Heat Transfer Enhancement of Heat Exchanger Using Vortex Generators

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Abstract- *High performance requirement for thermal systems in engineering applications have led researchers to search for enhancement techniques that will increase heat transfer rates in systems. Longitudinal vortex generation is a common technique for enhancing heat transfer performance. It can be achieved by employing small flow manipulators, known as vortex generator (VGs), which are placed on the heat transfer surface. The vortex generators (VGs) can generate longitudinal and horseshoe vortices. These vortices strongly disturb the flow structure and have significant influence on the velocity and temperature fields, which in turn cause heat transfer enhancement. The main aim of this study is The effects of the different configurations of the vortex generator types is used in the CFD simulation to obtain the accurate results the geometrical optimization is used in the project using the shapes like Gothic, Rectangular, Triangular, Parabolic, Ogive to determine which shape gives the optimum heat transfer in all the arrangement's standard boundary conditions is adopted to conclude the shape of the heat exchanger vortex generator.*

Keywords- CFD ,Vortex Generators ,Heat transfer , optimised Shapes

I. INTRODUCTION

1.1 Introduction

A heat exchanger is a complex device that provides the transfer of heat energy between two or more liquid, they are in a different temperature, the heat, the link between each other. Heat exchangers, use either separately or as part of a large cooling systems, in a wide variety of commercial, industrial and domestic applications, for example, electricity, Refrigeration, Ventilation and air conditioning systems, manufacturing, aviation and aerospace industry, electronic chip heat dissipation, as well as in environmental engineering. The improved performance of the heat exchanger has attracted many researchers for a long time, because they are very technical, economic, and not least, the ecological importance. Improved performance becomes essential, especially in the heat exchanger of gas, because the thermal resistance of the gases can be 10 to 50 times the liquid (tiggel beck et al., 1992), which requires a significant amount of heat per unit volume of gas. The traditional approach to reduce air-side thermal resistance is achieved by increasing the surface area of the Heat Exchanger, or to reduce the thermal boundary layer thickness on the surface of the heat exchanger. The increased surface area is effective, but it will result in an increase in the cost of materials and increase public awareness of the heat exchanger. One way to reduce the boundary layer thickness is determined by the next generation of passive vortices. In this type of technology in the field of circulation change an obstacle to produce a spiral toward the direction. The resulting change in flow, because of the changes in the local obstacles to a thermal boundary layer. The end result of this process is an average increase heat transfer to the affected area. The current work is to calculate the thermal enhancement can be achieved at all levels in a plate heat exchanger (and the heat sink in the triangle between the board with built in the vortex generator is mounted on the heat sink in the form of small rectangular wing.

1.2 Classification of Heat Exchangers

Heat exchangers may be classified according to Shah (2002) and Hewitt et al. (1994) as

(a) Recuperators or regenerators
(b) Transfer Process (Direct contact or indirect contact)
(c) Type of construction (tubes, plates and extended surfaces)
(d) Heat transfer mechanism (single phase and two phase)
(e) Flow arrangement (Parallel flow, counter flow or cross flow)

Many applications require the space to be occupied by the exchanger to be kept as low as possible. The Compact heat exchangers serve this purpose along with the required amount of energy exchange and low fluid inventory.

1.3 Compact Heat Exchangers

Compact Heat Exchangers for classification of a large heat transfer area per unit of volume. The compact heat exchanger, reducing the space, less weight, support structure and space, energy demand and costs, as well as process design, Plant layout and processing conditions, coupled with a low level of inventory. The compact heat exchanger can be a gas, gas, liquid or gas-liquid and liquid type. They are used in vehicles, aircraft of the heat exchanger cooling, car air conditioners, oil cooler, intercooler compressor, aircraft and aerospace industries. They are also used in cryogenics process, electronics, energy recovery and other industries. A heat exchanger is a compact heat exchanger, if it has a heat transfer surface, the surface area density is greater than about 700 meters of 2/m3. The compact heat exchanger pipe plate and the heat sink fins type, bundle and a smaller diameter and recycled are generally used in applications, the gas flow. The most common compact heat exchanger fins and tube plate heat exchanger fins in the short plate-fin heat exchanger for these types of switches on the heat sink or spacer with a corrugated sandwich board parallel or sub-table if liquid or phase change fluid flow to the other side of the farewell paper instead of the flat tube with or without plug-ins or track. The template or flat lines separate the two fluid flow and heat sink forms of a single stream of the channel. Spare fluid channels are connected in parallel to the appropriate header to form two or more liquid level switches. In the metal and heat sink are made of various materials such as metal, paper and ceramic. The heat sink is a chip or roll, in connection to the brazing, welding, adhesive bonding, welding, mechanical, or pinching. The heat sink can be used on both sides of the air-to-air heat exchanger. Gas-liquid heat sink application, usually only for the gas side, if employed in the fluid, they are mainly used for structural strength and the current mix of purposes. The heat sink is used in a plate heat exchanger fins are common or directly on the heatsink, plain, but the wavy heat sink fins, or interrupted, such as strip, Louvre Museum and multi-hole of the heat sink. To display a different fin geometry of plate heat exchanger heat sink.

Fin and tube heat exchangers are widely used in various engineering fields, such as heating, ventilation, air conditioning and refrigeration (HVACR) system. High Heat Exchanger Performance is important, meeting efficiency standards, low cost and the impact on the environment. For liquid and air and phase-change heat exchanger, is a typical HVAC & R system, air-flow resistance is usually the dominant cause is the physical property of hot air. Therefore, many efforts have been made to improve the air side heat transfer performance and variants of the fin pattern like waves, the Louvre and the slit fins have been adopted. There is a significantly enhanced heat transfer, the penalty is the voltage drop is great, these conventional heat transfer enhancement. In recent years, this is a very promising strategies to improve air-side heat transfer performance is to use Flow Control, known as the vortex generator. When liquid flows through the turbine generator, flow wise vortices are generated in the field of circulation, because traffic off the front edge of the vortex generator (Vgs), resulting in a large number of streams, mixed boundary layer to modify and destabilizing flow, heat conduction is enhanced as a result of these vortices. Vertical turbine generator used in all kinds of heat exchanger received considerable attention for a small pressure drop.

The Vortex generator into the fin tube heat exchanger can be classified according to the configuration of the heat pipe that is passed down the "common" and "Universal flow up. Passed down the common configuration of the vortex generator is mounted on a tube (downstream).

In the conversion, utilization, and the amount of energy recovered in each of the industrial, commercial and residential applications involves a heat exchange process. Some common examples are the Steam condenses in the power generation and power and cogeneration plants; reasonable heating and cooling of the viscous medium heat treatment of chemical, pharmaceutical and agricultural products; the refrigerant in the evaporator and condenser for air conditioning and refrigeration equipment, gas flow heat recovery in manufacturing and wasteheat; air and liquid cooled engine and turbine mechanical systems; and the cooling of electrical and electronic equipment. Improved heat transfer, in a normal or standard practice, can greatly improve the thermal efficiency, such an application, as well as economy, its design and operation.

