PERFORMANCE ENHANCEMENT OF HEAT EXCHANGERS USING VORTEX FLAPS

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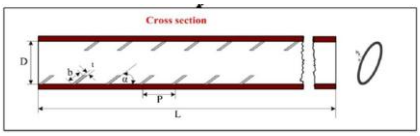
Abstract *-A heat exchanger is a system used to transfer heat between two or further fluids. Heat exchangers are used in both cooling and heating processes. They're extensively used in space heating, refrigeration, air exertion, power stations, chemical Shops, petrochemical shops, petroleum refineries, natural-gas processing, and sewage treatment. With the ever-decreasingly severe energy and terrain problems, there has been a swell of interest in largely-effective energy conversion and operation in recent times. It's well given that convective heat transfer marvels are generally involved in the process of energy application, and perfecting the convective heat transfer performance by heat transfer*

Improvement ways is significant for energy conservation and environmental protection.



In the present design we employ windy heat exchanger with twisted internal flaps of tube of length of L = 2000 mm, with 50.8 mm inner periphery(D), 53 mm external periphery(Do), and mm consistence(t). The dimension of twisted whirlpool delirium is defined by its length = b and its angle α we design heat exchanger with α = 30 °, L/ D rate of0.1 and0.2 and pitch (P/ D) of0.5, 1 and1.5. twisted whirlpool flaps would have minimal resistance to mass inflow rate. The end at using the whirlpool flaps is to produce counter-rotating maelstroms inside the tube to help increase the turbulence intensity as well as to convey the colder fluid from the core governance to the heated- wall region.

The proposed design is meant to ameliorate the heat transfer rate due to the enhanced curve and turbulence. The twisted whirlpool flaps are precisely designed so as to have minimal effect in mass Inflow rate. The numerical simulations will carried out using ANSYS fluent.

1.INTRODUCTION

Heat transfer addition fashion is used to enhance heat transfer rate and meliorate their thermal performance. The fashion rate was divided into two active system which requires external power for illustration mechanical aid. Another System was unresisting system which does not bear an external aid. Generally unresisting system was used generally. also the vortex/ wind flux in the thermal system. Insertion of vortex generators in a circular tube is a simple fashion for enhancing the convective heat transfer measure on the tube side of a heat exchanges due to their advantages of fabrication, operation and conservation. Performance of tabulators of vortex generators strongly depend on their figure. Different types of vortex Generators employed in the heat exchanger tubes are helical coiled line, circular/ crooked rings angle finned tapes. A heat exchanger is a system used to transfer heat between two or farther fluids. Heat exchangers are used in both cooling and toast processes. They are considerably used in space heating, refrigeration, air exertion, power stations, chemical shops, petrochemical shops, petroleum refineries, natural- gas processing, and sewage treatment. With the ever- increasingly severe energy and Terrain problems, there has been a swell of interest in largely-effective energy conversion. It's well known that convective heat transfer sensations are generally involved in the process of energy operation, and perfecting the convective heat transfer performance by heat transfer enhancement ways is significant for energy conservation and environmental protection. In the present design we design and stimulate the effect of vortex flaps in the innards of a heat exchanger. crooked vortex flaps would have minimum resistance to mass flux rate. The end at using the whirlpool flaps is to produce counter- rotating vortices inside the tube for increasing the turbulence intensity to convey the colder fluid from core governance to heated- wall region. The proposed design improves the heat transfer rate due to the enhanced wind and turbulence. The numerical simulations are carried out using ANSYS fluent

2. Literature review

2.1 convective heat transfer in a circular tube with short-length twisted tape insert

S. Eiamsa- ard,C. Thianponge,P. Eiamsa- ard,P. Promvonge(2009) presents an experimental study on the mean Nusselt number, disunion factor and improvement effectiveness characteristics in a round tube with short- length twisted tape recording insert under invariant wall heat flux boundary conditions. In the trials, measured data are taken at Reynolds figures in a turbulent region with air as the test fluid. The full- length twisted tape recording is fitted into the tested tube at a single twist rate of y/ w = 4.0. The short- length tape recording is introduced as a swirling inflow device for generating a strong curve inflow at the tube entry before decaying along the tube. The full- length tape recording(LR = 1.0) is anticipated to produce a explosively swirling inflow over the whole tube. The variation of heat transfer and pressure loss in the form of Nusselt number(Nu) and disunion factor(f) independently is determined. The experimental result indicates that the short- length videotapes of LR = 0.29,0.43 and0.57 perform lower heat transfer and disunion factor values than the full- length tape recording around 14,9.5 and6.7; and 21,15.3 and10.5, independently

2.2 Thermal performance in circular tube fitted with coiled square wires

P. Promvonge(2008) Experimentally delved the goods of cables with square cross section forming a coil used as a turbulator on the heat transfer and turbulent inflow disunion characteristics in a invariant heat flux, indirect tube. In the present work. The trials are performed for overflows with Reynolds figures ranging from 5000 to. Two different spring curled line pitches are introduced. The results are also compared with those attained from using a typical curled indirect line, piecemeal from the smooth tube. The experimental results reveal that the use of curled square line turbulators leads to a considerable increase in heat transfer and disunion loss over those of a smooth wall tube. The Nusselt number increases with the rise of Reynolds number and the reduction of pitch for both indirect and square line coils. The curled square line provides advanced heat transfer than the indirect one under the same conditions. Also, performance evaluation criteria to assess the real benefits in using both coil cables of the enhanced tube are determined..

