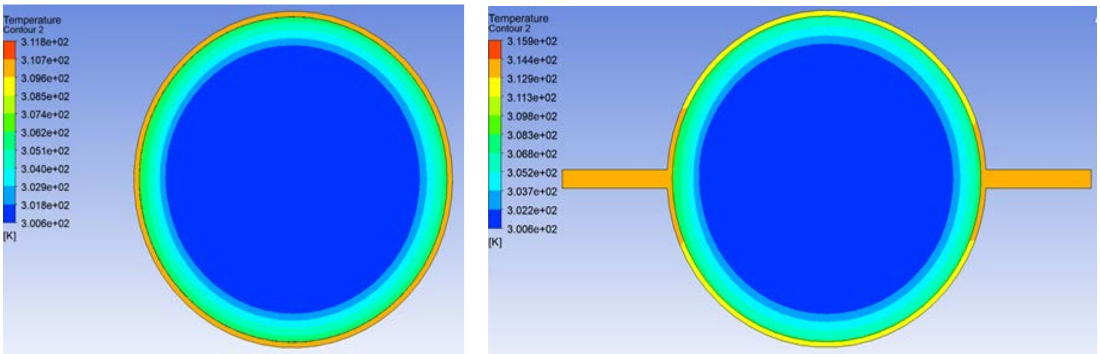
- Distance of 0.2 m Velocity of 0.395 m/s




(a) (b)

**Figure 6.** Contour temperature distance 0.2 m from a plain pipe outlet (a), Fin Pipes (b)

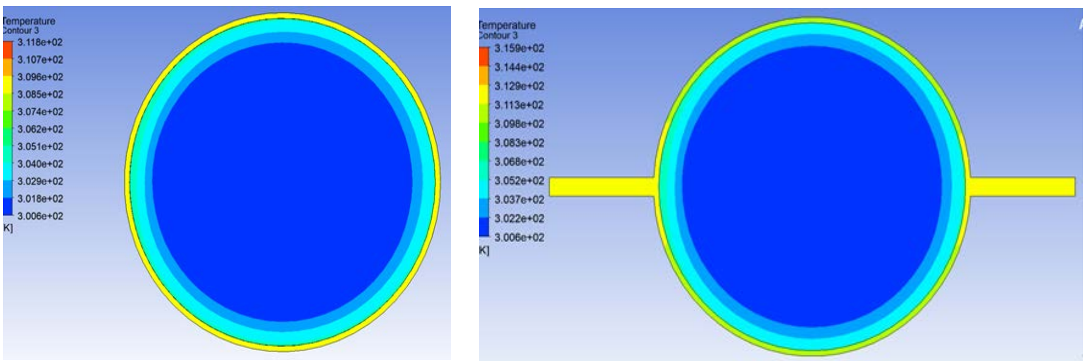
- Distance of 0.4 m Velocityof 0.395 m/s




(a) (b)

**Figure 7.** Distance of temperature calculation of 0.4 m from a plain pipeline(a), Pipe Fins(b)

- The distance of 0.6 m is the speed of 0.6 m/s




(a) (b)

**Figure 8.** Contour temperature distance of 0.6 m from a plain pipe outlet (a), Fin Pipes (b)

## 4. Conclusion

From the results of simulation of 2 pipe designs there is an increase in fluid outflow temperature of 0.9291% and this does not have a significant effect on the efficiency of solar water heater. And can be confirmed from countur to two pipes when cut, there is no change which means at each cutting point 0.2 m, 0.4 m and 0.6 m.

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