The project recognizes the need to improve the thermal performance of the heat exchanger to achieve energy, material and cost savings, and reduce environmental degradation has led to the development and use of many heat transfer enhancement technology. In the past, these methods have a wide range of known as enrichment and enhancement, in addition to the other conditions that enhance the technology radically reduces the thermal resistance of a conventional heat exchanger, through the promotion of a higher convective heat transfer coefficient, with or without the increase in surface area (on behalf of the heat sink or the expansion of the surface). As a result, the size of a heat exchanger may be reduced, or the heat load heat exchanger can increase or pump power requirements can be reduced, or switch to the temperature difference can be reduced.

II. INTRODUCTION

This chapter reviews previously reported work by other researchers in the field of effect of vortex generators on heat transfer enhancement.

Jacobi and Shah [1] gave an excellent review on heat transfer surface enhancement through the use of longitudinal vortices. They looked into both active and passive implementation of vortex generators induced heat transfer. The review given below is focused on articles which are particularly relevant to the current research.

The use of cubes and delta winglets as vortex generators was looked into by Edwards and Alker [2]. A uniform heat flux was applied to a flat surface, and the impact of the heat transfer enhancement was evaluated by measuring local surface temperatures with a luminescent phosphor technique. Experiments were performed with various generator sizes and spacing at a constant Reynolds number of 61000 (based on generator height). Data were collected for both co- and counter-rotating vortex pairs. The results indicated that cubes provide a maximum local heat transfer enhancement of 76 percent over the smooth case. The highest enhancement achieved with delta winglets was 42 percent which occurred for a counter-rotating vortex pair.

Russell et al. [3] used vortex generators to enhance the performance of a finned-tube heat exchanger. Experiments were conducted using a transient-melt-line technique to record the local heat transfer enhancement of delta and rectangular-winglet vortex generators. The pressure drop penalty associated with the enhancements was also recorded. The authors found that, rectangular winglets placed in two staggered rows gave the best overall performance. A full-scale finned flat-tube heat exchanger was tested with rectangular winglets at a 20° angle of attack. The experimental data were then compared to plain-fin correlations from the literature (not to experimental data from an identical heat exchanger with no heat transfer enhancement). At a Reynolds number of 1000, the Colburn j factor was increased approximately 50 percent while the friction factor f increased by about 20 percent.For Reynolds numbers between 1500 and 2200, the ratio of j/f was reported to exceed 0.5. The authors concluded that the vortex generators offered a powerful type of heat transfer enhancement.

Turk and Junkhan [4] evaluated the impact of varying the aspect ratio and angle of attack of rectangular-winglet vortex generators on local heat transfer on flat plates. During the experiments, a known, constant heat flux was applied to the flat plate downstream of the Vortex generators. The local surface and air temperatures were measured using thermocouples, and from these measurements, the local heat transfer coefficients were deduced. The authors considered flows with a zero or favorable pressure gradient and reported that, in general, the enhancement increased with a favorable pressure gradient. Local span wise-averaged heat transfer enhancements as large as 250 percent were reported.

Fiebig et al. [5] studied the heat transfer enhancement of delta wings and winglets in flat-plate channels for Reynolds numbers based on plate spacing in the range 1360-2270. Qualitative data were recorded using a laser-sheet flow visualization technique, and the heat transfer behaviour was measured using unsteady, liquid crystal thermography. In this technique, an initially cool fin cascade was suddenly inserted into a warmer air stream in a wind tunnel. The transient heating of the fin surface was recorded by tracking the movement of a single isotherm on the plate surface. The convective heat transfer was then equated to the storage of internal energy within the fin, and the local heat transfer coefficients were calculated. The authors reported that the delta wing geometry was the most promising one, with local enhancements as high as 200 percent. Overall Colburn j-factors were increased by 20 to 60 percent at a Reynolds number of 1360 for delta wing with angles of attack varying from 10° to 50°.

Biswas et al. [6] performed, one of the first numerical works on vortex-induced heat exchanger enhancement by investigating the impact on mixed convection 'in a rectangular channel. Calculations were performed at Reynolds numbers of 500 and 1815 with Grashof numbers of 0, 2.5E5, and 5.0E5.They evaluated the impact of a single delta wing with an aspect ratio of one and angles of attack of 20° and 26°. The wing was attached to the bottom wall of the channel by its trailing edge. It should be noted that this study did not include the hole under the wing which would result from its being punched out of a fin.

Biswas and Chattopadhyay [7] determined numerically as an extension of earlier work, the structure of flow and heat transfer characteristics in a rectangular channel with a built-in delta wing protruding from the bottom wall. They computed the numerical solution of complete Navier-Stokes and energy equations. They looked into the effect of a punched hole, beneath the wing-type vortex generator, on the heat transfer and skin friction characteristics has been determined. They investigated influence of the vortex generator's angle of attack and Reynolds number on heat transfer and skin friction. They showed average Nu number increases as large as 34% at an angle of attack of 26°.

Gentery and Jacobi [8] presented 50% to 60% enhancement of average heat and mass flow over a flat plate at law Reynolds numbers using delta-wing vortex generators by new data. They used a straightforward method for evaluating parameter from flow visualization data. They found optimal delta-wing geometries for Reynolds number of 600,800 and 1000 based on wing-chord length. Their results used to develop a clearer understanding of the interaction between the vortices and boundary layer. They reported, when a high circulation vortex is placed near the edge of boundary layer, it effectively thins the boundary layer.

Brockermeier et al. [9] performed an analogous numerical study to evaluate the impact of vortex generation in forced convection between parallel plates. Delta wings and winglets were considered, and the impact of the hole under the wing was included. A delta wing with an aspect ratio of one was considered for attack angles varying from 10° to 50°, while the Reynolds number was varied from 1000 to 4000. The computations predicted maximum cross flow velocities in the vortex on the same order as the mean axial velocity. The cross-section of the vortex produced by the delta wing was reported to be elliptical because the turning of the vortex by the wall distorted its cross-section. With the delta winglets at a 30° angle of attack and a Reynolds number of 4000, an average increase in the Nusselt number of 84 percent was predicted.

Fiebig et al. [10] extended the work of Brockermeier et al. [9] by reporting that there is an axial velocity defect in the vortex core, allowing the vortex to remain stable at delta-wing angles of attack exceeding 50°.

Fiebig et al [11] extended their earlier work ([5]) by evaluating the impact of vortex generation in channel flows. Delta and rectangular wings and winglets were evaluated using the unsteady, liquid crystal thermography technique for aspect ratios varying from 0.8 to 2.0, angles of attack varying from 10°to 60°, and Reynolds numbers varying from 1000 to 2000. In these experiments, the pressure drop was so low that the authors chose to measure changes in drag force on a specimen suspended in the wind tunnel. They mentioned numerical results that report the error associated with their implicit equating of drag and total pressure drop to be less than 6%.