2.3 Flow-induced vibration analysis of conical rings used of heat transfer enhancement in heat exchanger

K. Yakut,B. Sahin(2004) reported the effect of conical- ring turbulators on the heat transfer, pressure drop, inflow-convinced vibration and maelstroms. In addition, the thermal performance for employing the turbulators at constant pumping and entropy generation was estimated. From the evaluation of entropy generation, the conical-ring turbulators showed the merit as energy saving device only at low Reynolds number since low pressure drop was generated in that inflow region. In the present work, inflow- convinced vibration characteristics of conical- ring turbulators used for heat transfer improvement in heat exchangers are delved experimentally. The conical- rings, having 10, 20 and 30 mm pitches, are fitted in a model pipe- line through which air is passed as the working fluid. whirlpool- slipping frequentness and breadth are determined and St- Re, Prms- Re variations are presented graphically. Flow- aural coupling is also anatomized experimentally. It's observed that as the pitch increases, whirlpool slipping frequentness also increase and the maximum confines of the maelstroms produced by conical-ring turbulators do with small pitches. In addition, the goods of the promoters on the heat transfer and disunion factor are delved experimentally for all the arrangements. It's set up that the Nusselt number increases with the adding Reynolds number and the maximum heat transfer is attained for the lowest pitch arrangement.

2.4 Heat transfer behaviors in round tube with conical ring inserts

P. Promvonge(2008) studied the insertion effect of the conical ring arrangements, videlicet, clustering conical ring, diverging conical ring, and clustering diverging conical ring on the heat transfer rate, disunion factor and thermal performance in a round tube. The study showed that the diverging conical ring offered advanced thermal performance than the clustering and clustering diverging bones . To increase convection heat transfer in a invariant heat flux tube by a unresistant system, several conical rings used as turbulators are mounted over the test tube. The goods of the conical ring turbulator inserts on the heat transfer rate and disunion factor are experimentally delved in the present work. Conical rings with three different periphery rates of the ring to tube periphery(d/ D = 0.5,0.6,0.7) are introduced in the tests, and for each rate, the rings are placed with three different arrangements(clustering conical ring, appertained to as CR array, diverging conical ring, DR array and clustering – diverging conical ring, CDR array). In the trial, cold air at ambient condition for Reynolds figures in a range of 6000 – is passed through the invariant heat flux indirect tube. It's set up that the ring to tube periphery rate and the ring arrays give a significant effect on the thermal performance of the test tube. The experimental results demonstrate that the use of conical ring inserts leads to a advanced heat transfer rate than that of the plain face tube, and the DR array yields a better heat transfer than the others. The results are also identified in the form of Nusselt number as a function of Reynolds number, Prandtl number and periphery rate. An addition of over to 197, 333, and 237 in Nusselt number is attained in the turbulent inflow for the CR, DR and CDR arrays, independently, although the effect of using the conical ring causes a substantial increase in disunion factor.

2.5 Heat transfer and exergy loss in cut out conical turbulators

A. Durmus(2004) excavated the effect of angle arrangement of the conical- ring type turbulators on the heat transfer and disunion loss. The excavated results revealed that heat transfer rate as well as disunion factor increased with the increase in the conical- ring angle. therefore, energy saving aspects are truly important in the design, construction and operation of the heat exchangers. For this reason, various active or unresistant styles have been sought to save energy by adding the heat transfer portions in the cold and warm fluid sidesintheheatexchangers.In this study, the effect of cut out conical turbulators, placed in a heat exchanger tube at constant external face temperature, on the heat transfer rates was excavated. The air was passed through the exchanger tube, the external face of which was toast with logged water vapor. The trials were conducted for air flux rates in the range of ⩽ Re<. Heat transfer, pressure loss and exergy analyses were made for the conditions with and without turbulators and compared to each other. Some empirical correlations expressing the results were also derived and mooted.

