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RESEARCH ARTICLE

HEAT TRANSFER ENHANCEMENT USING HELICAL PIPES

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Abstract

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The enhancement of laminar forced convection inside helical pipes is studied numerically and compared with plain pipes. The study is achieved numerically using the (Fluent-CFD 6.3.26) software program for solving the governing equations. The heat transfer factor and friction factor are calculated using the enhancement technique and compared with the plain tube. In this research the factors that affect the enhancement technique using helical pipes are studied, these factors are the ratio of (pitch /pipe length) (SL), Reynolds number and the heat flux applied to the external surface of the pipe. The results showed that there is an increasing in the heat transfer factor is related to the decreasing of (SL), increasing of Reynolds number and heat flux. The performance of the helical pipes is evaluated depending on the calculation of (Enhancement ratio), and it's found that the enhancement ratio increases as Reynolds number increases and (SL) decreases. It is found that the best enhancement ratio was (200%) at (SR=0.05), (Re=2000),(Heat flux=3000W/m2).The results are compared with the literature and there is a good agreement.

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Introduction:-

The energy crisis is one of the most important problems facing the world, owing to the large and continuous increase in its consumption rates, the increasing shortage of conventional energy resources and the high prices of energy, so researchers have increased the efficiency and downsizing of heat exchange systems in order to reduce their energy consumption rates.

Economic considerations in resources and energy have generated an incentive to expand efforts to produce more efficient heat exchangers (in terms of energy consumption). Likewise, in some applications used in aerospace, the size and weight of the heat exchanger are variables that must be considered.

The most significant variable in reducing the size and cost of the heat exchanger is the heat transfer and drop-pressure factor generated through the exchanger and thus the desired pumping capacity. The only way to increase the heat transfer factor is by reducing the thermal resistance of the secondary layer, by increasing the fluid main current disturbance so that the disturbance forces enter more into the adjacent layer, reducing the total thermal resistance of the overheat resistance. The problem with this process is that increased fussing leads to a significant loss of power that increases friction pressure drop in the tube and increases the cost of pumping fluid (Pumping Power) so the optimal design needs an assessment process (Optimization) between increased heat transfer factor and

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the cost of pumping. Increasing the speed of thermal exchange of thermal systems and reducing the pumping capacity can be referred to in ways that Enhancement Heat Transfer [1].

In general, methods of Enhancement of Heat Transfercan be divided into two main groups: The first is the self-contained methods in which heat transfer is stimulated without the need for external power, for example, rough surfaces, extended surfaces or twisted pipes. The second method is called Active methods and heat transfer is stimulated by external power, resulting in additional energy consumption so use only in applications where energy losses are not significant.

The researcher (Bergles, et.al) [6] presented a comprehensive study of the most important ways to improve self-heat transmission and efficiency and how to Enhancement of Heat Transferin heat exchangers used in oil and steam plants, which was an important study at the beginning of interest in these technologies.

The researchers (Kumar and Prasad) [7] and the researcher (Webb) [8] have listed the stages that have taken place in the past decades to develop techniques for improving large-scale heat transfer and have been applied in the use of heat exchangers in frostbite systems, industrial systems, solar heaters, etc.

Many researcheshave been done to examine the impact of using self-induced heat transfer techniques to demonstrate the impact of these technologies on the generation of localized disturbances by inducing Swirl Flow. As a result, the thickness of the adjacent layer is less, reducing thermal impairment (thermal resistance). This results in an Enhancement of Heat Transfer factor. Researchers (Raineriet.al) [9] observed a process of heat transfer and pressure drop in a stored pipe from inside, spirally tube to improve forced heat transmission and researchers found that such pipes precipitate the transition from stratospheric to emergency runoff with less-than-(2000) ringleader numbers and associated increases in heat transmission. Researchers (Pimental et.al) [10] presented a study of the coarse-surface galves and noted in their study that a rough increase in the internal surface of these streams would Enhancement of Heat Transfer.

Researchers (Hibbs et.al) [11] examined the effect of the induced sub artery due to surface coarse on the run between the turbine blades and researchers observed that a significant Enhancement of Heat Transfer was achieved.

The two researchers (Kim and Kim) [12] performed a numerical study to evaluate the use of coarse increase technique the inner surface of the channels and the evaluation mechanism was based on the Enhancement of Heat Transfer factor and pressure drop factor.

Many researcheshave been conducted in the last 10 years to address these technologies and focus on assessing their performance due to increased energy costs. The researcher [13] has provided a comprehensive review of these technologies and their preference for their use.

