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Aluminum Pipe Orientation and Diameter Change Effect on overall heat transfer coefficient in Heating System

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ABSTRACT: The objective of this work is to study experimentally the effect of water flow rate on the overall heat transfer and the rate of heat rejected from aluminum pipe of diameter (30 mm, 50 mm). Experimental data are obtained from tested rig with different conditions. Results obtained from calculations with its curves are discussed with conditions changing. The U results show when water flow rate increase, its values increase for horizontal and vertical tested pipe because of increase in the internal thermal resistance due to increase in the Res number and water velocity. The results show that the values of U for 50 mm pipe diameter are less than for 30 mm pipe diameter for the same flow rate because of water velocity and Res number decrease. The heat rejected rate results through the pipe to ambient shows when water flow rate increase; its values increase for horizontal and vertical tested pipe because of increase in U value and temperature difference. The results show that the values of heat rejected rate for 50 mm pipe diameter are greater than for 30 mm pipe diameter for the same flow rate because of pipe outside area increase. The heat rejected rate in the pipe of 50mm diameter are greater than in the pipe of 30mm diameter for the same water flow rate and for all average water temperatures because of outside pipe area increase.

KEYWORDS: aluminum pipe; rig; thermal resistance; velocity; ambient

INTRODUCTION

Fluid or gas move through channels or pipes is usually utilized in warming and cooling applications. The liquid in such applications is compelled to stream by a pump or fan through a cylinder that is adequately long to achieve the desired heat transfer. Non-circular tubes are commonly used in applications such as heating and cooling systems for buildings where pressure differentials are relatively small and manufacturing and installation costs are lower. [1]. The lack of engineering tools is one of the biggest barriers to applying advanced fluid physics science. For example, is it appropriate to use total predictive methods for scaling small channels for the required single-stage heat transfer and pressure drop? Some published data on friction characteristics for small channels show a great discrepancy between the small channel data and overall channel forecasts. Laminar flow, turbulence flow,and pressure drop in the micro ducts can vary greatly from overall range predictions. This manuscript deals with several phenomena in terms of possible cause difference between "micro" measurements and "macro" prediction methods. [2]. Derivation of temperature solutions includes channels with different cross-sectional geometry. Primarily, the modified Graetz problem is considered in parallel plate ducts and circular tubes. This presentation includes digital features to solve the exact series of these two channels using the Brinkman model. Results were compared to the results of another numerical study based on the two measured measures. Moreover, as a test case, the weighted waste method provided flow and heat transfer in elliptical paths. The results include calculating the transfer of heat to the fluid flow through elliptical passages in different transverse proportions [3]. The value of U is a measure of how easily heat can be transferred to something. The maximum required maximum value of U is 0.3 for building the entire wall, from room temperature to outside temperature. Local U values can be specified at any point (instead of the vertical plane) within the wall. The U value of the left side of the air gap is in the bore, as the heat travels from the insulation to the air. Another U value exists for the inner surface of the outer wall, as the heat travels from the air gap to the outer wall [4].

The object of this work is to study experimentally the effect of water flow rate and tested pipe diameter on the U value and the rate of heat rejected through aluminum pipe to ambient. In the following sections, experimental tests runs are performed with different operating conditions. Experimental results obtained are discussed with water flow rate and pipe diameter.

EXPERIMENTAL SETUP

The experimental rig had been designed and constructed in the present work to investigated aluminum pipe orientations and diameter change effect on U in heating system. The rig that used in this experiment consists from the hot water tank heatedby electricity, rubber pipes joints the parts with other, flow meter measure the hot water flow rate passes through in (Liter/min.), Two aluminum test pipes one of different diameters, digital thermocouple records temperatures of different positions at same time and thermocouples placed on the region needed. The schematic diagram of test rig is shown in figures (1) and (2).

