ABSTRACT

Heat transfer is involved in some processes such as heating, drying, cooking, and cooling. The amount of heat transferred depends on the area, temperature difference, fluid properties, geometry of duct, and heat transferred mechanism. An advantageous heat exchanger for tropical country is a solar collector. Water or air is the common fluid heated in the collector. The air solar heater is better in some ways compare to water solar heater, such as it is lighter, no leakage problem, and not corrosive. Unfortunately, air has much less thermal conductivity and convection heat transfer coefficient than water.

Two of many findings that are proven able to improve the air solar heater’s performance are: 1) using v-corrugated absorber plate instead of flat plate, 2) inserting obstacles in a flat plate air solar collector. Yet, no research was conducted to combine both. This research was done to find the effect of inserting obstacles on the bottom plate to the performance of a v-corrugated-air solar heater. Obstacles are chosen because it directs the flow toward the absorber plate and increase the turbulence in the air flow. Since obstacles increase the pressure drop, it will be better if we fold the obstacles. So, the effect of folding obstacles vertically on the heat transfer and pressure drop inside air collector is observed in this research, too.

The research was conducted experimentally and numerically. Gambit 2.4.6 and Fluent 6.3.26 are used for numeric simulation. The simulation was conducted for no obstacle-air flow, straight (0°) obstacle air flow, and other obstacle angles, i.e., 10°, 20°, 30°, and 40°. Domain of the numerical simulation is the same as for the experimental studies. It is air flow in a duct which cross section is triangle. The duct is comprised of absorber plate in upper and a flat plate in bottom. The first step in numerical simulation is ensuring the grid independency and then choosing the suitable viscous model. When the grid size does not change the result of simulation, then it satisfies the grid independency. The suitable viscous model is chosen when it gives the same result with experiments.

Numerical simulation gives detail velocity vector of air flow when it is near, struck, and over the obstacles. The flow separation happens near the tip of the obstacles and the vortex is formed at the downstream of the obstacles. Vortex formation is reduced when the obstacle is folded vertically. The velocity vector of air between the tip of obstacles and absorber plate is high in downstream of the flow where vortex happens. This high velocity improves the
convection heat transfer and increases the outlet air temperature when obstacles are inserted in the flow. Yet, obstacles increase the pressure drop, too.

The larger the angle of obstacles folded vertically, less vortex and lower velocity near plate is found. These makes convection heat transfer, outlet air temperature, and pressure drop are reduced when obstacles folded with large angle.

Temperature distribution show the temperature increase along the duct. Obstacles folded vertically lower the outlet air temperature compare to straight obstacles. The temperature distribution shows that air temperature reaches its "free stream” temperature ($T_\infty$) faster with straight (0°) obstacles than folded obstacles. The larger the angle of obstacles, the lower the air free stream temperature $T_\infty$.

Experiment conducted indoor to maintain the room in fix condition. Four halogen lamps are used to replace Solar with four adjuster separately to emit the same radiation on the cover glass. The measurement devices are installed complied with ASHRAE’s regulation. A blower is used to draw air. There will be five different air flow rates, three different radiation intensities, and nine different obstacle angle. A variable-frequency drive (VFD) is used to adjust the rotation of blower’s motor to maintain the same air flow rate during an experiment. The variables to be measured are inlet and outlet air temperature, absorber plate temperature, air velocity at outlet, and radiation intensity.

From experiments conducted between 2,000 and 10,000, it was found that the highest air temperature was 34.9°C. It happened when the radiation intensity was 716 W/m², Reynolds number was 2,000 with straight obstacle which spacing is 1 x its height and gave 6.5 Pa of pressure drop.

The highest efficiency was 0.85 when the the radiation intensity was 430 W/m², Reynolds number was 10,000 with straight obstacle which spacing is 1 x its height and gave 409 Pa of pressure drop.

The collector’s efficiency is reduced when the obstacle is folded, but its pressure drop is reduced, too. A rasio ($\Delta P/\Delta Eff$) is created to obtain the optimal obstacle’s angle. The high rasio shows the optimal collector. From the experiment, it was found that the optimal angle is 30°.

From the experiment, the empirical equation of Nusselt number as a function of Reynolds and Prandtl numbers for air flow with 30° obstacle folded vertically is $Nu = 0.00064 \cdot Re^{1.386} \cdot Pr^{0.4}$.