The current research aims to examine the effect of the use of the stored tube on forced convection and the face friction factor of the tube's outer surface. The effect of the Spacebar ratio (SL), the Reynolds number, and the changes in the heat flate values on the above variables will be addressed, and the performance of the tube in the case of using this enhancement technology will be compared to the normal tube condition by calculating the so-called optimization efficiency.

Ruling Equations:
The effect of the use of helical pipes (containing grooves) on the process of Enhancement of Heat Transfer has been studied. The outer surface of the tube is exposed to a regular heat sink. The image of the real model of the balancer tube is shown in Figure (1) and Figure (2). The ruling equations for forced pregnancy inside the tube in terms of the two-dimensional polar coordinates were summarized by the equations below considering the hypotheses below to solve these equations
[16-14] :
1.The situation is stable.
2. The two-dimensional run.
3.The fluid is subject to Newton's wife's law.
4. Fluid, not compressed.
5. Neglect of losses caused by viscosity and internal energy sources.

6.application of an approximation (boussinesq) that is, all properties of air are constant except for density.

$$\rho \cong \rho_o * (1 + \beta * (T_o - T))$$

2D Continuity Equation

$$\frac{\partial V_r}{\partial r} + \frac{V_r}{r} + \frac{1}{r}\frac{\partial V_\theta}{\partial \theta} = 0 \quad (1)$$

Momentum equation for Radial-axis

$$\rho\left(V_r \frac{\partial V_r}{\partial r} + \frac{V_\theta}{r}\frac{\partial Vr}{\partial \theta} - \frac{V_\theta^2}{r}\right) = -\frac{\partial p}{\partial \theta} + \mu\left[\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial}{\partial r}(V_r r)\right) + \frac{1}{r^2}\left(\frac{\partial^2 V_r}{\partial \theta^2}\right) - \frac{2}{r^2}\frac{\partial V_\theta}{\partial \theta}\right] \quad (2)$$

Momentum equation for Tangential-axis

$$\rho\left(V_r \frac{\partial V_\theta}{\partial r} + \frac{V_\theta}{r}\frac{\partial V_\theta}{\partial \theta} - \frac{V_r V_\theta}{r}\right) = -\frac{1}{r}\frac{\partial p}{\partial \theta} + \mu\left[\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial}{\partial r}(V_\theta r)\right) + \frac{1}{r^2}\left(\frac{\partial^2 V_\theta}{\partial \theta^2}\right) + \frac{2}{r^2}\frac{\partial V_r}{\partial \theta}\right] \quad (3)$$

Energy equation

$$\left(V_r \frac{\partial T}{\partial r} + \frac{V_\theta}{r}\frac{\partial T}{\partial \theta}\right) = \alpha\left[\left(\frac{1}{r}\frac{\partial}{\partial r}(r)\frac{\partial T}{\partial r}\right) + \frac{1}{r^2}\left(\frac{\partial^2 T}{\partial \theta^2}\right)\right] \quad (4)$$

$$Cf = 4f \quad (5)$$

$$\mathrm{Re} = \frac{\rho . V_r . D_h}{\mu} \quad (6)$$

$$Nu = \frac{h * D_h}{k} \quad (7)$$

Solve the equations above and find the speed compounds ( ) and the temperature at the entire points of the arithmetic grid these values can be used to calculate the Friction factorand Nusselt number that is given from the equations:

Number modeling

Use the software (fluent-CFD 6.3.26) to solve block conservation, momentum conservation, and energy conservation equations using the specified volume method (FVM) to demonstrate the effect of using heat transfer improvement technology on heat transfer factor and friction factor. The geometric shape of the tube and the generation of the mesh generation was constructed using the subprogram (Gambit 6-2.3.16) and as shown in Figure 3 and for all the ratios of the separation distance (SL= 0.05, 0.01, and 0.15) the continuity equation was solved using the semi-implicit method of pressure correction or the so-called algorithm (simple Algorithm Method) The specified volumetric route involves converting the equations above into equations by which a property can be valued at the center of the volume controlled by the value of the property in the adjacent points. All iterative processes for accessing speed and temperature values in the running field have been implicitly resolved and require access to the convergence process for numerical solution for more than 1500 iterations.

Results And Discussion:-

In the current research, the impact of several variables on the mechanism for Enhancement of Heat Transferusing helical pipes was examined, with the following variables:
Reynolds number changed by range (100-2000)
Changing the value of the clot heat flate (500 - 3000 W/m2)
Change the gap ratio (step/tube length) or SL as follows:
(SL = 0.05 , 0.1 , and 0.15)

The distribution of temperatures represented by the contours shown in figures (4) and (5) at 3000 W/m2,Rennold 500 and 2000, and for all separation distance ratios. In figures (6) and (7), the speed vector is introduced for the above conditions and the generated gyres can be observed which help penetrate the adjacent layer and thus reduce thermal resistance and as a result of Enhancement of Heat Transferrates.

