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ARTICLE

FIELD STUDY OF FLOW AND HEAT TRANSFER IN TUBE MICROPHONE

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ABSTRACT

In this study, the flow field and temperature inside the tube has been equipped with micro fin. To this end a tube with an internal diameter of 2.2 cm and a length of one meter aluminum is considered. Micro fin a micrometer diameter is 1,000 mm. It is assumed that the wall of the tube at a constant temperature of 100 ° C should be applied. Micro fin for different torsion angles and different input speeds of the working fluid (water) temperature changes quickly and Central line tube and Nusselt number is calculated. Comparing friction coefficient and Nusselt number shows that the use of micro fin in the pipe hub to drastically increase the average Nusselt number of the tube is simple. Also shown that adjustments in the range of twist angle of 30 degrees to 60 degrees in about 9% on average Nusselt number is impressive. As well as the results of numerical simulations with data provided by third parties compare been. This comparison indicates very good results in this study is consistent with previous research results.

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KEY WORDS
Microfin, numerical simulation, flow field, temperature field

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INTRODUCTION

Heat exchangers are widely used in various industries, transportation, power generation, air conditioners, electronic equipment and spacecraft are used, so a lot can be said with regard to the use of heat exchangers to improve the coefficient of performance heat exchanger can be a significant savings in costs, materials and the space occupied. For this reason, the increase in heat transfer has been the subject of interest for researchers. In all these researchers to review and select the appropriate operating fluid, the right makeup, the choice of materials with good thermal transfer properties and design of various geometries for heat exchanger to increase its productivity were illuminated. To do this, there are two general methods- active and passive methods. The methods often require an external energy source is active. These methods are often faced with turbulent flow using the fan, turn the heat transfer surface, vibration and heat transfer surface with electrostatic fields are produced. Mechanical methods such as turning the heat transfer surface in applications such as cooking or drying etc. are used, but in general it can be said that active methods of increasing the heat transfer due to high initial costs, the need for an external power supply, high maintenance costs and less complexity in industry is not normally used. The use of passive methods has been considered as a very effective method. For this reason, experimental and numerical studies in this field have been done a lot in recent decades. Perhaps most importantly, the interest of researchers in this area can be applied simply being passive methods for heat transfer, he said. In other words, we can say that in this way requires no external power supply is to increase the heat transfer rate and this is important. In fact, increasing the amount of heat transfer in a converter converter to improve efficiency, reduce costs, reduce weight and volume becomes; therefore, it is possible to design heat exchangers enable small. High energy costs and environmental problems, researchers have tried to find ways to increase the rate of heat transfer and increase performance heat exchanger is thrown. It should be noted that is always on the side of the blades, the more heat resistance. For we know that the heat transfer coefficient air - and generally gases - much less than the coefficient of heat transfer fluids. Using blades is not only to increase the heat transfer surface but also turbulent flow as well. We know that the heat transfer coefficient in the turbulent flow over the heat transfer coefficient in laminar flow. Several plug-ins are used for this purpose. These plug-ins can be as turbulator larger or micro fin.

Literature

In 2003, Miyara and et al [1] laboratory studies conducted on micro fin Herringbone different geometries. They showed that by increasing the angle of micro fin increase heat transfer and pressure drop increases.

In 2007, Islam and Miyara [2] examined the flow behavior inside of the tubes micro fin and outlines mechanisms involved in this phenomenon occurred. They also stated that during the two-phase flow rate drops to increase the rate of heat transfer plays an important role. In other words Numerical methods for studying the inside micro fins achieved better results.

In 2004, Koyama and et al [3] studies on a pipe with a length of 6.02 mm and angle of 24 degrees 52 micro fin and did. They flux mass flow of 362 kg m sec and 39.9 times the input pressure and steam quality 0.1 to 0.95 were considered. They reported that the heat transfer coefficient of thermal flux, but the quality is not affiliated steam.

