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Different Criteria Affecting Friction Factor of the Pipe

Viraj Nileshkumar Kakadia
Mechanical Engineering Department
BMCET
Surat, Gujarat, India

Harikrishna Vinodray Gohil
Mechanical Engineering Department
Dr. S. & S. S. Ghandhy College of Engineering & Technology,
Surat, Gujarat, India

***Abstract*—In this paper, analysis of different criteria affecting the friction factor in pipe has been presented with the reference of various research papers. The major criteria like Reynolds number, Nusselt number, turbulence, velocity, surface roughness, swirls, different phases, cavitations, bubbles, foreign particles, synergy angle, pressure drop, pipe geometry, chemical properties of fluid and position of pipe. Further, the active and passive methods used to enhance heat transfer rate, also affects friction factor of pipe.**

Keywords:- Friction factor, Nusselt number, Reynolds number, turbulent low, pipe, pressure drop, velocity, surface roughness,synergy angle.

I. INTRODUCTION

This paper involves major details about criteria influencing friction factor. Further, the need of considering friction factor is due to its enormously wide application in the entire world. As each building, automobile, drinking water and others utilizes pipe for transportation of fluid medium.

The analytical solution for laminar flow can be evaluated by using equation of motion, while in case of turbulent flow it is quite different. For the evaluation of turbulent flow, advance theories are needed and at some point depends on results of practical. Fluid flowing through pipe is generally turbulent in practice.

One of the key points of information is that an engineer needs energy, essential to drift fluid at a certain steady rate via pipe. With the help of available empirical and theoretical information, the key information is furnished in practice through some routine solution of pipe flow problems.

A fluid is transported through close passage when it is required to maintain a certain pressure with respect to atmospheric pressure. Circular pipes, in most of the cases are widely used to carry fluids over a certain distances.

1.1 FRICTION LOSS IN PIPE FLOW (DARCY WEISBACH FORMULA FOR MAJOR LOSS)

Darcy equation relates the head loss due to frictional or turbulent flow through a pipe to the velocity of the fluid, friction factor, and diameter of the pipe.

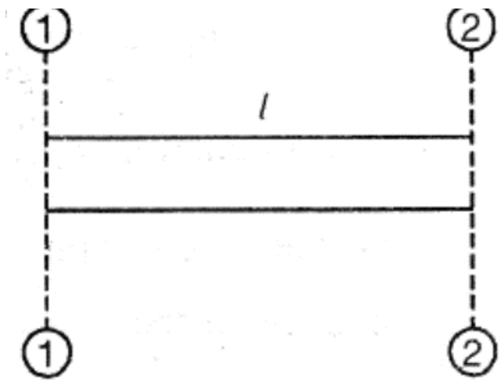

FIGURE: 1.1

Consider a fluid flowing fully through a pipe of diameter d and the pipe of length l between sections 1-1 and 2-2 as shown in figure 1.1.

As the liquid propagates in the pipe, there is a reduction in energy by doing work in overcoming the frictional resistance.

Energy loss per second = work done to overcoming the frictional resistance per second.

Weight of liquid discharged per second is ‘gAV’, where A is area of a pipe.

Loss of energy head [hf] = loss of energy per unit weight of the liquid.

$$h_f = \frac{f' * (Pl) * V^3}{\rho g A V}$$

For circular pipes, P = πd, A = πD²/4 and f’=fρg/2g in above equation we get,

$$h_f = \frac{(\frac{f\rho g}{2g}) * \pi dl * V^3}{\rho g * \frac{\pi}{4} d^2 * V}$$

$$h_f = \frac{4flV^2}{2gD}$$

Above equation is known as Darcy-Weisbach equation for loss of head due to friction.
For non-circular pipes, where m is the ratio of pipe area to pipe perimeter.

$$h_f = \frac{f' * l * V^2}{2gm}$$

Let Q=V/A then, in terms of the discharge Q the equation is,

$$h_f = \frac{f * l}{d} * \frac{Q^2}{2g} * \frac{16}{\pi^2 d^4}$$

$$h_f = \frac{flQ^2}{12d^5}$$

For laminar flow, f =64/Re and for turbulent flow, for $4x10^3<Re<1x10^5$.

$$f = \frac{0.316}{Re^{\frac{1}{4}}}$$

These equations are based on friction factor, which are influenced by the factors elaborated further.