2.6 Heat transfer behaviors in a tube with combined conical-ring and twisted-tape insert

P. Promvonge,S. Eiamsa- ard(2007) examined the concerted effect of the conical- ring and crooked- tape recording for heat transfer improvement in a indirect tube. As reported, the use of the conical- ring in common with the crooked- tape recording handed an average heat transfer rate up to 10 over that of the conical- ring alone. Heat transfer, disunion factor and improvement effectiveness characteristics in a indirect tube fitted with conical- ring turbulators and a crooked- tape recording curve creator have been delved experimentally. The heat transfer test section is hotted electrically assessing axially and circumferentially constant wall heat flux boundary conditions. In the trials, two improvement heat transfer bias are applied. One is the conical- ring used as a turbulator and placed in the tested tube and the other is the crooked- tape recording curve creator placed at the core of the conical- ring. Air as the tested fluid is passed both improvement bias in a Reynolds number range of 6000 to. Two crooked- videotapes of different twist rates, Y = 3.75, and7.5, are introduced in each run. The experimental results reveal that the tube fitted with the conical- ring and crooked- tape recording provides Nusselt number values of around 4 to 10 and improvement effectiveness of 4 to 8 advanced than that with the conical-ring alone. A maximum heat transfer rate of 367 and improvement effectiveness of around1.96 is set up for using the conical- ring and the crooked- tape recording of Y = 3.75. For all the bias used, the improvement effectiveness tends to drop with the rise of Reynolds number and to be nearly livery for Reynolds number over. In addition, correlations for Nusselt number, disunion factor and performance evaluation criteria to assess the real benefits in using the turbulator and curve creator of the enhanced tube are determined..

2.7 Heat transfer and friction behavior in rectangular channels with varying number of ribbed walls

P.R. Chandra,C.R. Alexander,J.C. Han(2003) studied the heat transfer behaviours in a square channel with nonstop caricatures on four walls where caricatures were placed superimposed on walls. They set up that the heat transfer increases with the proliferation in the number of ribbed walls and with reducing Reynolds number while the disunion factor increases with both cases. piecemeal from experimental examinations, the numerical studies on heat transfer improvement by means of the indirect ring turbulators were also reported. An experimental study of face heat transfer and disunion characteristics of a completely developed turbulent air inflow in a square channel with transverse caricatures on one, two, three, and four walls is reported. Tests were performed for Reynolds figures ranging from to. The pitch- to- caricature height rate, P/ e, was kept at 8 and caricature- height- to- channel hydraulic periphery rate, e/ Dh was kept at0.0625. The channel length- to- hydraulic periphery rate, L/ Dh, was 20. The heat transfer measure and disunion factor results were enhanced with the increase in the number of ribbed walls. The disunion roughness function, R(e), was nearly constant over the entire range of tests performed and was within similar limits of the preliminarily published data. The heat transfer roughness function, G(e), increased with roughness Reynolds number and compared well with former work in this area. Both correlations could be used to prognosticate the disunion factor and heat transfer measure in a blockish channel with varying number of ribbed walls. The results of this disquisition could be used in colorful operations of turbulent internal channel flows involving different number of caricature planed walls.

2.8 Enhancement of heat transfer in a tube with regularly-spaced helical tape swirl generators

Smith Eiamsa- ard, Pongjet Promvonge(2004) Influence of spiral videotapes fitted in a tube on heat transfer improvement is studied experimentally. A spiral tape recording recording recording is fitted in the tube with a view to generating wind flux that helps to increase the heat transfer rate of the tube. The flux rate of the tube is considered in a range of Reynolds number between 2300 and 8800. The swirling flux bias conforming of(1) the full-length spiral tape recording recording recording with or without a centered- rod, and(2) the regularly- spaced spiral tape recording recording recording, are fitted in the inner tube of a concentric tube heat exchanger. The experimental data attained are compared with those attained from plain tubes of published data. Experimental results vindicated that the use of spiral videotapes leads to a advanced heat transfer rate over the plain tube. The full-length spiral tape recording recording recording with rod provides the topmost heat transfer rate about 10 better than that without rod but it increased the pressure drop. To overcome this, different free- distance rate(s = Ls/ Lh) of0, and2.0 were examined. It was set up that the space rate value should be about unity for Re< 4000. The regularlyspaced spiral tape recording recording recording inserts at s = 0.5 yields the topmost Nusselt number which is about 50 above the plain tube.

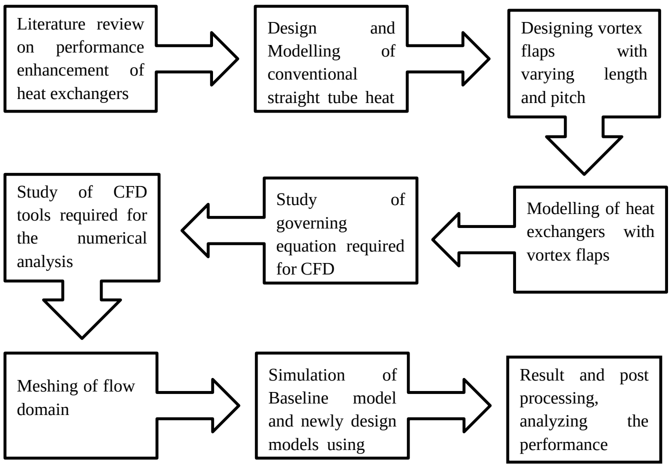
2.9 A review on single-phase convective heat transfer enhancement based on multilongitudinal vortices in heat exchanger tubes