In 1988, Yoshida and et al [4] to review the working fluid flow in the pipe R22 with a length of 15.8 mm and 60 fin micro fin the angle of 308 and 5.9 times their working pressure. They are your experiments

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aimed at providing a clear pattern to the inside of the tubes micro fin did. flow pipe into the groove in the longitudinal direction of flow, but by increasing the fluid mass flux at the top of the pipe to flow down. After mass flux of 200 kg per square meter seconds of angular mode varies the flow pattern of a wave mode.

In 1995, Fujii and et al [5] the pattern of fluid flow in the pipe micro fin of R-22 of 9.52 mm and the angle of 188 degrees with 60 micro fin began. They experiment inlet pressure of 4 times to 6.5 times have changed, as well as 110 to 220 Kg.m2/s were considered. They are Sinuous – angular patterns, angular, angular-mist species and behavior for the species reported in May. They ultimately your results with patterns that Scott [6] reported compared. Although the reported differences between the two models showed significant flow into the pipe micro fin.

In 2001, Yashar and et al [7] experimental studies on phase flow boiling and condensation inside the tube also being examined with simple and micro fin treaty. Several years later, in 2003, Newell et al. [9,8] also conducted a similar experiment. They succeeded in that position liquid film thickness on the flow pattern within the tube slots micro fin of the measure. in this case, more uniform distribution of fluid in the pipe micro fin is a simple tube.

In 2002, Pettersen [10] to investigate the flow of carbon dioxide in its saturation temperature of 20 ° C and for the mass flux of 100 to 580 kilograms per square meter flat micro-channel payment within seconds. They reported that in the conditions prevailing pattern of fluid flow and creep model for fluid flow pattern position but high mass and high vapor resolutions of May is observed as well. They reported that in their experiments, the wave pattern not seen in any case.

Governing equations

To analyze the flow behavior for all of flow, conservation of mass and momentum equations solved. For compressible flows or flows of heat transfer, energy conservation equations are solved. When turbulent flow should be used for modeling turbulence. The purpose of turbulent flow modeling to determine terms such as Reynolds stresses, turbulent mass flux or using turbulent heat flux linking these values to current values and average gradients especially in the middle.

continuity of conservation of mass equation is written as follows:

$$\frac{\partial \bar{\rho}}{\partial t} + \frac{\partial}{\partial x_i}(\overline{\rho u_1}) + \frac{\partial}{\partial x_i}(\overline{\rho' u_1'}) = 0 \tag{1}$$

Where ρ is the fluid density and ui is velocity components.
Momentum equation is written as follows:

$$\rho \frac{D\bar{V}}{Dt} + \rho \frac{\partial}{\partial x_i}(\overline{\rho u_1' u_j'}) = \rho g - \nabla \bar{P} + \mu \nabla^2 \bar{V} \tag{2}$$

Inertia tensor perturbation momentum equation includes an additional term $\overline{\rho u_1' u_j'}$ that of any current turmoil is not negligible and the main reason is the complexity of turbulent flow analysis. In the above equation P is static presure and ρg is physical force of gravity. Formula (3-2) may be also wrote the following:

$$\rho \frac{D\bar{V}}{Dt} = \rho g - \nabla \bar{P} + \nabla \tau_{ij} \tag{3}$$

Relationship stress tensor defined as follows:

$$\tau_{ij} = \tau_{ij,Laminar} + \tau_{ij,Turbulent} = \left[\mu\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right)\right] - \overline{\rho u_1' u_j'} \tag{4}$$

Mathematical terms, sentences inertia behave in such a way that the system disturbances, viscous tensions of Newtonian plus an additional stress tensor ρ(u_i^´ u_j^´)¯vortex which signified the effect of the turmoil on the average flow field.

Because chaos is a flow instability due to shear stresses (velocity gradients) is created, the stronger the shear stress, turbulent flow also will be more intense. Critical shear stress for turbulent flow, yet from a computational perspective is a bit complicated.