II.REVIEW

[1]The more surface added to the system for increasing heat transfer rate is directly proportional to the rate of increase of pressure drop due to friction. The pressure drop across the tube which helical ribs is causing drag force due to frictional loss between two different surfaces and turbulence augmentation and rotational force produced by the helical ribs causing internal friction between molecules of same medium. The use of coiled square wires tabulator's lead to a considerable increase in heat transfer and frictional losses over those of a smooth wall tube which in turn, it is a reason of high friction as more fluid comes in contact with wall. Additionally, turbulence causing extra friction between fluid molecules and also a prime factor for reducing life of a pipe or tube and increasing friction of wall via surface erosion.

[2]There are use of two methods active and passive method, where active methods are based on vibration and passive methods are based on surface expansion but active methods are more power consuming and lessens friction losses more power plant losses due to additional devices that consumes more power and overall efficiency is less then passive method. Further, passive method mainly focuses on significant increase in pressure drop via turbulent flow or providing corrugated design to produce swirls, both increases frictional losses with increase in not negligible amount of molecular friction.

[3]There is comparison between direct and indirect heat exchangers according to their energy conversations and its utilization from which indirect heat exchanger is Shell and tube heat exchanger with helical baffles which enhances frictional effect due to more surface area and molecular friction due to turbulent flow. Moreover, for the direct heat exchanger air-cooled heat exchanger are used which causes wavy flow. Additionally, bubble formation occurs, which is prime factor of cavitations and increase of surface roughness for a given life of heat exchanger. In short, it increases friction losses as time advances. It can be avoided by using same fluid of different phase to cool at critical pressure.

[4]There is a quite good progress in design as a new concept of rifle tube, which is more efficient than smooth tube for high pressure or critical conditions. It vividly describes that they need single-phase turbulent flow and to calculate this molecular friction by the use of fanning friction formula and as to overcome limitation of Darcy's equation and to calculate accurate friction value. As, the velocity of fluid is too high which is not possible to calculate by Darcy's equation so they have used Blasius friction formula. Moreover, astonishing progress is seen from this experiment that the pressure drop of a rifled or ribbed tube is 19. 61 kilo Pascal and for smooth tube is 22. 88 kilo Pascal for the same conditions. Thus, the energy utilization is comparatively more in ribbed tube.

[5]The greater turbulence intensity may cause greater energy loss. Therefore, the spiral rising angle should be further optimized, according to the heat transfer and resistance characteristics of the internally ribbed tube.

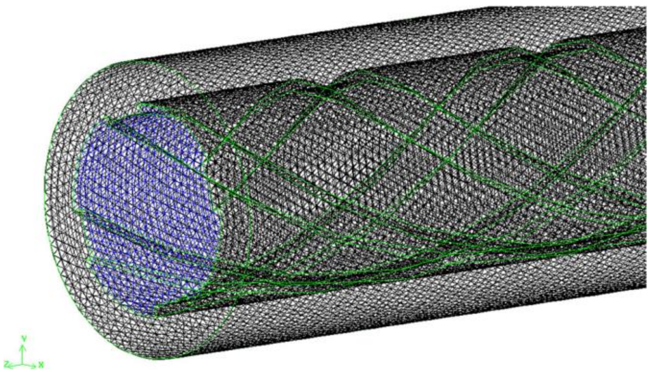

Fig. 2 Local unstructured grids on internally ribbed tube

As the spiral rising angle decreases, the tangential velocity of the fluid in the internally ribbed tube increases significantly. The relative velocity between the bulk fluid and the near-wall fluid may increase, which may reduce the thickness of the near-wall laminar boundary layer. Moreover, the centrifugal force induced by the spiral flow can also strengthen the mass and energy exchange between the fluid near wall and the bulk fluid. Obviously, the smaller the spiral rising angle is, the greater the tangential velocity is and the more widely the tangential velocity changes. For instance, under the same axial velocity, the greatest tangential velocity is 0.7 m/s when the spiral rising angle is 45^o, while the value is only 0.4 m/s when the spiral rising angle is 60^o.