Tiggelbeck et al. [12] investigated using the same flow visualization and unsteady liquid crystal thermography techniques. This research was further extended to include two aligned rows of delta winglets. They reported that the qualitative flow structure, the number of developing vortices per vortex generator, and their stream wise development were found to be nearly independent of the oncoming flow of the vortex generator, (uniform or vertical). In other words, the second row of vortex generators performed very much like the first row. The local heat transfer enhancement was highest behind the second row of generators, but the effect of the enhancement decreased faster in the stream wise direction for the second row of generators than for the first row. For a Reynolds number of 5600, local heat transfer enhancements of several hundred percent were reported, and the average heat transfer was increased 77 percent by two aligned rows of vortex generators. No pressure drop data were recorded.

Tiggelbeck et al. [13] extended this multiple row vortex generators work by including staggered vortex generators and pressure drop experiments. Again, the qualitative flow structure, number of vortices per generator, and stream wise development were reported to be nearly independent of upstream flow conditions. The staggered arrangement gave slightly lower heat transfer enhancements than the inline arrangement, but the staggered pressure drop was also lower than the inline arrangement. The average heat transfer was observed to be increased by80 percent for an angle of attack of 45°at Reynolds number of 6000.

Tiggelbeck et al. [14] looked into longitudinal vortices generated in a channel flow by punching or mounting small triangular or rectangular pieces on the channel wall. They compared heat transfer enhancement and the flow losses in the Reynolds number range of 2000 to 9000 and for angles of attack between 30° and 90°. They showed that winglets perform better than wings and a pair of delta winglets can enhance heat transfer by 46% at Re=2000 to 120% at Re=8000 over the heat transfer on a plate.

Fiebig et al. [15] evaluated the impact of a delta-winglet pair on heat transfer in a channel with a tube (to simulate plate fin geometry) as shown in Fig 2.4. Experiments were conducted for Reynolds numbers ranging from 2000 to 5000, and the local heat transfer coefficient was reported to increase by 200% when compared to the smooth case. The average heat transfer coefficient increased by up to 20%, while the drag decreased by as much as 10 percent. They cited, “The reduction in flow losses can be explained by the delayed separation on the tube due to the strong counter rotating longitudinal vortices generated by the delta-winglet pair which introduced high momentum fluid into the region behind the cylinder.” The heat transfer results were obtained using the previously described unsteady liquid crystal thermography technique, and the drag was measured by suspending the test section in the wind tunnel and measuring the change in force.

The horseshoe vortex formed at the junction of the tube and fin, and the delta winglet is shown in Fig 2.1.

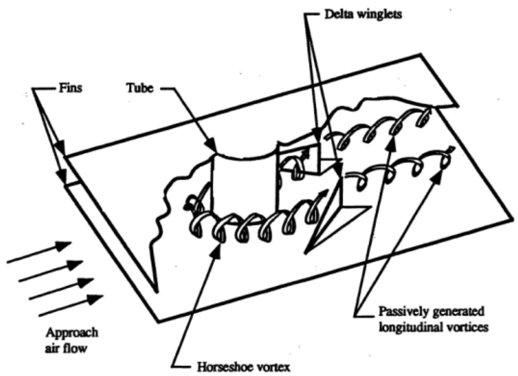


Fig 2.1 The arrangement of fin, tube, and delta-winglet vortex generators [15]

III. COMPUTATIONAL FLUID DYNAMICS

3.1 Introduction

Computational Fluid Dynamics also generally called CFD is an important branch of fluid mechanics and it uses numerical methods and algorithms to analyze and solve fluid flow problems. It has become popular since the previous methods, experimental and theoretical are either very expensive, time consuming, or involve too much labor. In CFD, computers are used to solve the algorithms that define and analyze the fluid flow. Due to the increase in the computational capabilities over time and better numerical solving methods, most experimental and theoretical work has been done using CFD. CFD is not only cost effective but it helps one analyze and simulate complex geometries, heat transfer, and shock waves in a fluid flow. It also helps solve partial differential equations (PDE) of any order in a fluid flow. CFD mainly helps analyze the internal or external fluid flow. The use of CFD has become increasingly popular in branches of engineering such as Aerospace to study the interaction of the propellers or rotors with aircraft fuselage, Mechanical to obtain temperature distribution of a mixing manifold, Bio-medical engineering to study the respiratory and circulatory systems. There are a few simple generic steps that must be followed for CFD analysis.

3.1.1 Pre-Processing and Geometry Modeling

The first step to any problem is, knowing the problem. A problem well stated is a problem well resolved Data already known is used in this process. Hence, the type and size of the geometry is already known. Geometry modeling tools such as Creo Parametric, AutoCAD, Pro/ENGINEER, and SolidWorks are used to create and model the geometry. The problem has an objective which helps specify the objective functions and apply the given constraints to a fluid flow. Creo Parametric 2.0 was used in this study to model the geometry.

3.1.2 Meshing

Meshing (also called grid generation) is the process of splitting flow domains into sub domains which are primarily composed of triangles or quadrilaterals for 2D geometry or tetrahedral or hexahedra in 3D geometry. Governing equations are discretized and solved in every single sub domain. The sub domains are called cells or elements. Combined, they are collectively called mesh. Grids are normally classified as structured, unstructured, or mixed. Grids are generated in Pointwise, Gambit, or ANSYS Workbench. In this study ANSYS Workbench 12.0.1 was used to mesh the geometry that was imported from Creo Parametric 2.0.

The Finite Volume Method (FVM) is the most common approach used for obtaining CFD simulation. As the name suggests, the governing equations are solved over discrete control volumes. This method reforms the governing partial differential equations, especially the Navier-Stokes equation in a conservative form and then discretizes the new equation. The Finite Element Method (FEM) is commonly used in the structural analysis of solids. In FEM, the problem is divided into very small elements which are related to one another. FEM is more stable than FVM and, at times, can require more memory than FVM. The Finite Differential Method (FDM) is a method for approximating solutions to differential equations.

3.1.3 Setup

Boundary conditions at inlet, outlet, and across the whole fluid flow along with viscosity, property of the fluid, and operating conditions are the various parameters that need to be defined once the meshing is completed. In this study FLUENT 12.0.16, the most commonly used commercial software, is used to set up and solve the flow. The choice of algorithms, models, solution methods, and accuracy convergence are also chosen to solve the flow.

3.1.4 Post-Processing

The desired results are processed according to the requirement of the problem, Various properties such as temperature, velocity, Mach number, and pressure are extracted from the results. At times the entire process is repeated to insure better results by controlling the under relaxation factor and improving the mesh quality.

3.2 Governing Equations

Navier-Stokes equation plays a very important role for simulation of CFD problems. This comes from applying Newton's second law to fluid motion. Partial differential equations define mass, momentum, and energy flow conservation.

In this study, the flow in the rectangular channel is considered laminar, incompressible, and steady state. The Navier-Stokes equation is shown in the simplest form. The following assumptions were made,

- It is a steady flow. Thus, this study does not depend on the time.
- The fluid has constant density and viscosity which means it is incompressible ρ = constant. Thus, the thermal changes that occur in the fluid because of constant density are neglected in this study.
- The only velocity component at inlet is in the direction of the flow, $u = V$. Thus, $v = w = 0$.