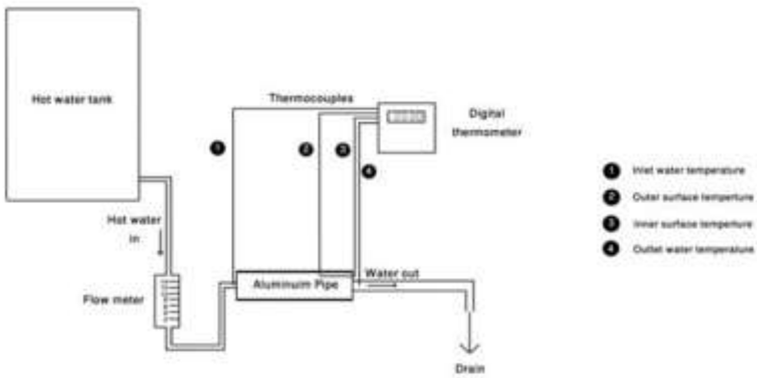

Figure 1. Horizontal tested pipe rig

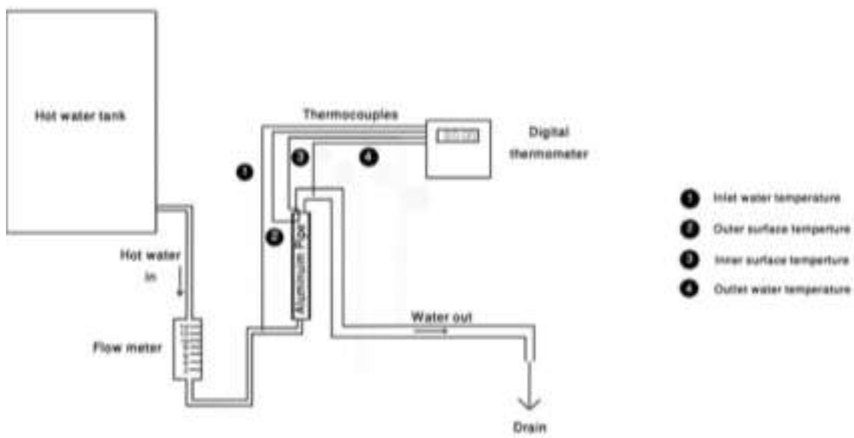

Figure 2. Vertical tested pipe rig

Experimental Procedure

Preparation of test:-

1- Preparation the hot water in the tank.

2- Jointing the pipe needed for test.

3- preparation the thermocouples with the thermometer.

Tested procedure for 30mm horizontal pipe:-

1- Opening the valve of entering the hot water rate at 2 Liter/minute.

2- After the water flow stabilization and attaining steady temperature of water, the temperature of water inlet and exit through pipe had been recorded. Also the temperature of inside and outside of the had been recorded. These two later temperatures have been recorded to assure heat rejection from water through walls and so the ambient.

3- Changing the water flow rate to 3 Liter/min. and then record the same temperatures in item (2). The water flow rate changed and same temperatures have been recorded until it reaches 6 Liter/minute.

4- Changing the hot water temperature passed through the pipe and repeat the same steps of the test.

Tested procedure for 30mm vertical pipe :-

The same procedure in items above has been repeated for vertical position of pipe.

Tested procedure for 50mm horizontal pipe :-

1- Opening the valve of entering the hot water rate at 2 Liter/minute.

2- After the water flow stabilization and attaining steady temperature of water, the temperature of water inlet and exit through pipe had been recorded. Also the temperature of inside and outside of the had been recorded. These two later temperatures have been recorded to assure heat rejection from water through walls and so the ambient.

3- Changing the water flow rate to 3 Liter/min. and then record the same temperatures in item (2). The water flow rate changed and same temperatures have been recorded until it reaches 6 Liter/minute.

4- Changing the hot water temperature passed through the pipe and repeat the same steps of the test.

Tested procedure for 50mm vertical pipe :-

The same procedure in items above has been repeated for vertical position of pipe.

RESULTS AND DISCUSSION

Results of 30mm pipe diameter

(U) results

Figure (3) illustrate the variation of U based on outside area of the pipe versus water flow rate for horizontal pipe. The results show when water flow rate rises; the U increases because of increase in the value of water (inside) heat transfer coefficient due to increase in the Re number and water velocity. When average water temperature increases; the U increases too because of increase in the inside thermal resistance. Figure (4) illustrate the variation U based on external area of the pipe versus water flow rate for vertical pipe. The results show the same trend of U with water flow rate increase for a horizontal pipe tested, and approximate values of the U at the near values of average water temperature of (49.9 ºc) and (59 ºc); except at (93.12 ºc) average water temperature because it has a high value with respect to a horizontal pipe of (87.74ºc).