[6] The tubes tested were one smooth tube, two rib-roughened tubes, five dimpled tubes, and two offset strip fin tubes. The pressure drop where increased comparatively more than the heat transfer. According to graph, Reynolds number more than laminar or transition number, the surface friction reduces and remains constant.

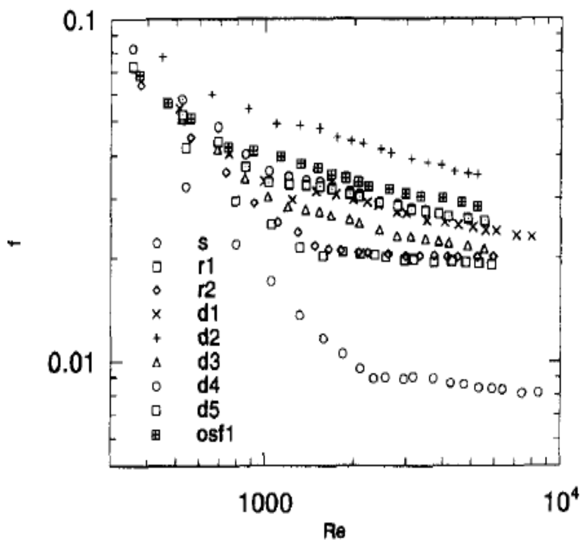

Fig. 3. Fanning friction factor vs Reynolds number.

[7]The experimental data shows that theme measured fanning friction factor and heat transfer coefficient of the copper-in-therminol 59 Nano-fluids of particle volume concentration concentrations of 0.5 percentage and 0.75 percentage are well predicted by the Blasius equation and Gnielinski equation. By adding additives in the base fluid, the friction factor increases slightly because of nanoparticles.

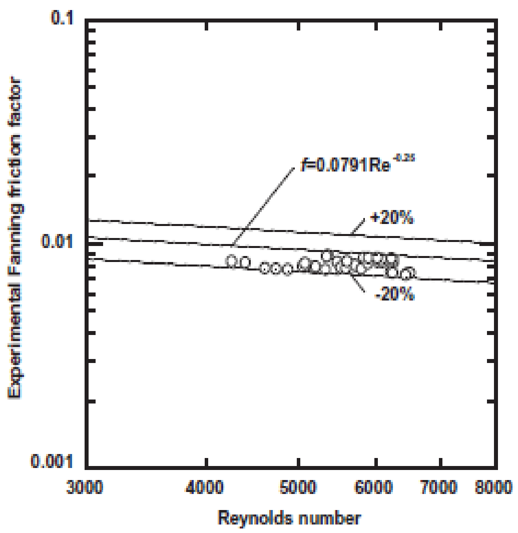

Fig. 5. Base fluid Fanning friction factor comparison.

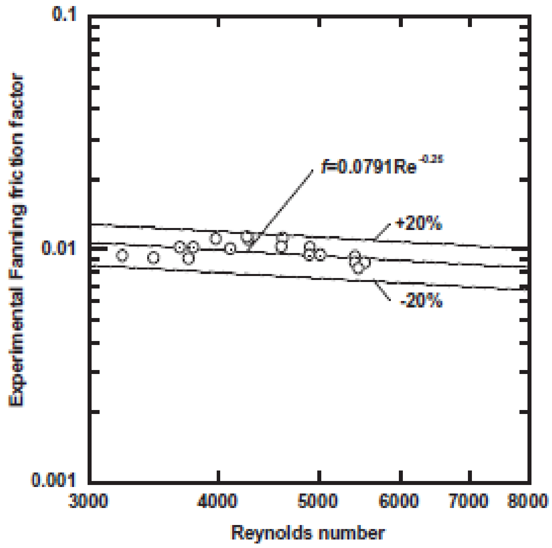

Fig. 7. 0.50 vol.% Cu-in-Therminol 59 nanofluid Fanning friction factor comparison.