3.3 Model description

3.3.1. Physical Model

The figure. 3.3 (a) shows an example of the representative of the geometry of a four-fin tube heat exchanger is considered for numerical analysis. The small rectangular wings are installed on the managed the highest flow configuration. Tubes are staggering. Fin slice thickness, spacing, and size of the tube-like fin tube heat exchanger, widely used in the condenser Industrial refrigeration systems. As a result of the symmetrical arrangement, the area occupied by the dashed line, you can select the calculation domain, which is to be considered as a channel of Height H = 15.875 mm and L = 111.76mm.

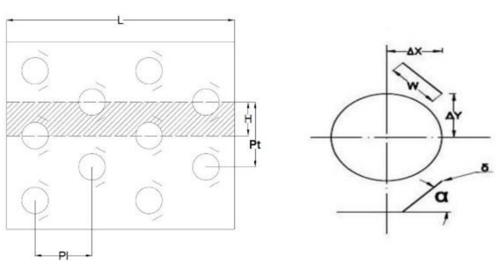


Fig.3.3 (a): computational domain
Fig. 3.3(b): Tube and VGs parameters

Tube Outside Diameter 12.7mm, so that the horizontal spacing pt is 1.25 inches, the longitudinal spacing pl is 1.1 inches, the FIN spacing fp is 2.12 mm, the leaf thickness of ∂ f is 0.15 mm. The aspect of the small rectangular wing has three different values (w = 5mm and 5.5mm and 6mm) thickness 0.15 ∂=false and is located in the (Delta X and Delta Y = 1.3). Also the angle of attack, the little wings are different, 300 and 450. The actual calculation domain is extended for 30 mm, exit, in order to ensure a free flow of recycling. The tube and rectangular turbine generator parameters, as shown in the figure. 3.3(b).

3.4 Boundary conditions

The air flow is assumed to be incompressible and volatile. RNG k-ε model is used as a turbulence model, taking into account the complex flows (wake-up or split) and anisotropic turbulence. All of the boundary conditions are given in the figure. 3.4(a)

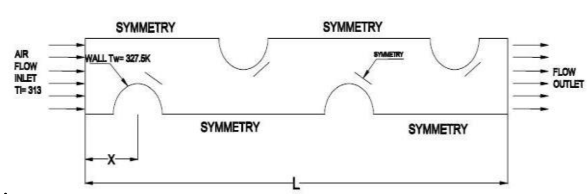


Fig. 3.4(a): The computational domain and boundary conditions.

The boundary conditions are as follows. One of the entry speed of boundary conditions (3.8 m/s) is established for the front-end of the field, and a pressure outlet boundary conditions are used for back-end symmetric boundary conditions are specified by the end of the side air flow paths. A constant temperature condition is set on the wall. The temperature of the solid surface is set so that the heat flux of the solid part of the balance and the adoption of the adjacent air. The top and bottom surface is set to heat. The inlet temperature is fixed at 313 K to all of the simulation. In the heat pipe wall temperature is set to 327.5 K to indicate the status of the Refrigerant condenser. The symmetric boundary conditions are used for the winglet VG.

IV. RESULTS

Case 1: Rectangular VG

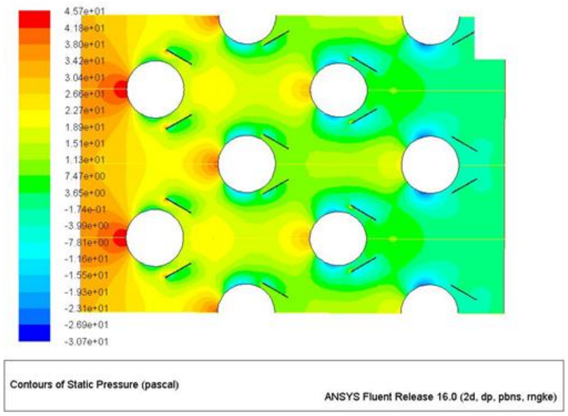


Fig 4.1 Contours of Static Pressure with Rectangular VG

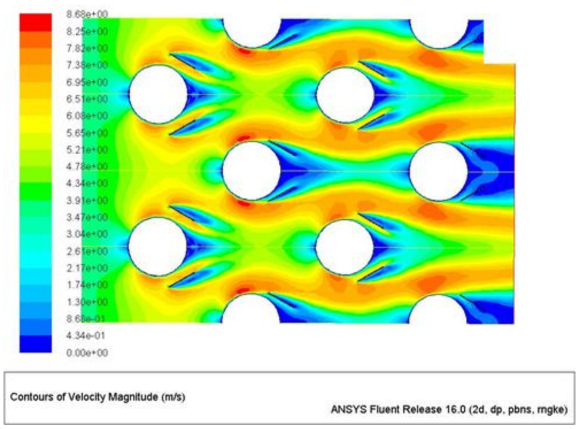


Fig 4.2 Contours of Velocity with Rectangular VG

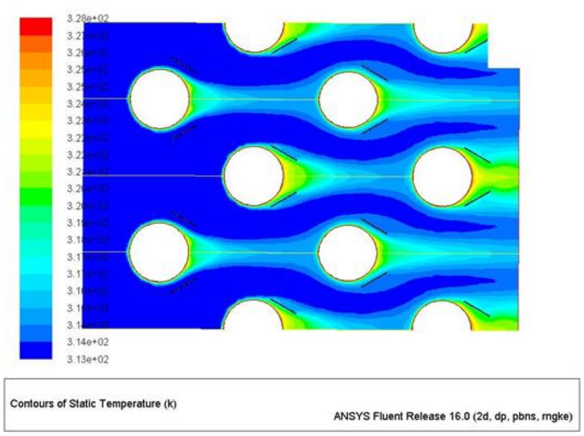
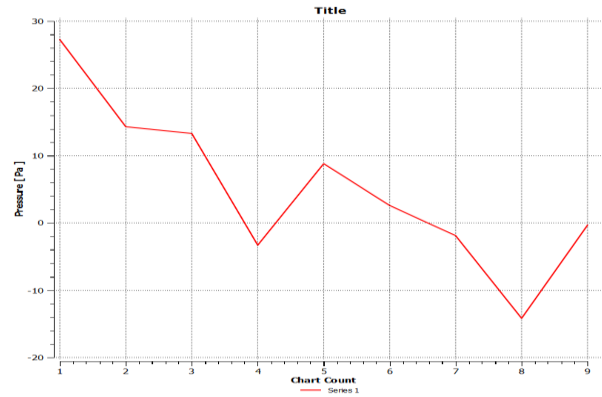
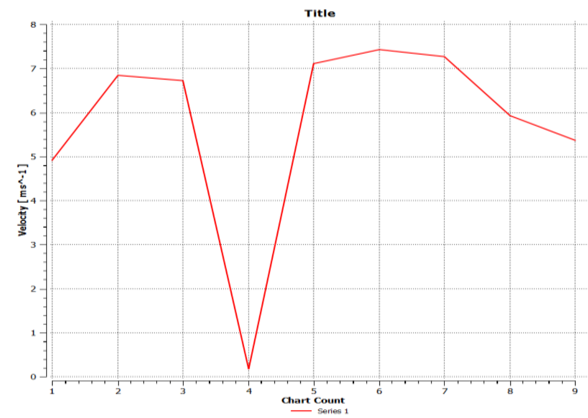