The energy equation is written as follows:

$$\rho C_P \frac{D\bar{T}}{Dt} = -\frac{\partial}{\partial x_i}\left[-k\frac{\partial \bar{T}}{\partial x_i} + \rho C_P \overline{u_1' T'}\right] + \frac{\mu}{2}\overline{\left[\frac{\partial \bar{u}_1}{\partial x_1} + \frac{\partial u_1'}{\partial x_j} + \frac{\partial \bar{u}_j}{\partial x_1} + \frac{\partial u_j'}{\partial x_1}\right]^2} \tag{5}$$

Term $\rho C_p \overline{u_i' T'}$ correlation between velocity and temperature fluctuations and entropy in order to represent transmission and turbulent heat flux is called Turbulent Heat Flux.
Equation (1), (3) and (5), commonly called RANS equations.
Dittus and Boelter [11] empirical equation below to calculate the number of heat transfer tubes microfin proposed:

$$Nu = 0.0034\, Re^{1.1}\, Pr^{0.4} \qquad 2300 < Re < 19500 \tag{6}$$

Also in 1976 Ganielinski empirical equation below to calculate the number of heat transfer inside pipes nusselt proposed [11]:

$$Nu = \frac{\left(\frac{f}{8}\right)(Re-1000)Pr}{1+12.7\left(\frac{f}{8}\right)^{\frac{1}{2}}\left(pr^{\frac{2}{3}}-1\right)} \quad 3000 < Re < 5\times10^{6},\ 0.5 < Pr < 2000 \tag{7}$$

F the friction coefficient is high in relation to the Blasius equation for micro fin of the tube is calculated as follows [11]:

$$f = 0.316\, Re^{-1/4} \tag{8}$$

The coefficient of friction on the inside of the tube micro fin can be modified relationship Blasius also be calculated as follows [11]:

$$f = 0907\, Re^{-0.286} \tag{9}$$

Numerical Simulation

First micro fin pipe geometry in ANSYS software version 14.5 will be drawn Design Modeler environment. In this simulation study for three different groove angle of 30 °, 45 ° and 60 ° will be examined. The tube length equal to one meter internal diameter of 2.2 cm will consider it. It is assumed that the pipe is made of aluminum. You can view the geometry depicted in [Fig. 1] can be seen.

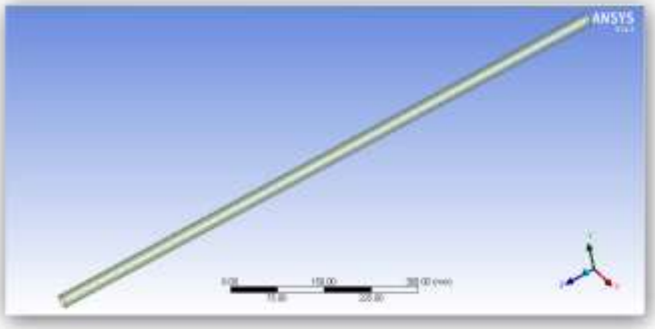

Fig. 1: Plotted geometry view in the Design modeler.

It is assumed that the working fluid is water and the walls are made of aluminum tubing and the well bore. It also assumes an incompressible fluid flow, and the flow of an incompressible fluid assumed to Pressure based method is used to solve the problem. The issue will be examined in steady state. The effect of gravity, is neglected. Thermo-physical properties of materials also are assumed to be constant with temperature change, not much has changed.

For the first simulation speed of 0.01 meters per second for our input. The entry into the fluid temperature ambient temperature of 300 degrees Kelvin considers. The pressure boundary condition for the output of output. It should be noted that the outlet pipe is discharged to the environment as a result of pressure gauges consider zero output. The last boundary condition that must be set boundary condition wall of the tube. Generally, two different modes can be considered for this boundary condition. The first condition of constant wall temperature condition and the second condition is a constant heat flux. The study examined the issue is fixed to the wall temperature. For constant wall temperature boundary condition, the wall temperature of 373 K to consider.
Simple algorithm will be used for problem solving.

RESULTS

Micro fin inside the tube with a twisting angle of 60 degrees, changing the speed in the center of the pipe line can be seen in [Fig. 2] can be observed.