(8) shows a change of Nusselt number that was given with a change in the Reynolds number and a different (gap/length) SL ratio. Nusselt number as a non-marginal group, the transmission factor of heat is initially based on runoff conditions that can be distinguished from the Reynolds. If the run inside the tube is stratified, there is no mixing of nearby hot fluid particles from the wall with cold fluid particles in the middle of the tube, the heat transfer is by conduction in this case and is relatively small. The fact that moods, if small, is causing a mixing process is breaking up the adjacent layer that is not obstructing the heat exchange and thus mixing hot and cold deposits with an improvement in the heat exchange process. Figure (8) shows that the Nusselt numberincreases with the Reynolds numberand all SL values and is higher than those for the tube without the use of the Plain Tube technology. The grooves inside the tube act like fins inside the tube and thus trigger a continuous cycle motion (swelling motion) of the fluid inside the tube, thereby increasing the mix of wall hot fluid with the cold fluid in the middle of the tube, thereby increasing the speed of heat exchange. The Friction factor is a measure of pressure loss within the tube and fluid's kinetic energy. The Friction factor is Figure 9 and we note that by increasing the Reynolds number, the Friction factor increases because of the increased kinetic energy of fluid particles due to the swirling run generated by the presence of the grooves that mix the fluid masses and thus increase the momentum of these masses, and also notice from the figure that the less The ratio of the separation distance for these SL brothers the friction factor is higher.

In order to predict the effect of using heat transfer improvement technology in heat exchange systems, performance is evaluated based on the so-called improvement ratio or efficiency of improvement, which represents the ratio of heat transfer factor using optimization technology to heat transfer factor without the use of optimization technology and can be represented by the equation below:

Enhancement Ratio = $\frac{Nu_{with\ enhancement}}{Nu_{without}}$

In Figure (10) the enhancement ratio of the enhanced tube was calculated using the yardstick 0at a temperature overflow q=500W/m2 and Q=3000w/m2 at a different distance ratio (SL) and the increase in temperature improvement with an increase in the number of yens was calculated. The maximum value for the improvement ratio is (%200) at 0.05SL= and Q=3000W/m2 and increases with the Reynolds number. The results of the current research of heat transfer technology used are compared with that of the researcher (AHMED A. Hussin) 2005 [17], and the results are very close in range of the Reynolds number used in this study. As shown in Figure (11)

Conclusions:-

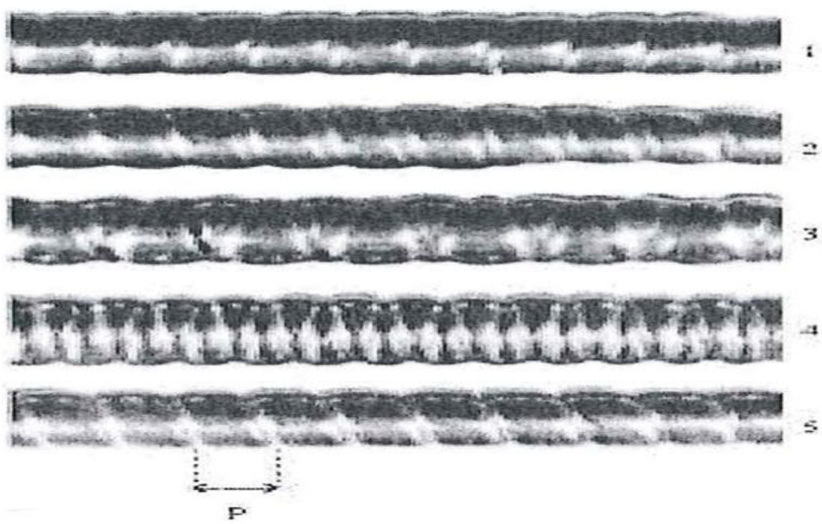
From the results of this numerical study, the following conclusions can be presented:
1.The technique of self-improving heat transfer by using tubes with grooves can enhance the heat transfer rates and reach the best improvement percentage with an increase in Nusselt number of up to (100%) compared to Plain tube without using the improvement
2.Theincrease in heat transfer and the accompanying increase of the friction factor can be explained by the generation of swirl flow due to the roughness caused by the grooves in the inner tube surface.
3. from an assessment of the performance of a technology that improves heat transmission, the best performance is shown to occur at the lowest separation ratio S/D = 0.05) and is increased by an increase in the Reynolds' number.