Fig 4.3 Contours of Static Temperature with Rectangular VG

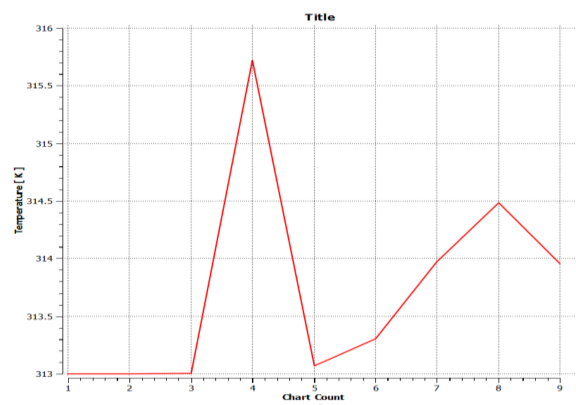
Plots



Plot 1 Pressure Vs Chart count through the heat exchanger length



Plot 2 Velocity Vs Chart count through the heat exchanger length with Rectangular VG



Plot 3 Temperature Vs Chart count through the heat exchanger length with Rectangular VG

Case 2: Triangular VG

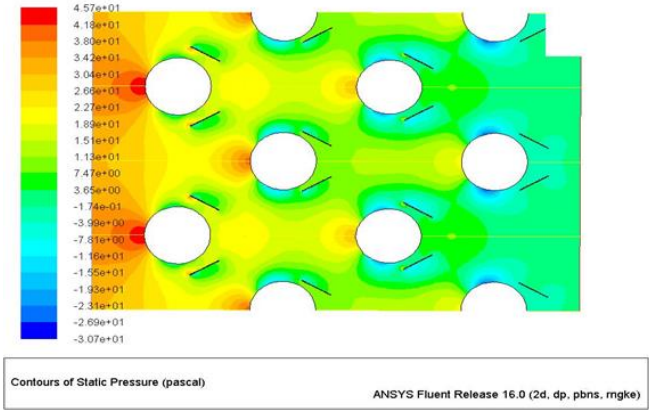


Fig 4.4 Contours of pressure Triangular VG

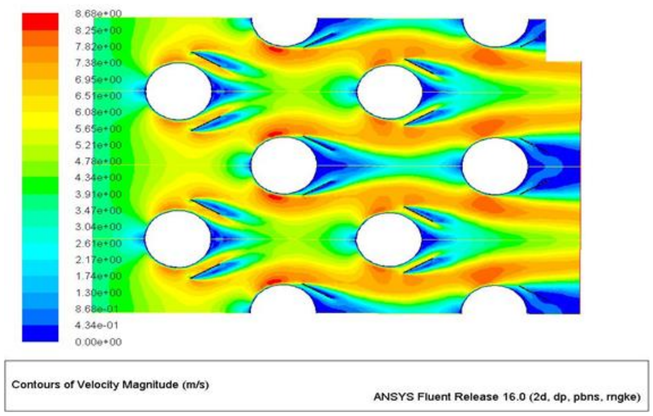


Fig 4.5 Contours of Velocity with Triangular VG

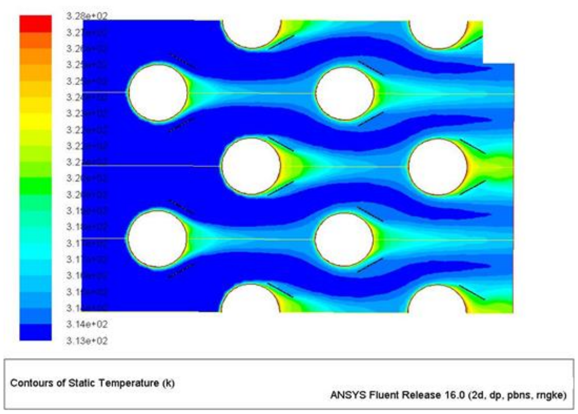
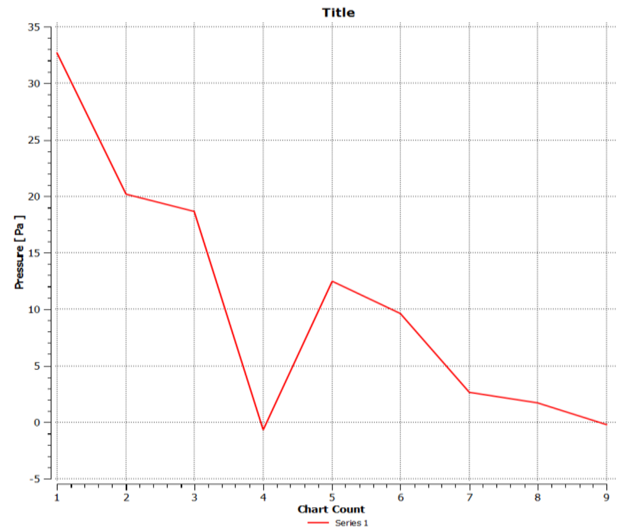
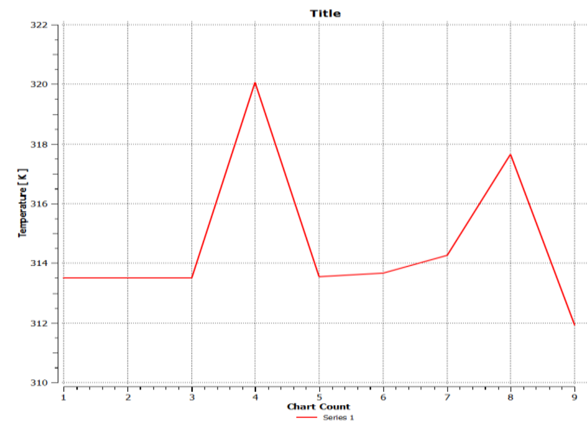


Fig 4.6 Contours of Temperature with Triangular VG

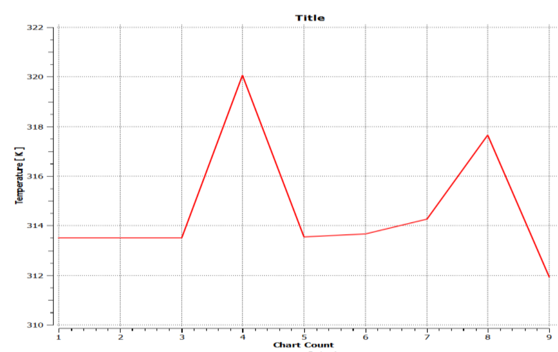
Plots



Plot 4 Pressure Vs Chart count through the heat exchanger length With Triangular VG



Plot 5 Velocity Vs Chart Count along the length of heat exchanger With Triangular VG