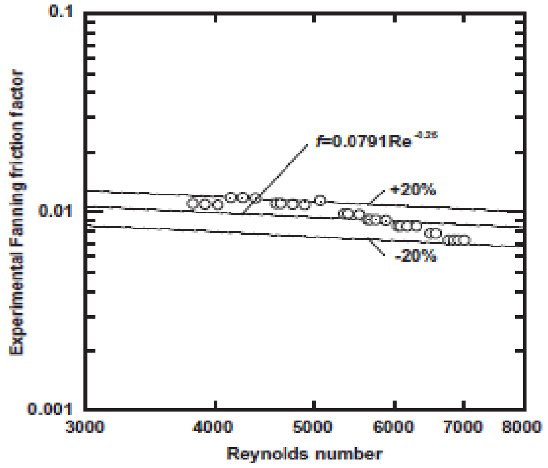

Fig. 9. 0.75 vol.% Cu-in-Therminol 59 nanofluid Fanning friction factor comparison.

[8]The most commonly used ribs of continuous arrangement in which single phase fluid flows, this results utilizes same arrangement with 15.54mm inner diameter tubes with roughened internal helical-ribs .The results obtained for the smooth tube from the numerical simulations were found to agree well with those from the correlations, within 5% and 2% for the Nusselt number and friction factor, respectively. The description above performed a validation of Nusselt number and friction factor for the smooth tube. Nevertheless, it seemed more appropriate to use some experimental results to further validate the numerical methods and results due to the fact that the structure of the ribbed tube was more complex than the smooth tube. The Nusselt number ratio and the friction factor ratio both increases as the inclination and angle of pipe increases. The Nusselt number ratio decreases as the Reynolds number increases, while the friction factor ratio exhibits the opposite trend. The friction factor ratio is increased by a factor of approximately 2.1-5.6, compared to a smooth tube.

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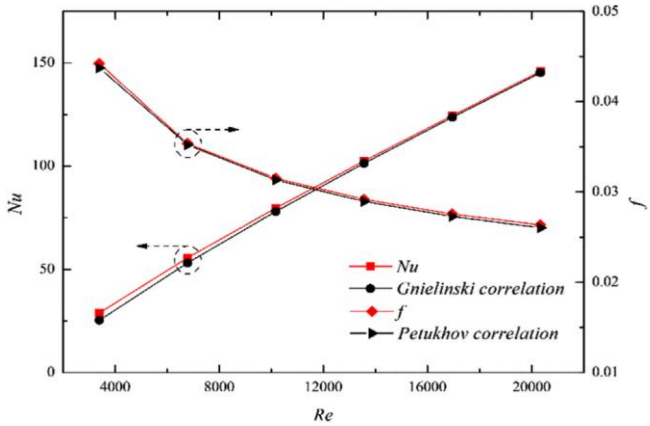

Fig. 5. Validation of Nu and f for the smooth tube.

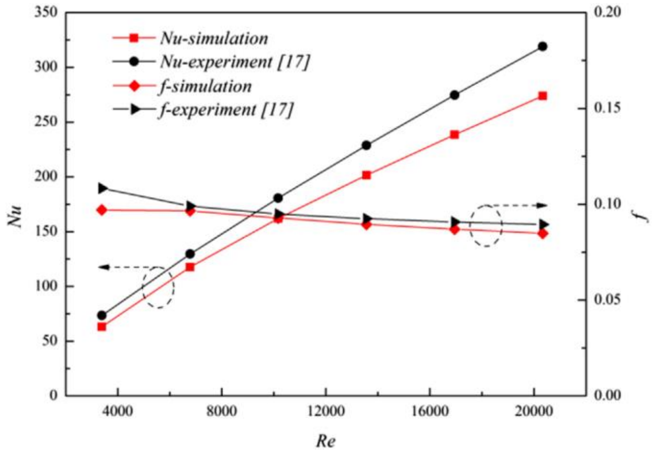

Fig. 6. Comparison between numerical results and experimental results for the proposed enhanced tube.