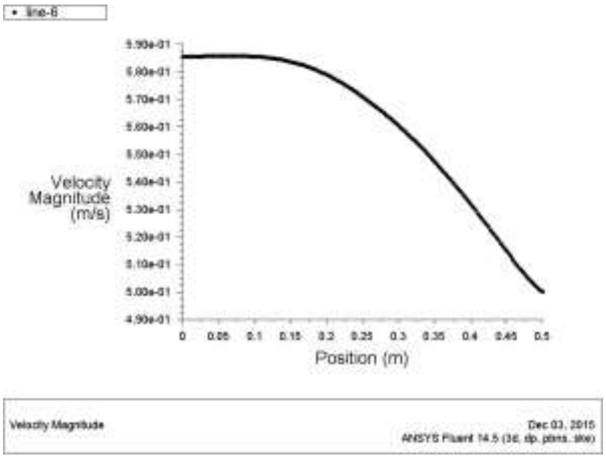

Fig. 3: Change the temperature in the center of the pipe line for micro fin tube with a twisting angle of 60 degrees and a speed of 0.5 meters per second input.

The numerical and experimental heat transfer rate and friction coefficient for different input speeds, in [Table 1] below.

Table 1: Comparison of experimental and numerical coefficient of friction and heat transfer obtained for different Reynolds numbers for microfin twisting angle 60

V(m/s)	Re	f(Calc)	f(CFD)	%diff	Nu(calc)	Nu(CFD)	%diff
0.1	2734	0.0943	0.117369	-24.463	28.57	33.62689	-17.7
0.2	5468	0.077373	0.089032	-15.069	64.97767	74.13303	-14.09
0.3	8202	0.068901	0.077891	-13.048	97.22466	112.907	-16.13
0.4	10936	0.063459	0.070958	-11.817	127.1792	147.6935	-16.1302
0.5	13670	0.059536	0.065248	-9.59459	155.5762	181.1325	-16.42687
0.6	16404	0.056511	0.060874	-7.72069	182.8069	212.7008	-16.35276
0.7	19138	0.054074	0.057933	-7.13758	209.1122	243.0705	-16.23925
0.8	21872	0.052047	0.055248	-6.14867	234.6548	273.207	-16.42931
0.9	24606	0.050323	0.053139	-5.59496	259.5513	303.1888	-16.8127
1	27340	0.04883	0.0512	-4.85437	283.8888	332.689	-17.1899
1.1	30074	0.047517	0.049612	-4.41	307.7353	349.4027	-13.54
1.2	32808	0.046349	0.048249	-4.1	331.1446	382.5383	-15.52
1.3	35542	0.0453	0.047044	-3.85	354.1607	402.1849	-13.56
1.4	38276	0.04435	0.045929	-3.56	376.82	438.0533	-16.25
1.5	41010	0.043483	0.044809	-3.05	399.1531	460.1437	-15.28

Table 2: Comparison of average Nusselt number and friction factor for Mykrvfyn with a twist angle of 30 ° and 60 °

V(m/s)	Re	f(CFD-30)	f(CFD-60)	Nu(CFD-30)	Nu(CFD-60)
0.1	2734	0.12709	0.117369	36.73421	33.62689
0.2	5468	0.096606	0.089032	81.24382	74.13303
0.3	8202	0.084143	0.077891	123.476	112.907
0.4	10936	0.076535	0.070958	161.5805	147.6935
0.5	13670	0.072652	0.065248	198.5089	181.1325

0.6	16404	0.064916	0.060874	232.9682	212.7008
0.7	19138	0.063732	0.057933	266.6545	243.0705
0.8	21872	0.057824	0.055248	299.4654	273.207
0.9	24606	0.05754	0.053139	332.3069	303.1888
1	27340	0.055841	0.0512	364.4208	332.689
1.1	30074	0.053521	0.049612	382.3286	349.4027
1.2	32808	0.052145	0.048249	419.2247	382.5383
1.3	35542	0.05194	0.047044	440.7452	402.1849
1.4	38276	0.049533	0.045929	479.2347	438.0533
1.5	41010	0.048621	0.044809	504.3321	460.1437