Symbol Table

Code	Meaning	Unit

C_f	Friction factor	-
D_h	Duct hydraulic diameter	m
H	Convective heat transfer factor	$W/m^2\ .^0C$
K	heat conductivity	$W/m\ .^0C$
P	the pressure	N/m^2
Pr	Prandtl number	-
Q	heat flux	W/m^2
T	temperature	^0C
V_r	Average velocity in the radial direction	m/s
VV_{θ}	Average velocity in the tangential direction	m/s
R	country coordinates	m
θ	tangential coordinates	m
$B = 1/T_f$	volumetric expansion factor	$1/^0C$
ρ	fluid density	Kg/m^3
μ	fluid dynamic viscosity	Kg/m.s
$Nu=h.D_h/\ \mu$	Nusseltnumber	-
$Re = \rho\ V\ D_h/\ \mu$	Reynolds number	-
$C_f = 4f$	Friction factor	-

Figure (1):- Models of (Helical Pipes).



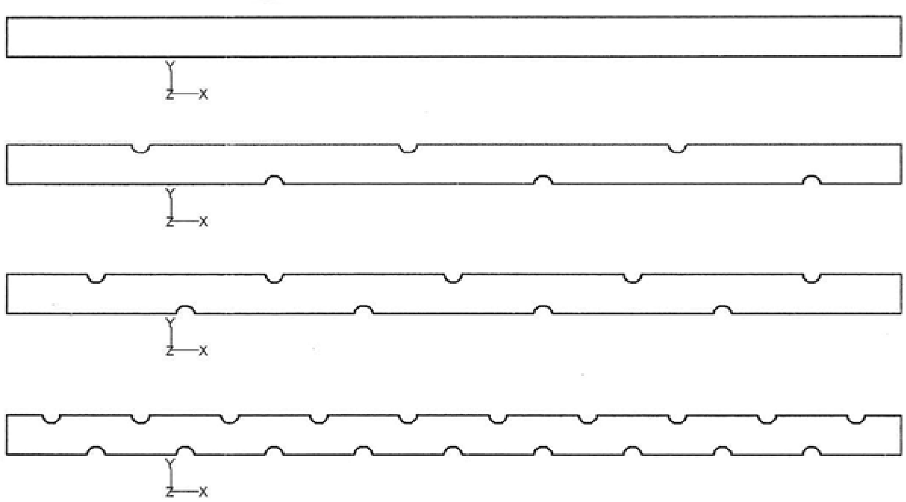


Figure 2:- Physical model of a Helical Pipe with different separation ratios.

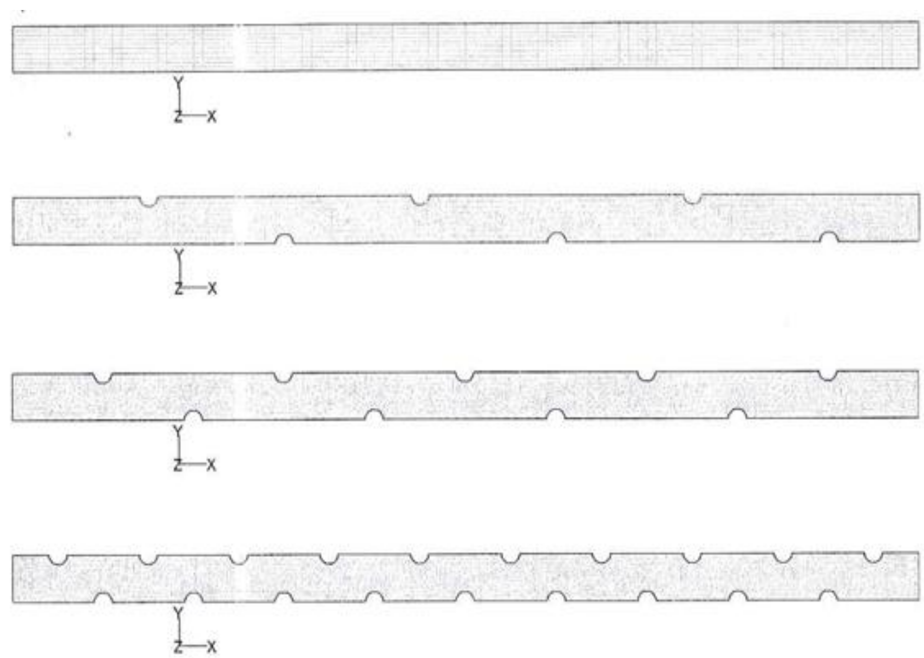


Figure (3):- The lattice generation model of the Helical Pipe with different separation ratios.