[9]The synergy angle between velocity U and pressure gradient Δp can be expressed as

$$\theta = \arccos\frac{((U * \Delta p)}{(lUl * l\Delta pl)}$$

From the above equation, it can be seen that the smaller the synergy angle θ is, the better the synergy between U and Δp will be. This will result in the decrease of flow resistance. The better the synergy between velocity U and driving potential Δp is, the smaller the pressure drop will be.

The below figure shows the relation between Re number and fluid resistance coefficient f in bare tube and thin cylinder-interpolated tube. As shown in the figure, the fluid resistance coefficient of thin cylinder-interpolated tube is about 2.2—2.6 times bigger than that of bare tube. The correlation of fluid resistance coefficient and pressure drop Δp can be expressed as

$$\Delta p = \frac{f L\rho U m^2}{2H}$$

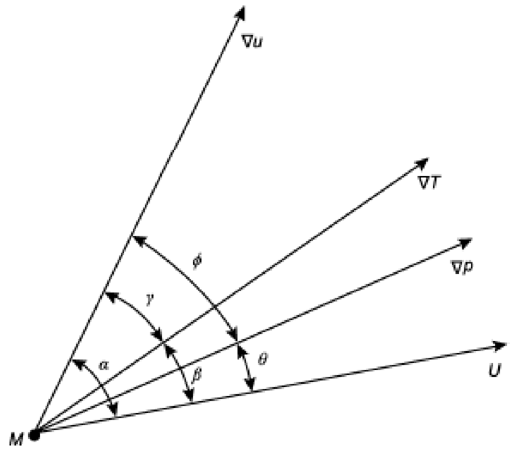

Figure 1 Synergy correlation among velocity, velocity gradient, temperature gradient and pressure gradient for fluid particle M.

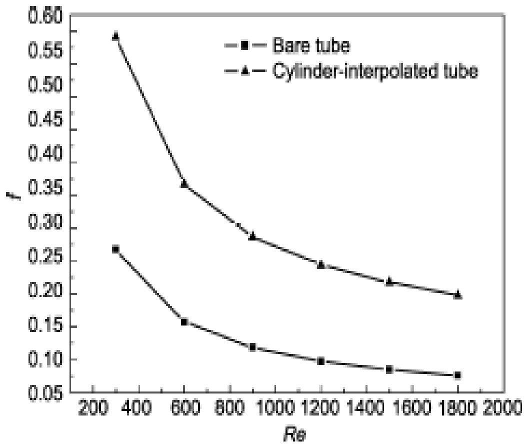

Figure 9 Relation between Re number and resistance coefficient f of fluid in bare tube and thin cylinder-interpolated tube.

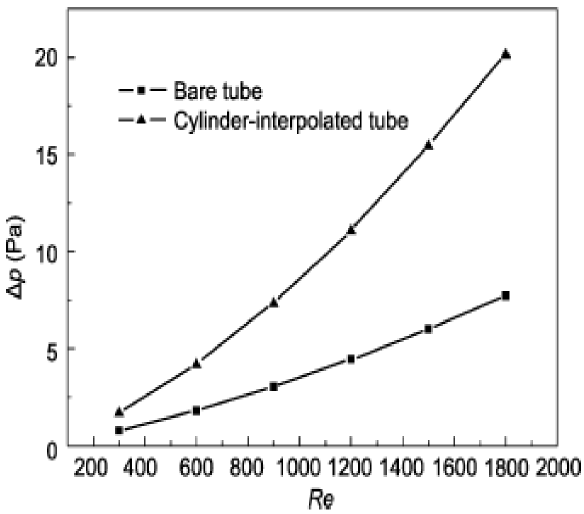

Figure 10 Relation between Re number and pressure drop Δp of fluid in bare tube and thin cylinder-interpolated tube.

The relation between Re number and fluid pressure drop Δp in bare tube and thin cylinder-interpolated tube is shown in Figure 10. It can be observed from the figure that, flow resistance and Nu number increase simultaneously with the increase of Re number. The smaller the synergy angle θ is, the smaller the fluid resistance co-efficient of friction f will be.