Nianben Zheng, Fang Yan, Kang Zhang, Tian Zhou, Zhiqiang Sun(2019) in this work, a review on single- phase convective heat transfer improvement grounded onmulti-longitudinal maelstroms is carried out. Theoretical examinations on convective heat transfer optimization from different principles similar as entropy generation minimization principle, field community principle, entransy dispersion extremum principle, power consumption minimization principle, and exergy destruction minimization principle for the better trade- off between heat transfer addition and inflow resistance reduction are originally estimated. It's set up that the optimal inflow fields are substantially characterized bymulti-longitudinal maelstroms, inferring that heat transfer improvement ways which can induce the inflow patterns analogous to the optimal inflow fields may also enjoy the satisfactory balance between heat transfer improvement and inflow resistance reduction. also, colorful ways similar as artificial roughness, special-structured tubes, multiple curve bias, and longitudinal whirlpool creators that can construct the inflow pattern ofmulti-longitudinal maelstroms are epitomized. Results indicate that utmost of the ways show excellent thermal-hydraulic performance, but some ways still suffer from high inflow resistance. Grounded on the discussion, some new perspectives on the being exploration gaps, grueling , and unborn exploration directions have been handed for the development of enhanced heat transfer ways by generating multi- longitudinal maelstroms in heat exchanger tubes.

2.10 Numerical investigation of laminar heat transfer in a square channel with 30° & 45° inclined baffles

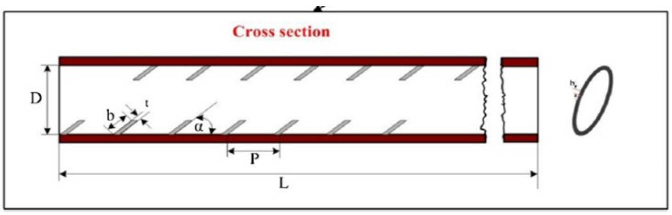
S. Kwankaomeng,P. Promvonge,S. Sripattanapipat,S. Tamna, S,C. Thianpong(2010) studied numerically the laminar periodic inflow over 30, and 45, angled baffles constantly mounted only on one wall of a square channel, independently. They noted that the heat transfer improvement for the 45, angled cocoon with BR ¼0.4 was about 2e3 fold advanced than that for the 90 ° cocoon while the disunion loss was some 10e25 lower. In addition, they set up that a single streamwise main whirlpool inflow created by the angled baffles/ fins can help to induce smash overflows on the upper, lower and cocoon running end walls of the channel. The appearance of the whirlpool convinced smash(VI) led to drastic increase in the thermal performance of the channel. In comparison, the 30 ° cocoon/ fin performs better than the 45 ° one due to lower pressure loss

Numerical Methodology



Geometry Modelling

We employ serpentine heat exchanger with curved internal flaps of tube of length of L = 2000 mm, with 50.8 mm inner diameter (D), 53 mm outer diameter (Do), and 1.5 mm thickness (t). The dimension of curved vortex flap is defined by its length = b and its angle α we design heat exchanger with α = 30°, b/D ratio of 0.1 and 0.2 and pitch (P/D) of 0.5, 1 and 1.5.