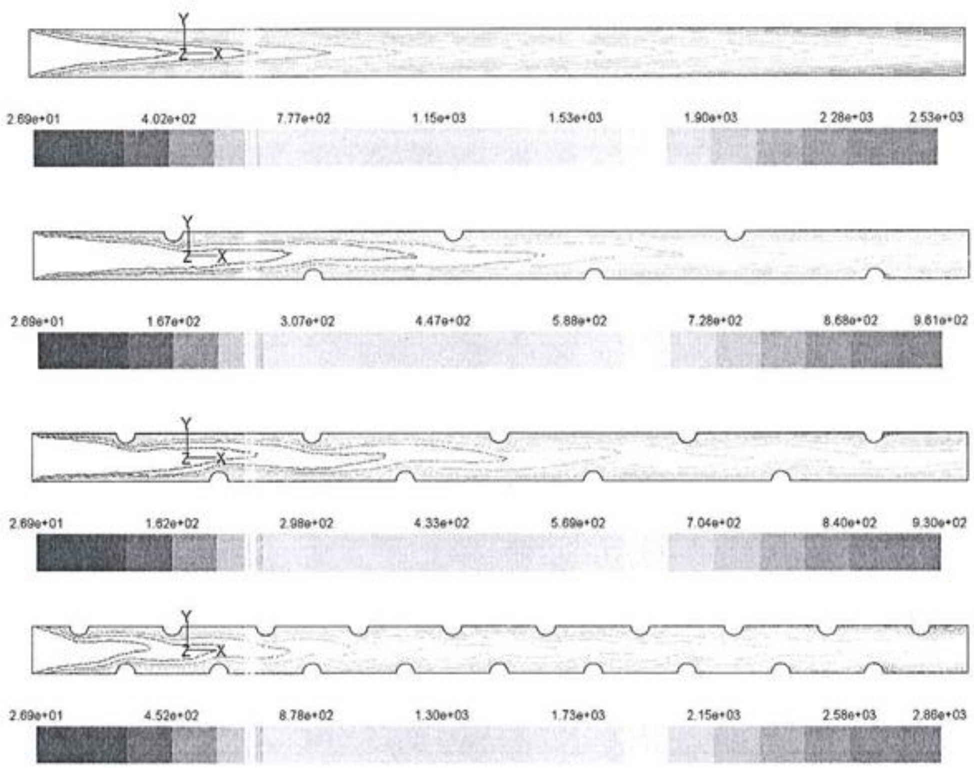


Figure (4):- Temperature distribution at Re = 500) and (Q = 3000.