[10]The friction factor tends to increase with increasing Reynolds number for all the interrupted micro channels, at the given Reynolds number the friction factor increases with the increase of the rib width, and the ribs lead to a substantial increase in friction factor over that in the one without ribs. As the average friction factor increases with the increase of Re with an approximately linear positive slope, but the average Nusselt number increases with the increase of Re with a gradually decreasing positive slope. The average friction factor markedly increases with the increase in rib width and the difference of average friction factor increases with the increase of Re, but the difference of average Nusselt number is less changed.

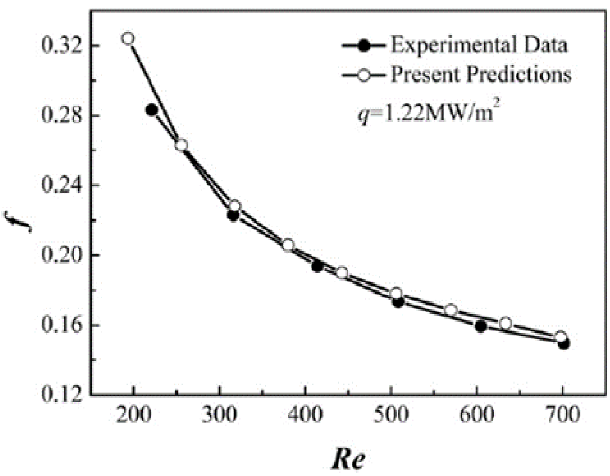

Fig. 3.Verification of friction factor for the new interrupted micro channel (w = 0.1 mm, L = 0.4 mm, d ¼ 0.35 mm and s = 3.7 mm).

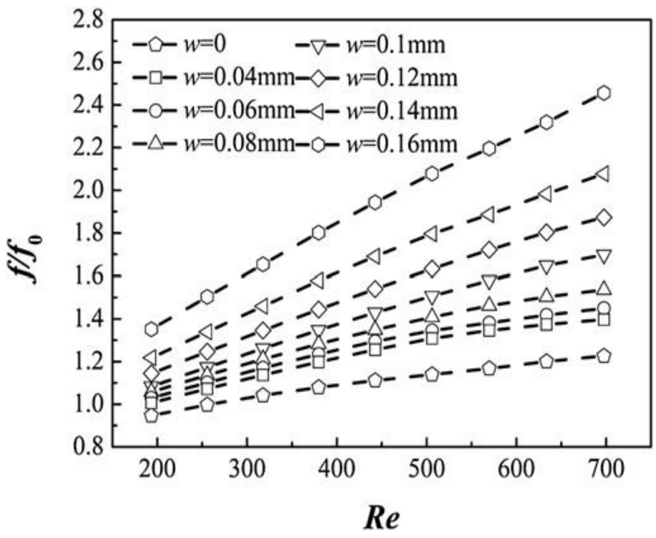

Fig. 8. Variation of f/f0 with Re number for different w parameter.

When Re > 600, the contribution of the ribs to the increased frictional pressure drop caused by flow blockage. As shown in Fig. 11, as Re < 400, the average friction factor increases with the increase of rib length, while as Re > 400 for the new interrupted micro channel, a shorter rib length results in a larger increase slope of the average friction factor. It is an indicator that the contribution of fluid mixing to the average friction factor is gradually higher than that of the length increase of the gap between two adjoining ribs.

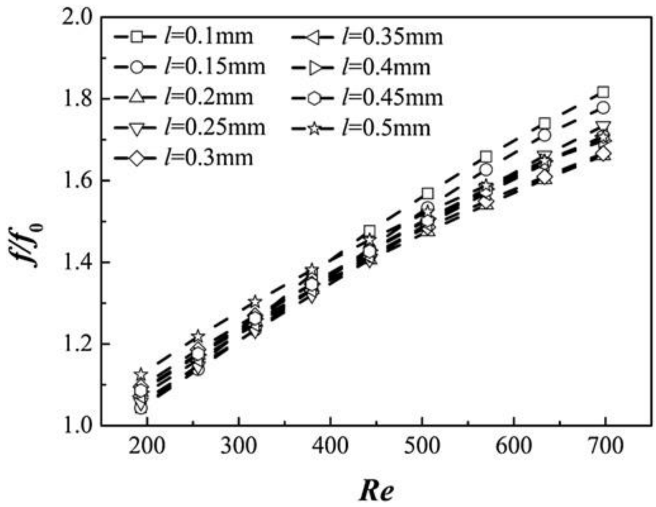

Fig. 11. Variation of f/f0 with Re number for different l parameter.