6.1 Case 1

Length, L= 2000mm

Inner Diameter, D= 50.8mm

Outer Diameter, Do= 53mm

Thickness of the flap, t= 1.5mm

Angle, α= 30°

b/D Ratio= 0.1

P/D Ratio= 0.5

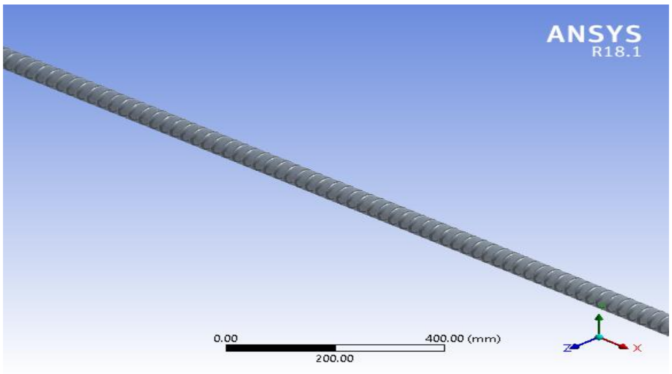


Fig 6.1 Geometric modeling of heat exchanger tube with b/D Ratio 0.1

6.2 Case 2

Length, L= 2000mm

Inner Diameter, D= 50.8mm

Outer Diameter, Do= 53mm

Thickness of the flap, t= 1.5mm

Angle, α= 30°

P/D Ratio= 0.5

b/D Ratio= 0.2

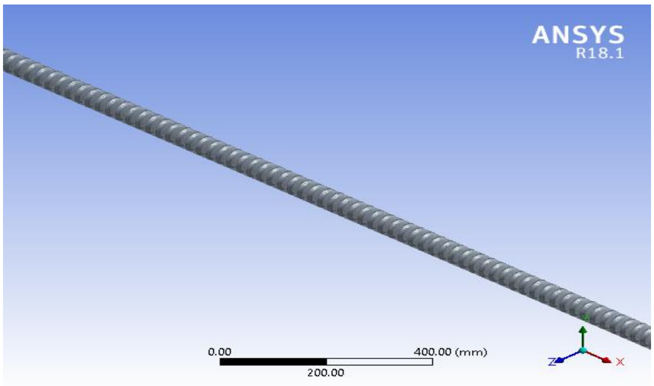


Fig 6.2 Geometric modeling of heat exchanger tube with b/D Ratio 0.2

3D Model of Heat Exchanger Tube & Fluid Domain

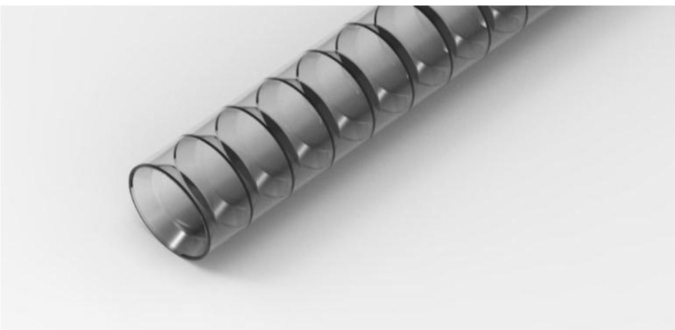


Fig 6.3.1 3D Geometry of heat exchanger tube

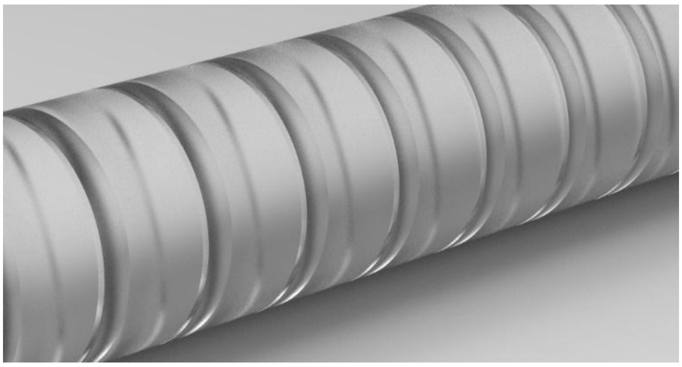


Fig 6.3.2 3D Geometry of fluid domain

Meshing

Object Name	*Geometry*
State	Fully Defined
Definition	
Type	DesignModeler
Length Unit	Meters
Bounding Box	
Length X	2000. mm
Length Y	53. mm
Length Z	53. mm
Properties	
Volume	4.0103e+006 mm³
Scale Factor Value	1.
Statistics	
Bodies	2
Active Bodies	1
Nodes	153146
Elements	738475
Mesh Metric	Element Quality
Min	0.137824962418471
Max	0.999998670961094
Average	0.82880829470036
Standard Deviation	0.102178591440126
Basic Geometry Options	
Parameters	Independent
Parameter Key	
Attributes	Yes
Attribute Key	
Named Selections	Yes
Named Selection Key	
Material Properties	Yes
Advanced Geometry Options	
Use Associativity	Yes
Coordinate Systems	Yes
Coordinate System Key	
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	Yes
Compare Parts On Update	No
Attach File Via Temp File	Yes
Temporary Directory	C:\Users\project\AppData\Local\Temp
Analysis Type	3-D
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	No

Simulation

For stimulation activates we are using ANSYS software. The requirements of the boundary condition will be asked according to the name information in meshing.

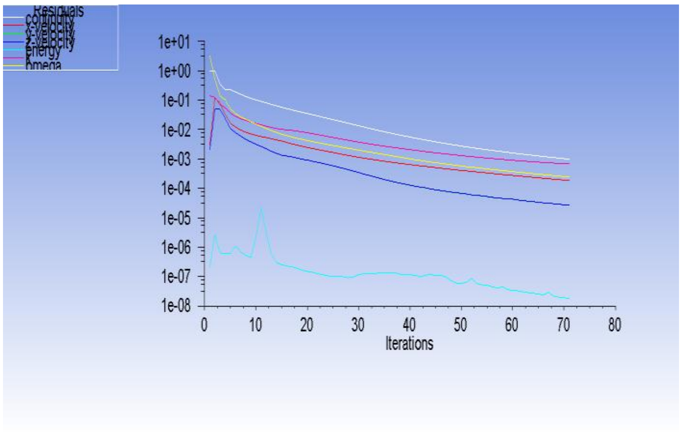


Fig 8.1 Residual Plot

Result and Analysis

We use CFD Post for result and post processing. Here we compare the result of low velocity flow through the heat exchanger tube without flaps & heat exchanger tube with flaps of 0.1 & 0.2 b/D Ratio.