Plot 6 Temperature Vs Chart Count Through the heat exchanger length using triangular VG

Case 3: PARABOLIC VG

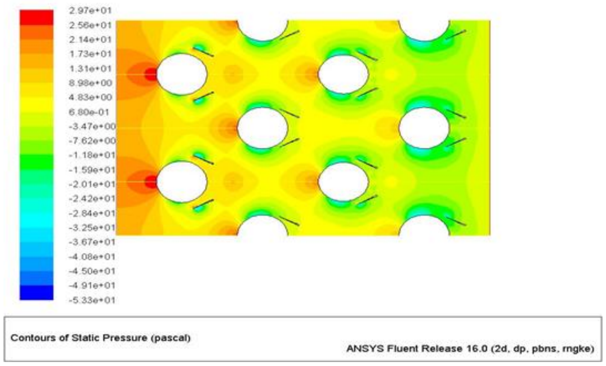


Fig 4.7 Contours of Pressure with Parabolic VG

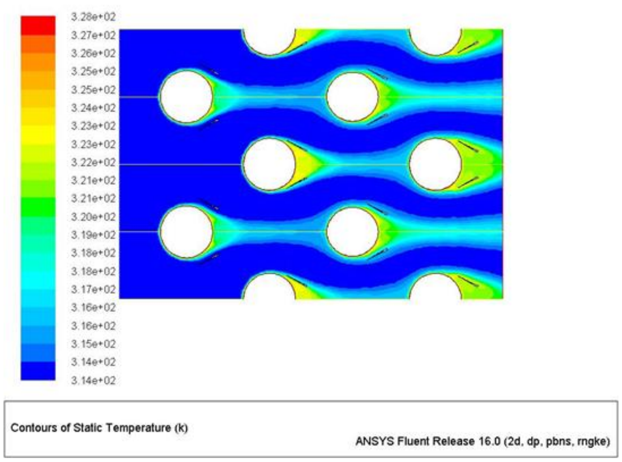


Fig 4.8 Contours of Static Temperature with Parabolic VG

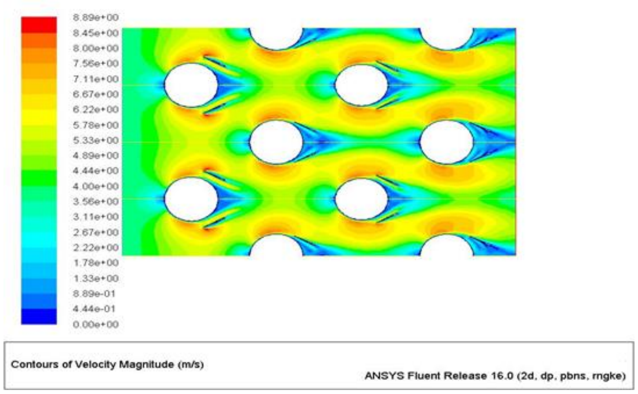
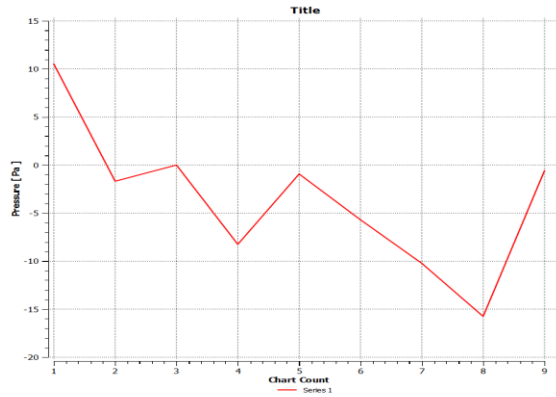
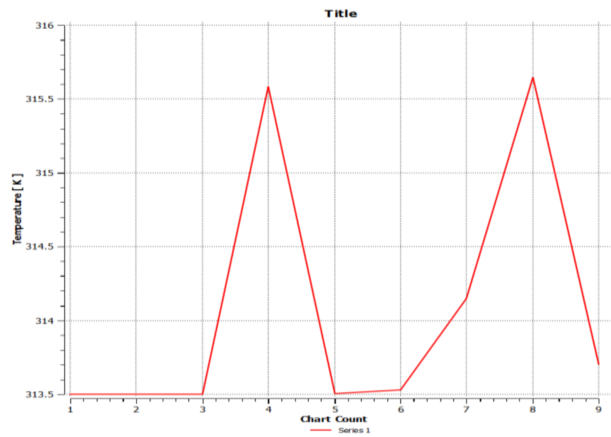


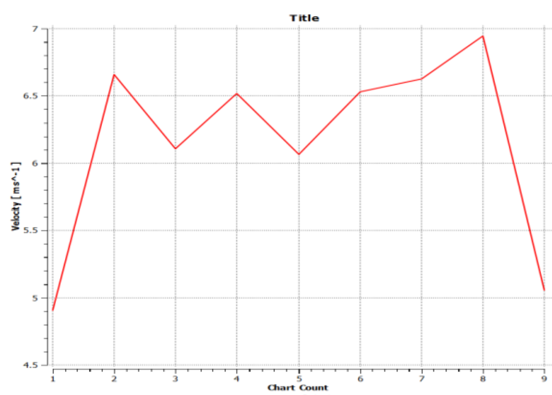
Fig4.9 Contours of velocity magnitude with parabolic VG



Plot 7 Pressure Vs Chart count through the heat exchanger length using parabolic VG



Plot 8 Temperature Vs Chart count through the heat exchanger length using parabolic VG



Plot 9 Velocity Vs Chart count through the heat exchanger length using parabolic VG.