Heat rejected rate results

Figure (5) shows the variation of heat rejected rate through the pipe to ambient versus water flow rate for horizontal pipe. The results show when water flow rate increase; the heat rejected rate increases because of the increase in the temperature difference between average water temperature and ambient temperature, and because of the increase of U value. When average water temperature increases, the heat rejected rate increases too because of temperature difference increase refer to the value for each average water temperature. Figure (6) shows the variation of heat rejected rate through the pipe to ambient versus water flow rate for vertical pipe. The results show the same trend of heat rejected rate with water flow rate increase for a horizontal pipe tested, and approximate values of the heat rejected at the near values of average water temperature of (49.9 ºc) and (59 ºc); except at (93.12ºc) average water temperature because it has a high value with respect to a horizontal pipe of (87.74 ºc).

Results of 50mm pipe diameter

Overall heat transfer coefficient (U) results

Figure (7) shows the variation of U based on outside area of the pipe versus water flow rate for horizontal pipe. The results show when water flow rate increases; the value of U increases because of increase in the value of water (inside) heat transfer coefficient due to increase of the Re number and water velocity. When the average water temperature increases; the overall heat transfer increases too because of the increase in the inside thermal resistance. By comparison the results of figures (7) and (3), it seems that the values of U in the pipe of 50mm diameter are less than in the pipe of 30mm diameter for the same water flow rate because of water velocity and Res number decrease, the same result obtained either by changing average water temperature or pipe position (vertical, horizontal). Figure (8) shows the variation of U based on outside area of the pipe versus water flow rate for vertical pipe. The results show the same trend of U with water flow rate increase for a horizontal pipe tested, and approximate values of U with average water temperature. The same trend for horizontal pipe obtained in vertical pipe by comparison the results of figures (8) and (4); which seems that the values of U in the pipe of 50mm diameter are less than in the pipe of 30mm diameter for the same water flow rate and the same reason.

Heat rejected rate results:

Figure (9) shows the variation of heat rejected rate through the pipe to ambient versus water flow rate for horizontal pipe. The results show when water flow rate increases, the heat rejected rate increases because of the increase in the temperature difference between average water temperature and ambient temperature, and because of U value increase. When average water temperature increases, the heat rejected rate increases too. By comparison the results of figures (9) and (5) it seems that the heat rejected rate in the pipe of 50mm diameter are greater than in the pipe of 30mm diameter for the same water flow rate and for all average water temperatures because of outside pipe area increase.

Figure (10) shows the variation of heat rejected rate through the pipe to ambient versus water flow rate for vertical pipe. The results show the same trend of heat rejected rate with water flow rate increase for a horizontal pipe tested, and approximate value of the heat rejected rate at the near values of average water temperature. The same trend for horizontal pipe obtained in vertical pipe by comparison the results of figures (10) and (6), which seems that the values of heat rejected rate in the pipe of 50mm diameter are greater than in the pipe of 30mm diameter for the same water flow rate and the same reason.