9.1 Result comparison of low velocity flow

9.1.1 Temperature drop comparison

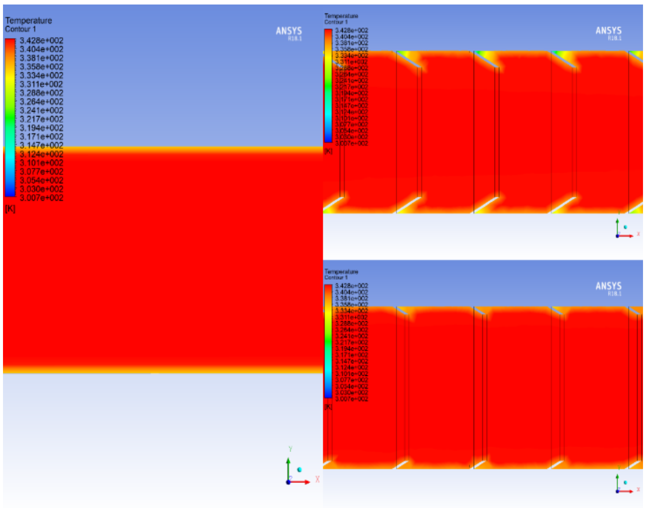


Fig 9.1.1 Figure showing the temperature drop inside heat exchanger tube with 0.1 & 0.2 b/D Ratio

From this figure we can say that the heat exchanger tube with b/D Ratio of 0.2 have the highest temperature drop

9.1.2 Velocity comparison

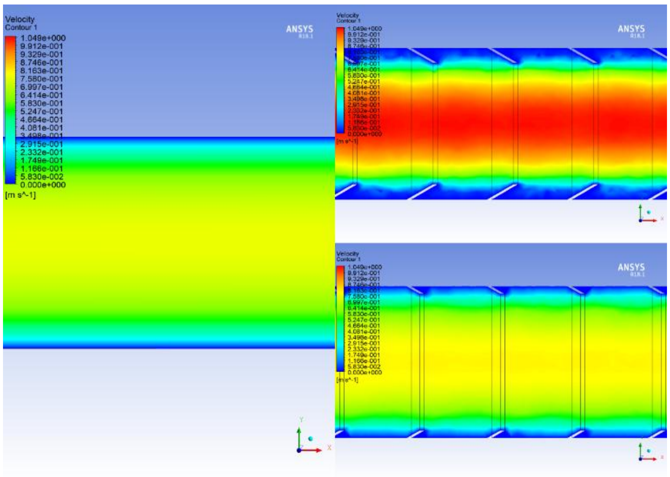


Fig 9.1.2 Figure showing the velocity difference in flow inside heat exchanger tube with 0.1 & 0.2 b/D Ratio

From this figure we can say that the heat exchanger tube with b/D Ratio of 0.2 have the highest flow velocity

9.1.3 Pressure drop comparison

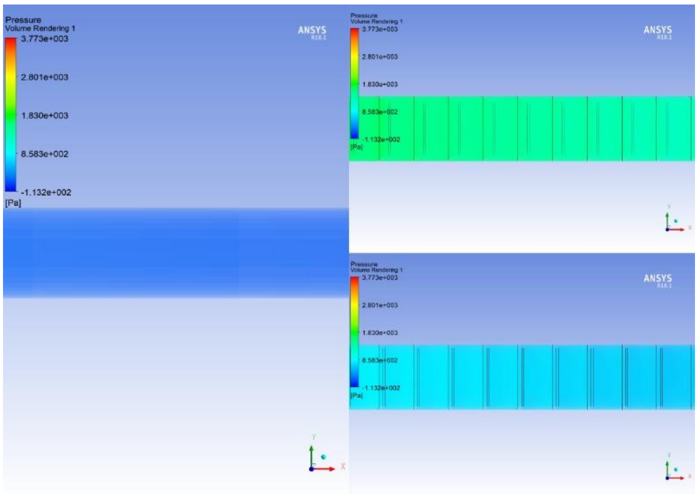


Fig 9.1.3 Figure showing the pressure drop inside the heat exchanger tube with 0.1 & 0.2 b/D Ratio

From this figure we can say that the heat exchanger tube with b/D Ratio of 0.2 have the lowest pressure drop