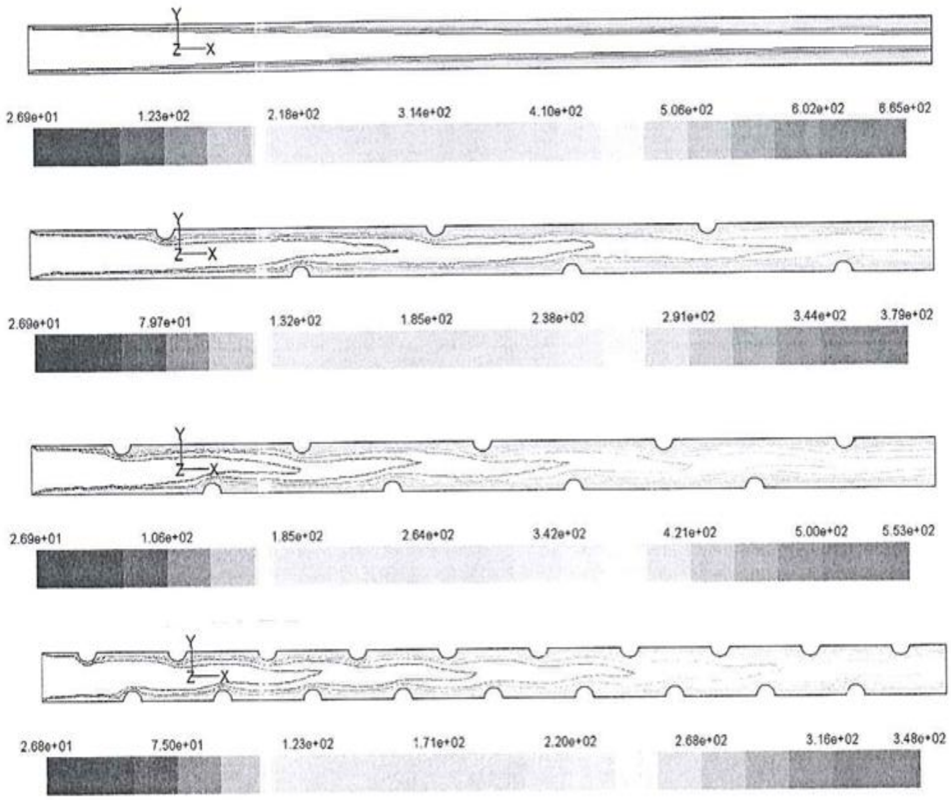


Figure (5):- Temperature distribution at Re = 2000) and Q = 3000.

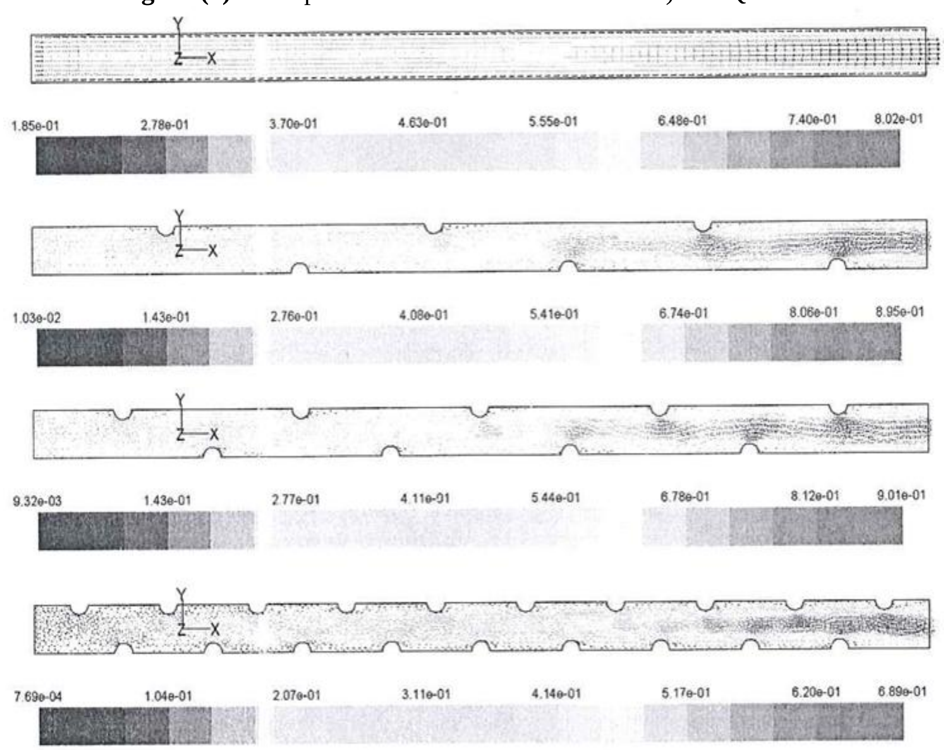


Figure (6):- Speed distribution at Re = 500) and (Q = 3000.