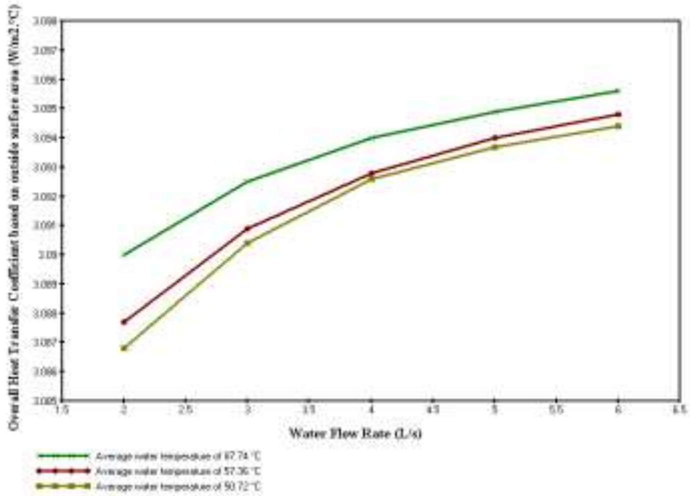

Figure 3. Overall heat transfer coefficient of 30mm horizontal pipe diameter

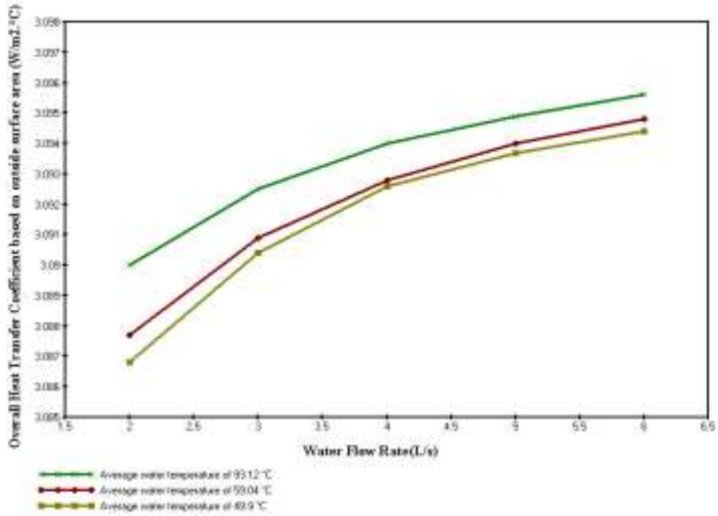

Figure 4. Overall heat transfer coefficient of 30mm vertical pipe diameter

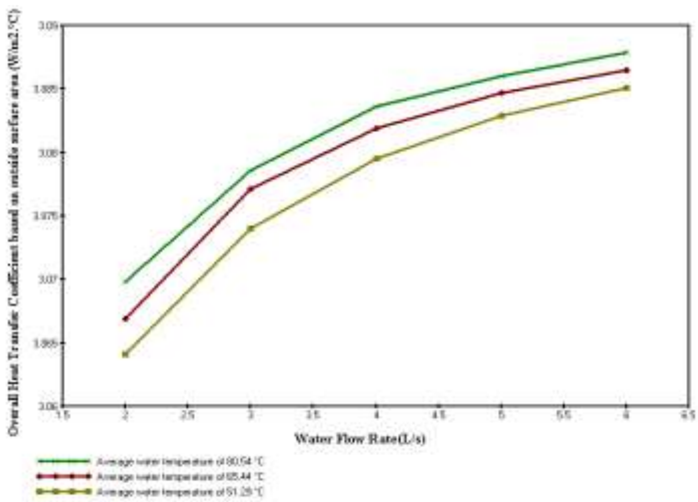

Figure 5. Heat rejected rate of 30mm horizontal pipe diameter

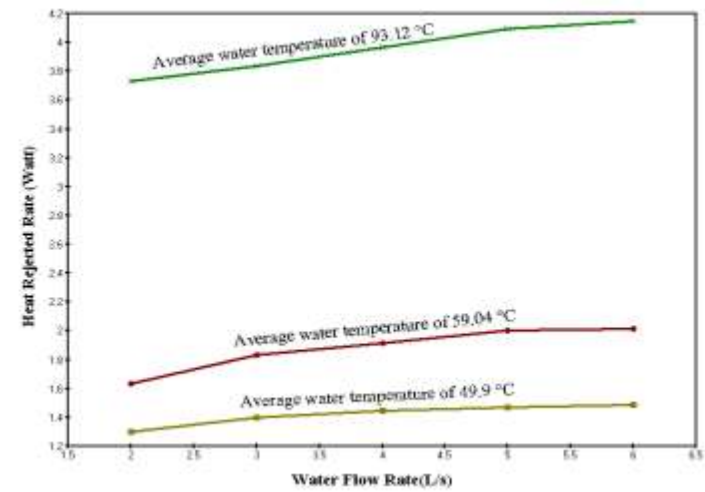

Figure 6. Heat rejected rate of 30mm vertical pipe diameter

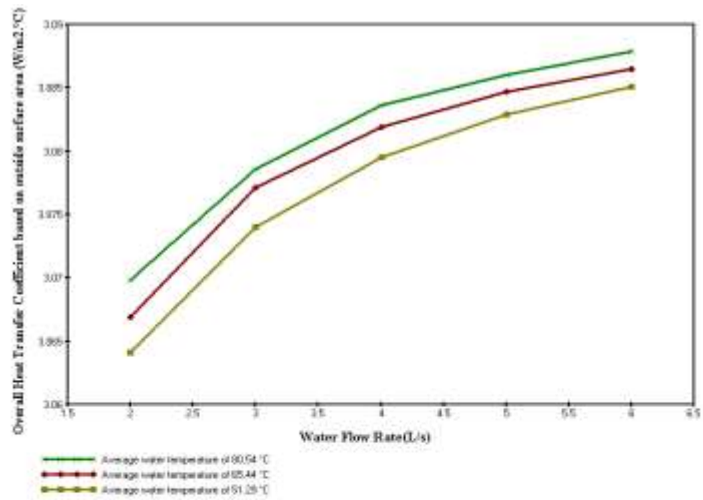

Figure 7. overall heat transfer coefficient of 50mm horizontal pipe diameter.