9.1.4 Swirl vortex core comparison

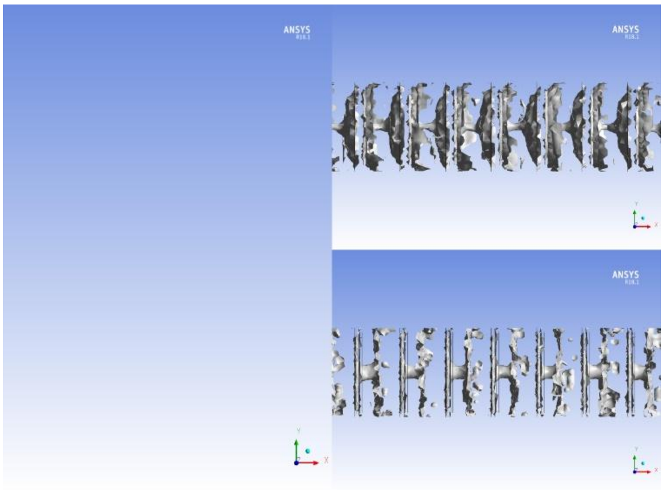


Fig 9.1.1 Figure showing the formation of vortex swirl inside heat exchanger tube with 0.1 & 0.2 b/D Ratio

From this figure we can say that the heat exchanger tube with b/D Ratio of 0.2 have the highest turbulency due to vortex swir formation.

9.1.5 Velocity streamline comparison

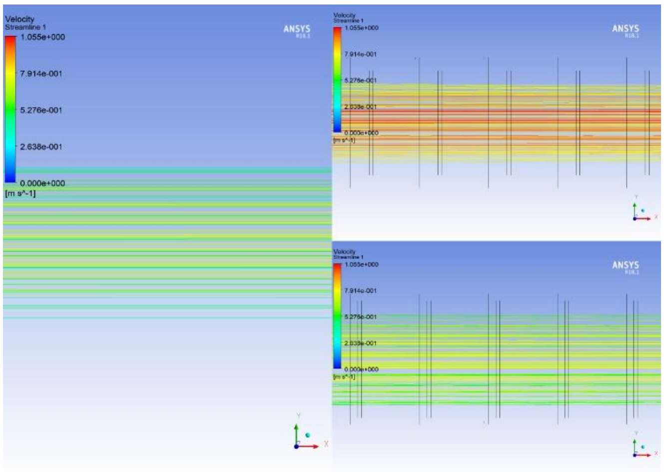


Fig 9.1.1 Figure showing the temperature drop of heat exchanger tube with 0.1 & 0.2 b/D Ratio

From this figure it's clear that the flow lines are parallel to one another. So there is no flow disruption due to our design. The heat exchanger tube with b/D Ratio of 1.2 have the highest flow velocity at the center which is represented by red lines.

9.1.6 Outlet temperature comparison

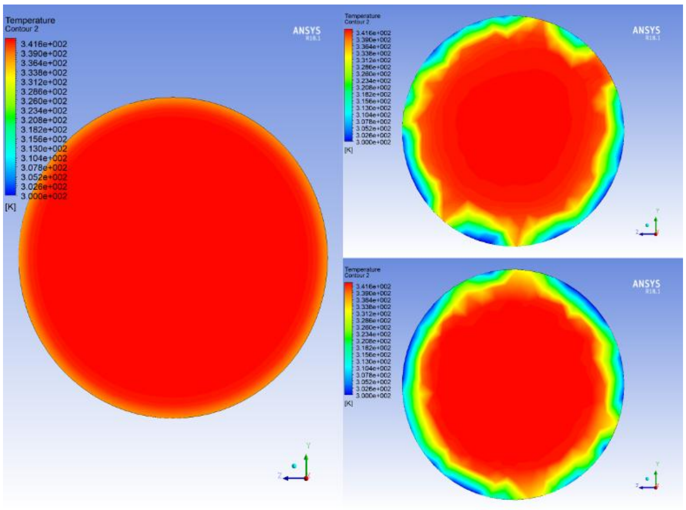


Fig 9.1.6 Figure showing the outlet temperature of heat exchanger tube with 0.1 & 0.2 b/D Ratio

From this figure we can say that the heat exchanger tube with b/D Ratio of 0.2 have the highest Outlet temperature drop.

9.1.7 Outlet pressure drop

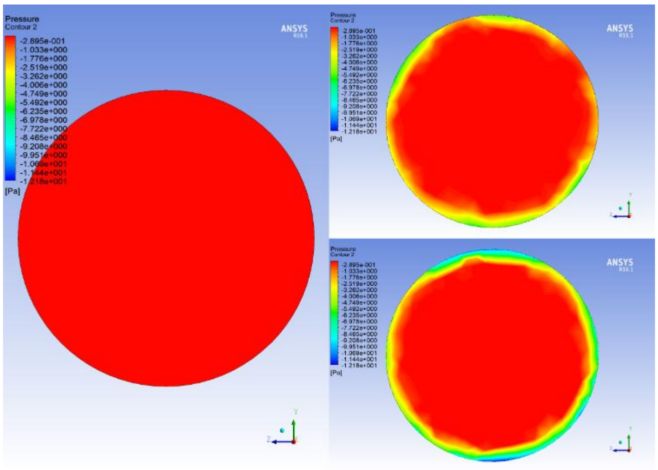


Fig 9.1.1 Figure showing the outlet pressure drop of heat exchanger tube with 0.1 & 0.2 b/D Ratio

From this figure we can say that the heat exchanger tube with b/D Ratio of 0.2 have the lowest Outlet pressure drop.