Case 4: OGIVE VG

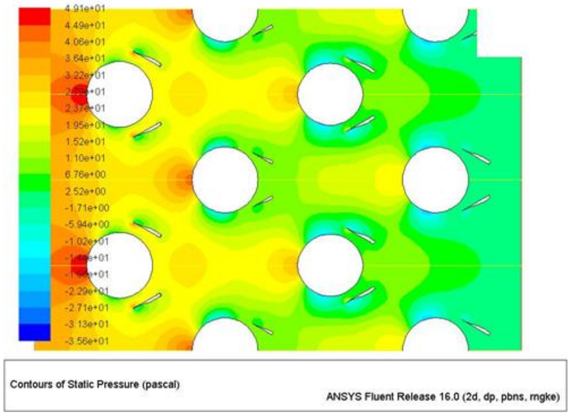


Fig 4.10 Contours of Pressure with Ogive VG

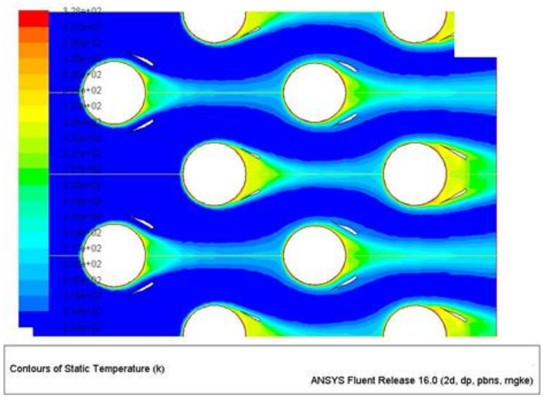


Fig 4.11 Contours of Static Temperature With ogive VG

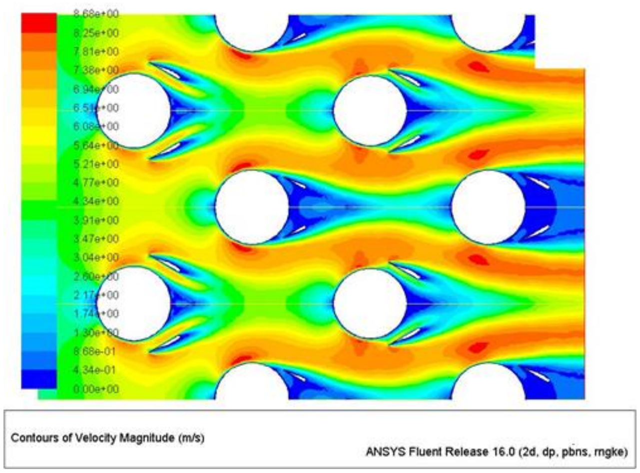
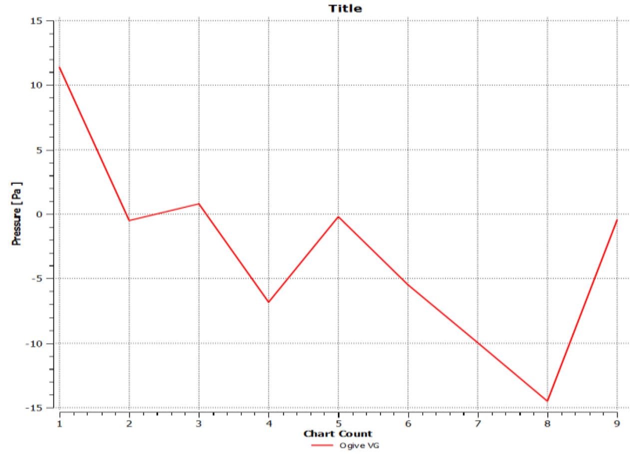
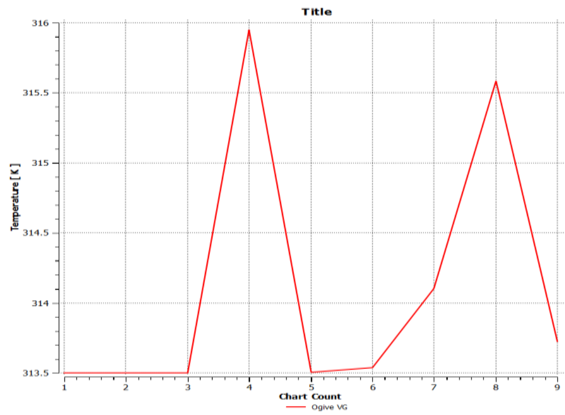


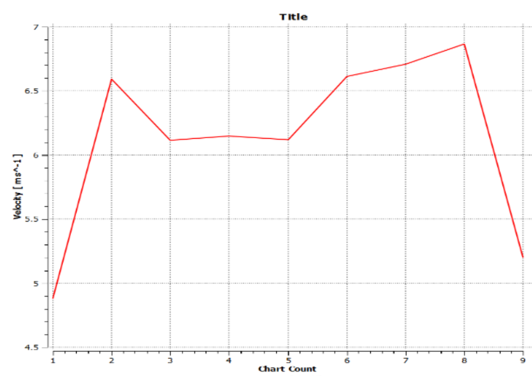
Fig 4.12 Contours of velocity magnitude with ogive VG



Plot 10 Pressure Vs Chart count through the heat exchanger length using ogive VG



Plot 11 Temperature Vs Chart count through the heat exchanger length using Ogive VG



Plot 12 Velocity Vs Chart count through the heat exchanger length using Ogive VG

Case 5: GOTHIC VG

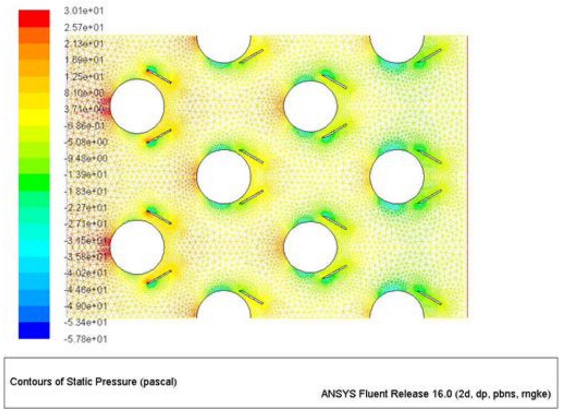


Fig 4.13 Contours of Pressure with Gothic VG

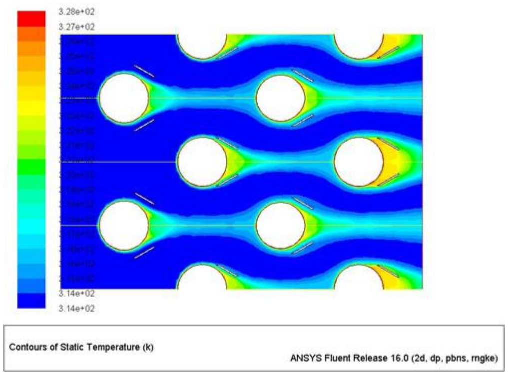


Fig 4.14 Contours of Temperature with Gothic VG

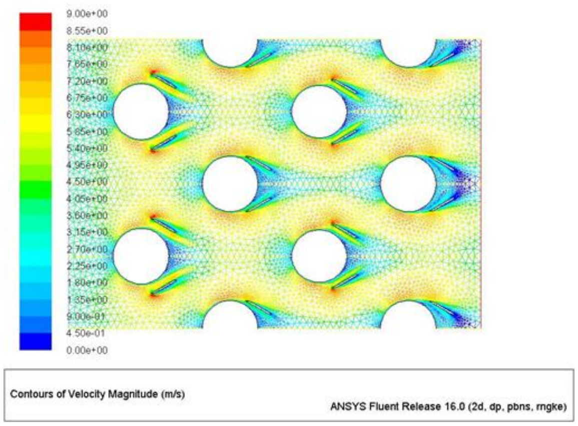
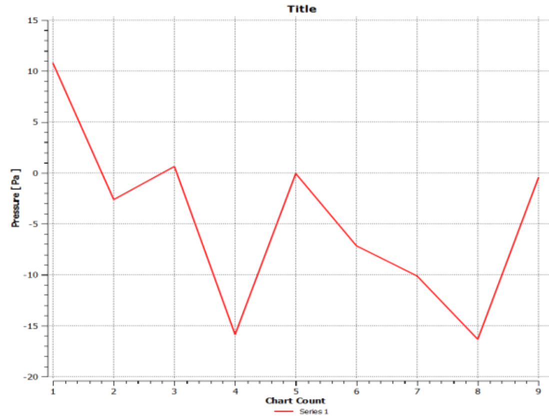
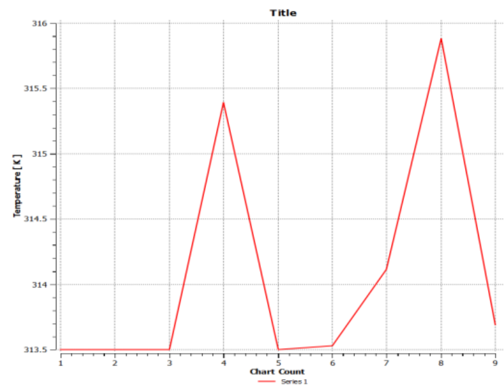