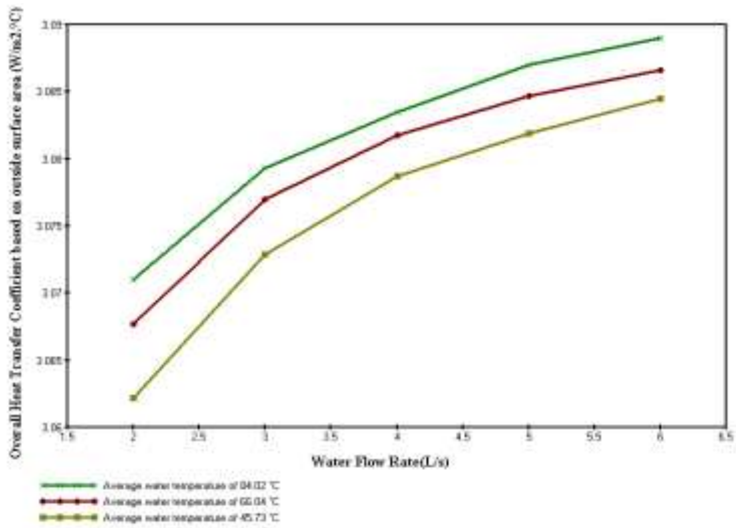

Figure 8. overall heat transfer coefficient of 50mm vertical pipe diameter

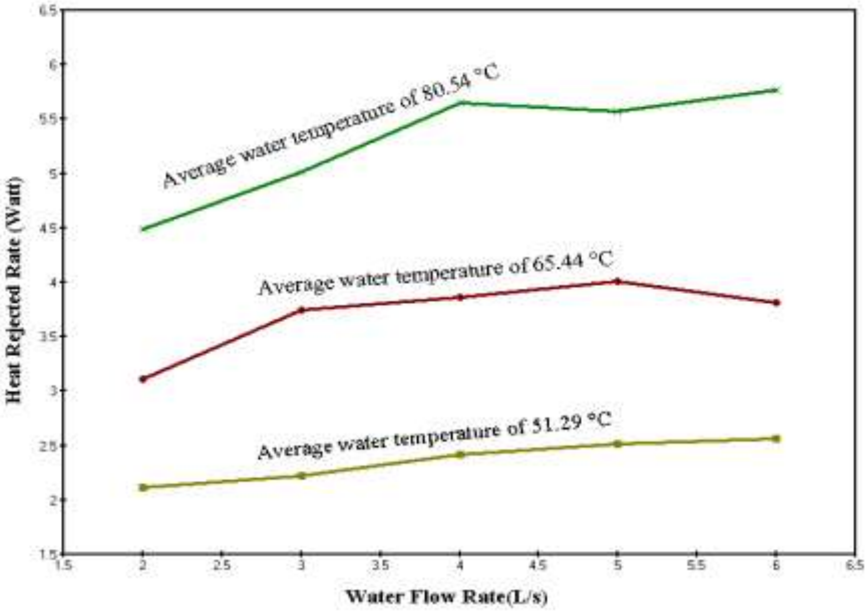

Figure 9. Heat rejected rate of 50mm horizontal pipe diameter

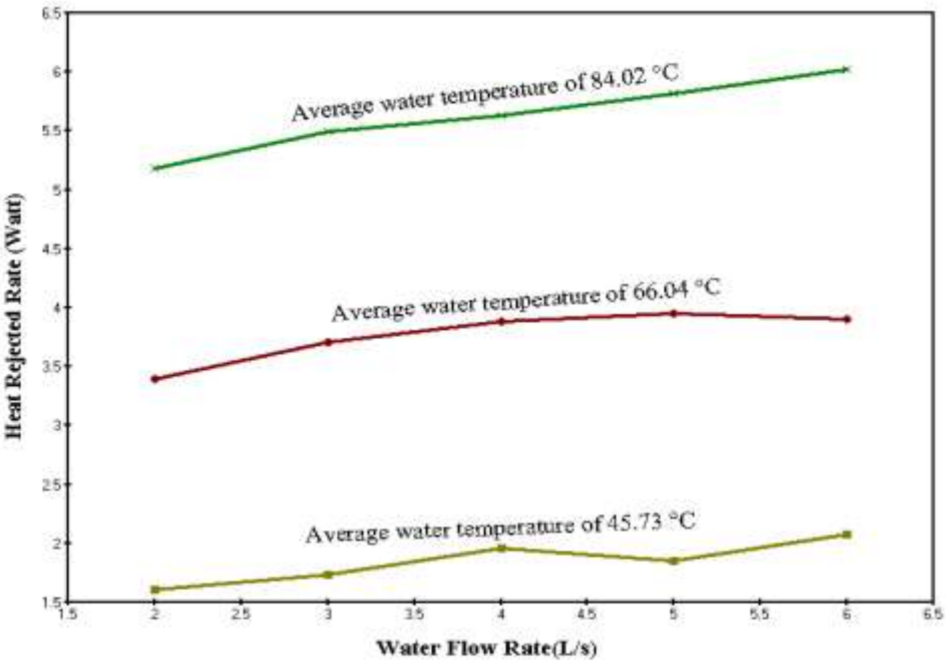

Figure 10. Heat rejected rate of 50mm vertical pipe diameter

COMPARISON

When comparing overall heat transfer coefficient for two different vertical pipe diameters (30 mm and 50mm), as shown in the figure (11), we found the heat rejection rate in the pipe with a diameter of 50 mm is greater than the pipe with a diameter of 30 mm for the same rate of water flow for all average water temperatures due to the increase in the area of the outer tube.

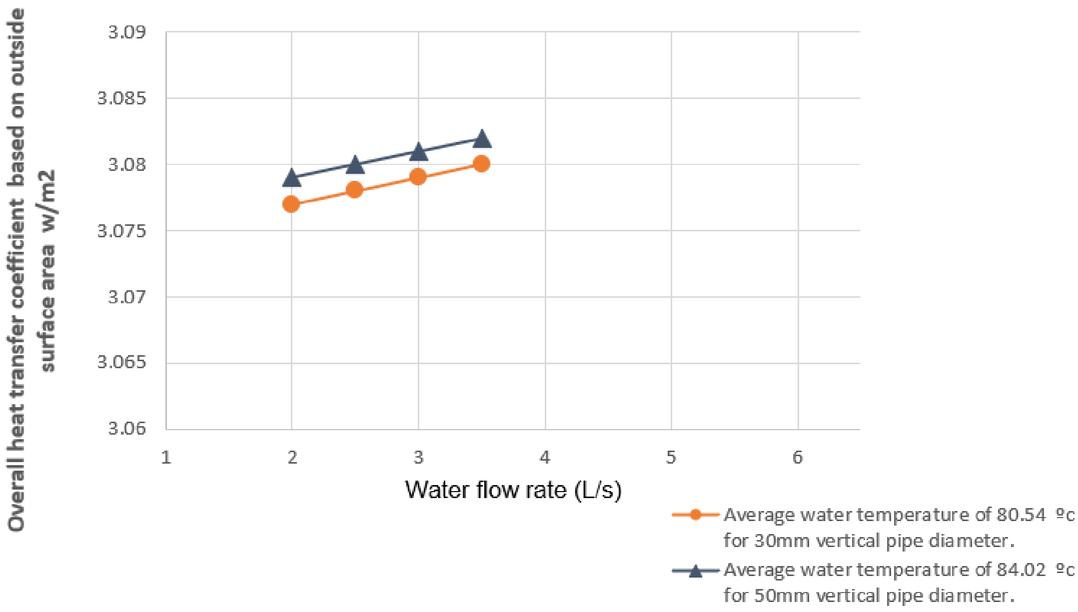

Figure 11. Comparison between the overall heat transfer coefficient for two different vertical pipe diameters (30 mm and 50mm)

CONCLUSION

For 30mm pipe diameter

The overall heat transfer coefficient increases because of increase in the value of water (inside) heat transfer coefficient due to increase in the Re number and water velocity

When average water temperature increases; the value of U increases too because of increase in the inside thermal resistance.

When water flow rate increase; the heat rejected rate increases because of the increase in the temperature difference between average water temperature and ambient temperature, and because of the increase of U value.

For 50mm pipe diameter

When water flow rate growths; the value of U increases because of increase in the value of water (inside) heat transfer coefficient due to increase of the Re number and water velocity.

When the average water temperature increases; the overall heat transfer increases too because of the increase in the inside thermal resistance.

The heat rejected rate in the pipe of 50mm diameter are greater than in the pipe of 30mm diameter for the same water flow rate and for all average water temperatures because of outside pipe area increase.

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