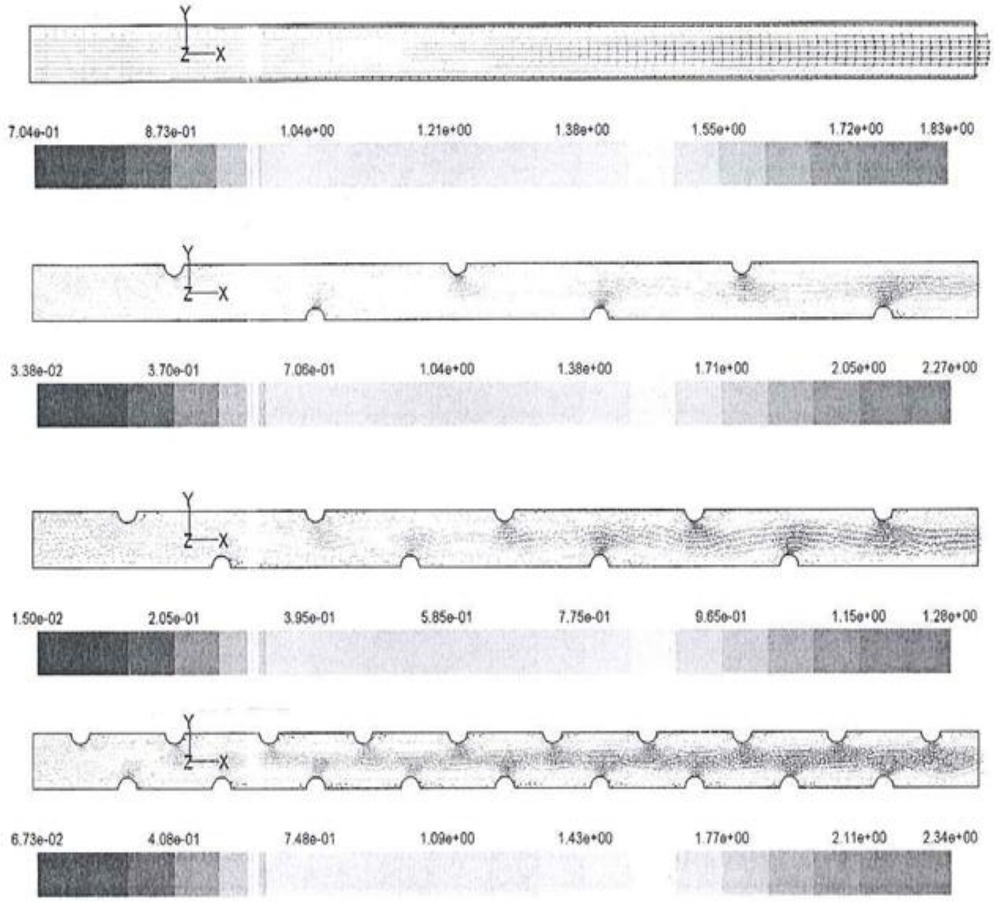


Figure (7):- Speed distribution at Re = 2000) and (Q = 3000.

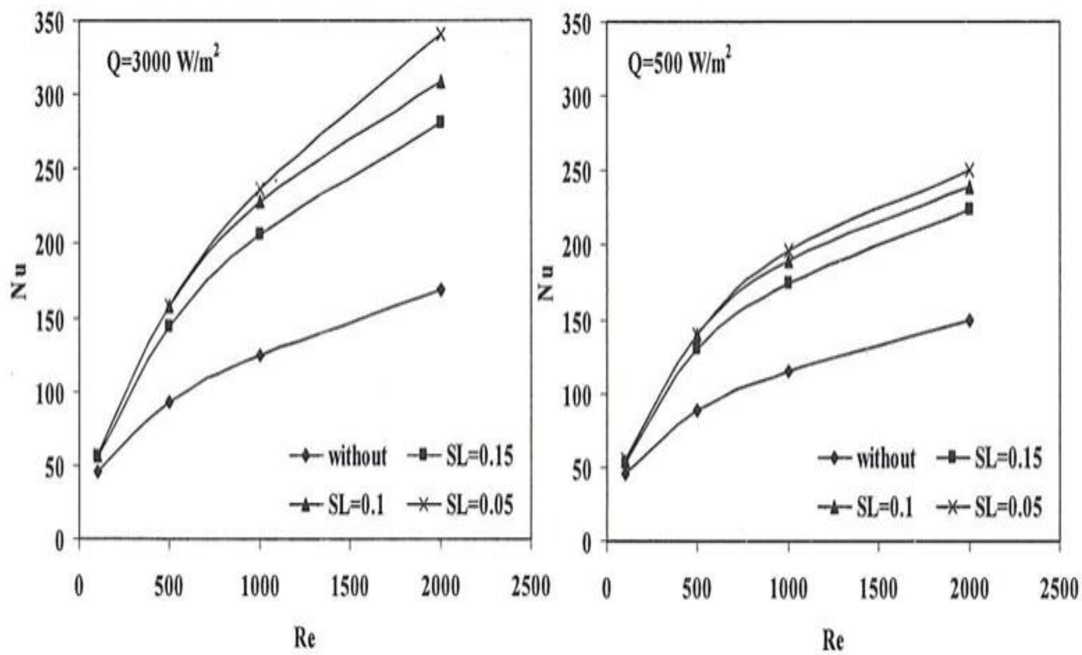


Figure (8):- Relationship between Nusselt number and Reynolds number.