Fig 4.15 Contours of Velocity with Gothic VG

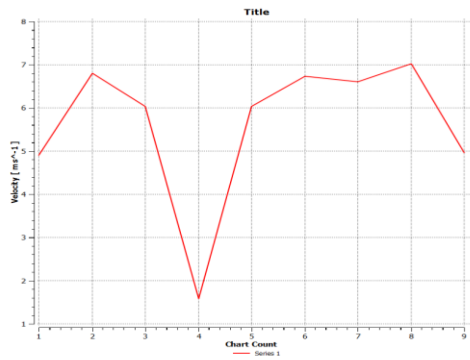
Plots



Plot 13 Pressure Vs Chart count through the heat exchanger length using Gothic VG



Plot 14 Temperature Vs Chart count through the heat exchanger length using Gothic VG

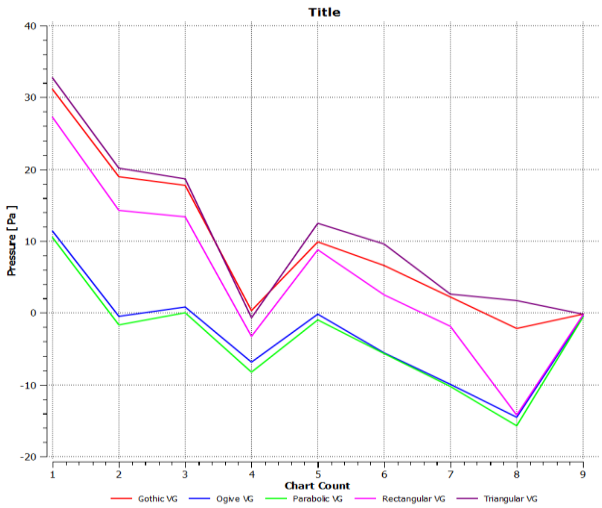


Plot 15 Velocity Vs Chart count through the heat exchanger length using Gothic VG

V. CONCLUSION

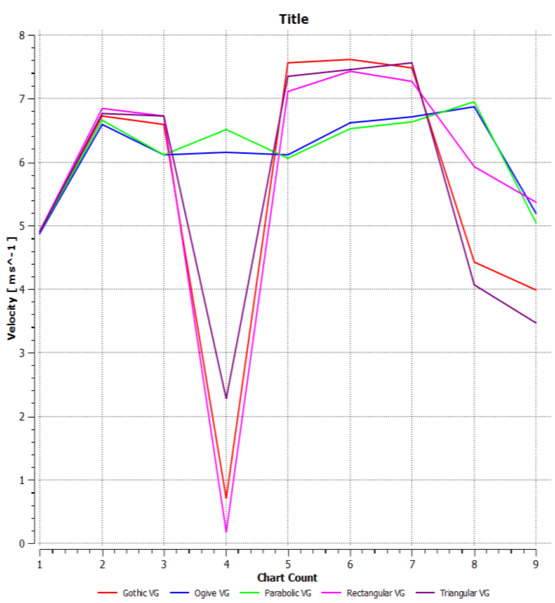
The results have been discussed in the Chapter 4 from the Results obtained through simulation following are the Comparison Graphs.

5.1 Pressure Comparisons of Different Vortex Generators.



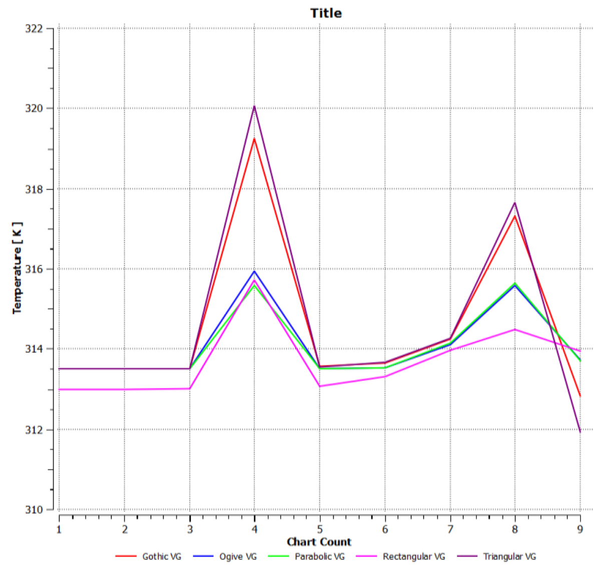
Plot 16 Pressure Comparison between Gothic, Ogive, parabolic, Rectangular and triangular

5.2 Velocity Comparisons of Different Vortex Generators.



Plot 17 Velocity Comparison between Gothic, Ogive, parabolic, Rectangular and triangular VG

5.3 Temperature Comparisons of Different Vortex Generators.



Plot 18 Temperature Comparison between Gothic, Ogive, parabolic, Rectangular, triangular VG

5.4 Conclusion

The fluid flow and heat transfer over a four rows tube bank in staggered arrangement with variation of Design of VGs, for Rectangular, Triangular, Parabolic, Ogive and Gothic, were studied numerically. The main results include:

1. The Results studied include the pressure velocity and temperature contours of the all five Vortex generators.
2. From the Plots we can say that triangular VG has the more heat transfer than considered with the other vortex generators.
3. Because of variant geometrical VG triangular generates more airflow in and around the heated wall when compared with other VGs such as Parabolic Ogive and Gothic.
4. Although parabolic and Ogive generated Recirculation in the VG area There is no change in the Heat transfer Rate.
5. From all these in the view we can conclude that for this particular application Triangular VG is suitable for more heat transfer

5.5 Scope of future work

The present study of "Efficiency enhancement of fin tube heat exchanger using new winglet vortex generator" can be extended to study further in future.

1. Experimentation may be done to rate the present findings.
2. Research is also needed to determine the behavior of the vortices with wet surface conditions
3. Most of the studies on fin heat transfer including present one have concentrated on the convective mode of heat

transfer. Contribution of radiation heat transfer may be executed along with the convection to make the study more comprehensive.

4. Testing also needs to be performed on a full scale heat exchanger with internal vortex generators to determine the enhancement at other placements than the leading edge.
5. The orientation and position of vortex may be varied to find the possibility of further enhancement of heat transfer.

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