Figs. 17 present variations of Nu/Nu0 and f/f0 with Renumber for different micro chamber spacing's with w = 0.1 mm, l = 0.4 mm and d = 0.35 mm. As, it can be seen from these figures, the increase of micro chamber spacing results in a decided increase of the average friction factor.

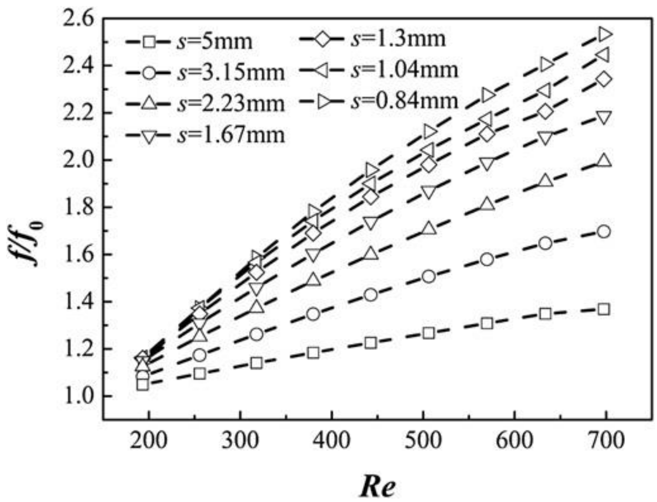

Fig. 17. Variation of f/f0 with Re number for different s parameter.

REFERENCES

[1] S. Mohsen, G. Mofid, D. Domiri, Review of heat transfer enhancement methods:focus on passive methods using swirl flow devices, Renew. Sust. Energ. Rev.49 (2015) 444–469.
[2] Z.S. Kareem, M.N. Mohd Jaafar, T.M. Lazim, S. Abdullah, A.F. Abdulwahid, Passiveheat transfer enhancement review in corrugation, Exp. Therm. Fluid Sci. 68(2015) 22–38.

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[3] Q.W. Wang, M. Zeng, T. Ma, X.Q. Du, J.F. Yang, Recent development andapplication of several high-efficiency surface heat exchangers for energyconversion and utilization, Appl. Energy 135 (2014) 748–777.
[4] A.M.M. Ibrahim, B.R.E. Wahab, H.A. Abas, Experimental study on heattransfer and fluid flow in vertical rifled, Adv. Mater. Res. 505 (2012) 524–533.
[5] Z. Zhao, X. Wang, D. Che, Numerical study on heat transfer and resistancecharacteristics of supercritical water inside internally-ribbed tube, Heat MassTransfer 50 (2014) 559–572.
[6] C.O. Olsson, B. Sunden, Heat transfer and pressure drop characteristics of tenradiator tubes, Int. J. Heat Mass Transf. 39 (1996) 3211–3220.
[7] W. Yu, V.T. Elena, S. Dileep, M.F. David, K.S. Roger, Investigations of heat transferof copper-in-Therminol 59 nanofluids, Int. J. Heat Mass Transf. 64 (2013)1196–1204.
[8] Z. Nianben, L. Wei, L. Zhichun, L. Peng, S. Feng, A numerical study on heattransfer enhancement and the flow structure in a heat exchanger tube withdiscrete double inclined ribs, Appl. Therm. Eng. 90 (2015) 232–241.
[9] W. Liu, Z.C. Liu, Z.Y. Guo, Physical quantity synergy in laminar flow field ofconvective heat transfer and analysis of heat transfer enhancement, Chin. Sci.Bull. 54 (2009) 3579–3586.
[10] L. Chai, G. Xia, M. Zhou, J. Li, J. Qi, Optimum thermal design of interruptedmicrochannel heat sink wit rectangular ribs in the transverse microchambers,Appl. Therm. Eng. 51 (2013) 880–889.