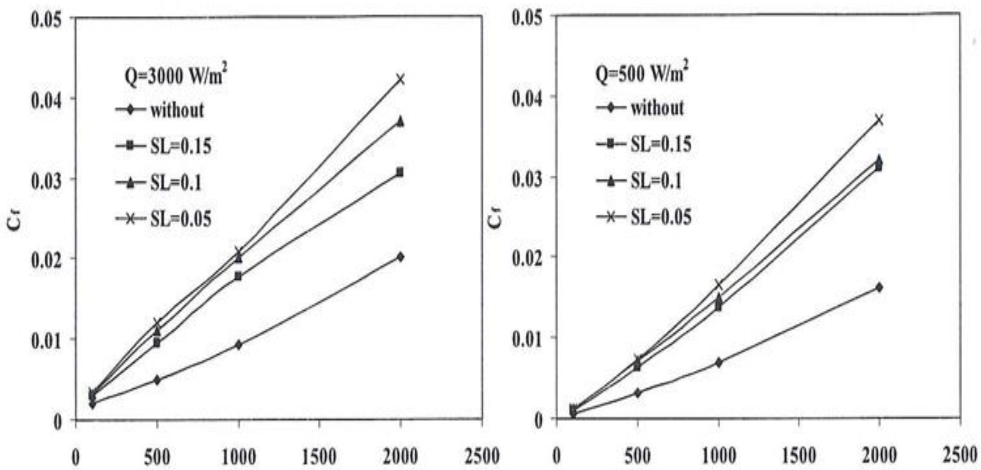


Figure (9):- Relationship between Reynolds number and the Friction factor.

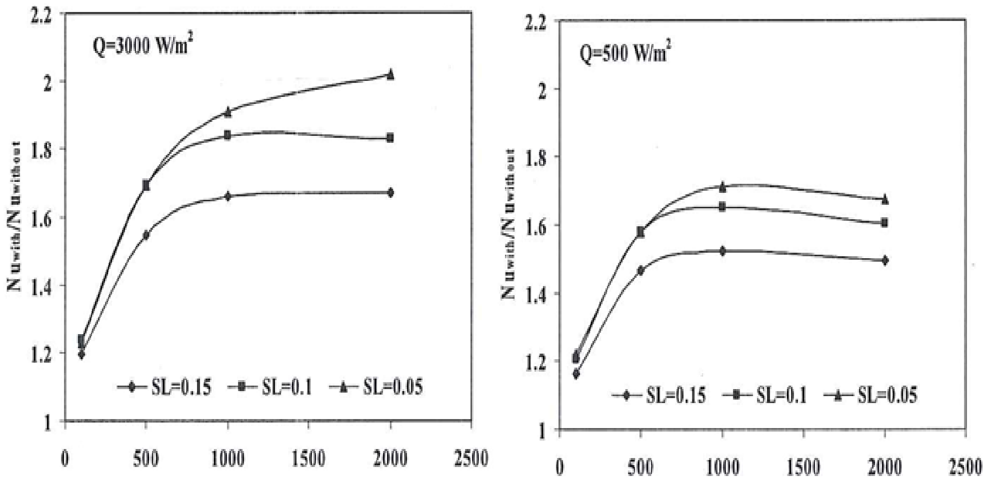


Figure (10):- The ratio of Enhancement of Heat Transfer with Reynolds number .

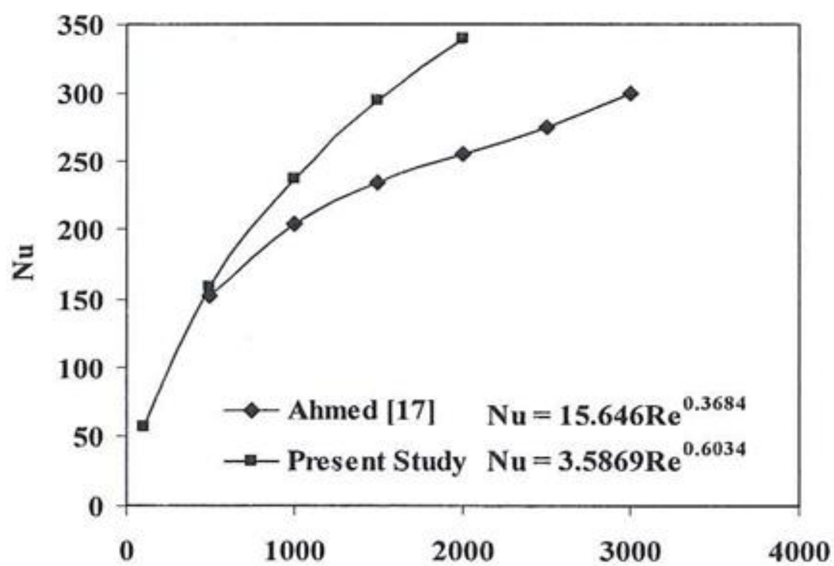


Figure (11):- Comparing the current research with the previous research (17).

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