CONCLUSION

Micro fin tube of the Nusselt number and friction coefficient is more than a simple tube, as well as in all cases with increasing speed, and thus increasing the Reynolds number, heat transfer coefficient and the average Nusselt number increases if the coefficient of friction is reduced. Micro fin pipes of general change in the angle of torsion micro fin very noticeable effect on the average heat transfer coefficient of friction and is also generally much lower torsion angle (step greatly reduced micro fin) to slightly heat transfer and the coefficient of friction increases. The answer is especially for micro fin torsional angle of 30 degrees as well. In empirical relations for pipes microfin angle of torsion and micro fin step in relations can not be seen. Perhaps the reason for this is because of the influence negligible.

Below in [Fig. 4] heat transfer values obtained from numerical simulations with experimental data obtained in previous research and empirical correlations were compared.

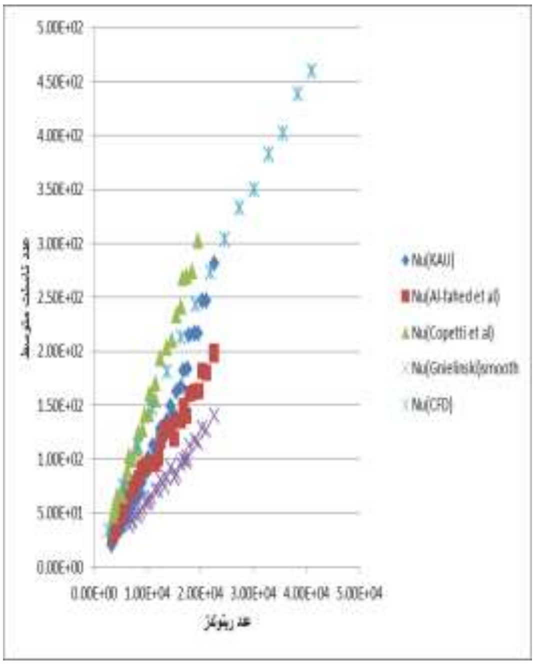

Fig. 4: A comparison of the Nusselt number of numerical simulations with experimental values.

As the [Fig. 4] shows the Nusselt number obtained from numerical simulations with experimental data in this study, earlier research has a very good match. Nusselt numbers in this study is calculated for Reynolds numbers about 45,000.

Also keep in [Fig. 5] friction coefficient values obtained from numerical simulations with experimental data obtained in previous research and empirical equations were compared.

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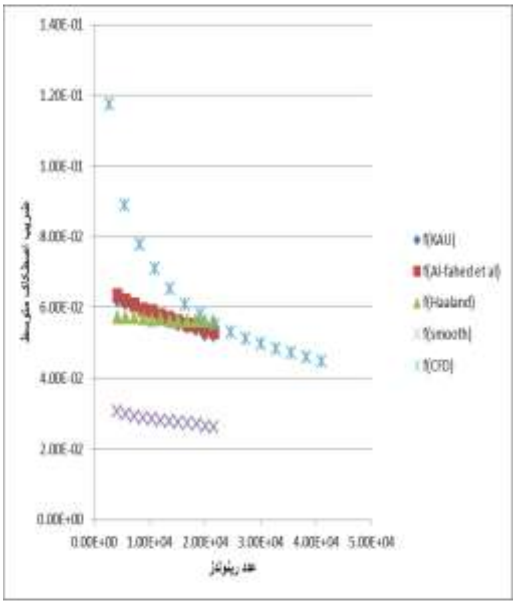

Fig. 5: Compare the coefficient of friction of numerical simulations with experimental values.

As shown in [Fig. 5] also has been shown, the friction coefficient of the numerical simulation is an excellent fit with the experimental data.

CONFLICT OF INTEREST

There is no conflict of interest.

ACKNOWLEDGEMENTS

None

FINANCIAL DISCLOSURE

None

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