9.1.8 Outlet velocity comparison

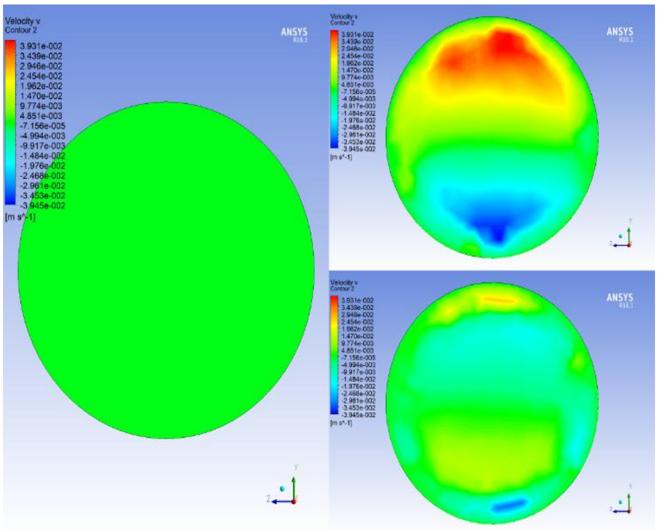
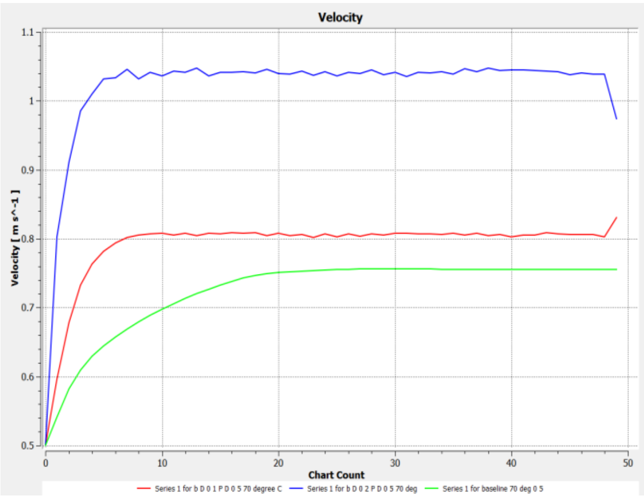


Fig 9.1.1 Figure showing the outlet velocity of heat exchanger tube with 0.1 & 0.2 b/D Ratio

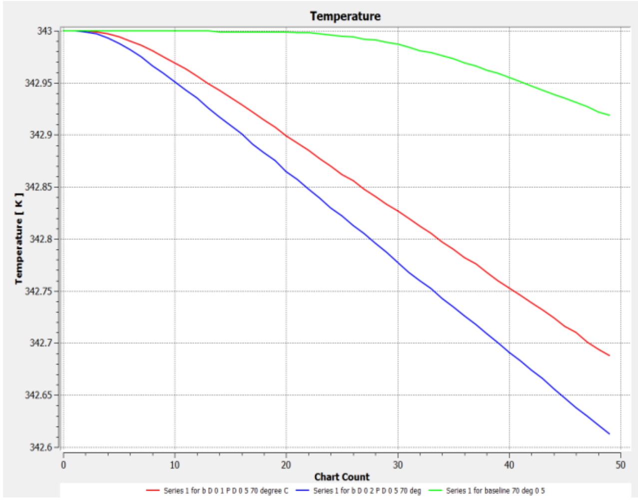
From this figure we can say that the heat exchanger tube with b/D Ratio of 0.2 have the highest Outlet velocity difference which cause turbulency.

9.2 Graphical result

9.2.1 Velocity



9.2.2 Temperature



From graph 9.2.1 & 9.2.2 we can say that the heat exchanger tube with b/D Ratio of 0.2 have the highest velocity and temperature drop

Conclusion

A heat exchanger is a system used to transfer heat between two or further fluids. They are considerably used in space heating, refrigeration, air exertion, power stations, chemical shops, petrochemical shops, petroleum refineries, natural- gas processing, and sewage treatment. With the ever- increasingly severe energy and terrain problems, there has been a swell of interest in largely-effective energy conversion and operation in recent times. It's well known that convective heat transfer sensations are generally involved in the process of energy operation, and perfecting the convective heat transfer performance by heat transfer enhancement ways is significant for energy conservation and environmental protection. The end at using the vortex flaps is to producecounter- rotating vortices inside the tube to help increase the turbulence intensity as well as to convey the colder fluid from the core governance to the heated- wall region. The proposed design is meant to meliorate the heat transfer rate due to the enhanced wind and turbulence. The crooked vortex flaps are precisely designed so as to have minimum effect in mass flux rate

Reference

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