FLOW AND HEAT TRANSFER ANALYSIS OF WIND THROUGH WIND CATCHER TO IMPROVE THE SPACE VENTILATION OF A BUILDING BY USING CFD TOOLS

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KARACHI PAKISTAN

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DEDICATION

I dedicate my Thesis to my loving

"PARENTS"

To my parents, who toiled, sacrificed and prayed for my success
and better future in life .It has been a long hard road and
We would never have made it to this point without
your unwavering love and support.

Also dedicated to my supporting

"TEACHERS"

To my teachers, from kindergarden till post graduation,
Who tought me everything I needed
to get successful.

With them I am here at this position to write such an extensive research

Thank you for every thing you do.

CERTIFICATE

ACKNOWLEDGEMENT

In the name of **Allah**, the Most Gracious and the Most Merciful Alhamdulillah, all praises to **Allah** for the strengths and His blessing in completing this thesis.

Following report is the accomplishment of my voyage in finding my M.S. I have not fall in a void in this. Following thesis has been retained on proper route with the help and encouragement of many fellows including my supporters, friends, colleagues and instructors. I highly thankful to all above people who made this thesis possible for me.

At this moment of accomplishment, first I wish to thank my Supervisor **Capt. Dr. Shafiq ur Rehaman Qureshi** for his editing skills in helping me to complete and write this thesis. For this I am sincerely thankful by my heart and soul.

Last but not least, I want to extend my sincere gratitude to my family especially my mother and father for the love, support and encouragement through this thesis. "It has been a rough journey but because of you, I never stop believing and hoping"

ABSTRACT

The aim of this study is to promote the natural cooling concept in the building construction. Global warming and energy crisis all over the world is a major concerned now days. By using natural resources to minimize conventional energy consumption, ventilation of a building is an essential need for human being, conventional techniques, like; fans air conditioners, Chillers, AHUs, Fan Coil Units etc. are used to condition the space, but those equipments consumes much energy. By using traditional wind catcher to minimize the power consumption. Traditional wind catchers are used in arid hot region in Iran, Iraq, Qatar, and other Persian Gulf region and Egypt and other Northern African coast. We use a shape to analyze wind velocity, pressure drop, and effect of heat transfer on flow rate ANSYS Workbench as a tool. Study of wind passing through wind chimney of different shapes to evaluate the heat transfer and mass flow rate of air via wind catcher of the best possible figure. This study investigates the effect on natural ventilation of a building by installing a vertical catcher at inlet and heated bend at outlet. The specific objectives are grid independent study, insight of Turbulence model used, and effect of temperature on flow rate. This work will help in the industry of building construction and provide them a better solution for natural ventilation in a building. Building development sector can construct their buildings environment friendly by using this type of methods.

Keywords: Wind Catcher, Velocity, Mass flow Rate, Solar Irradiance, Temperature

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SYMBOLS AND ABBREVIATIONS

P	DENSITY OF AIR
A	ABSORPTANCE
µ	DINAMIC VISCOUSITY
T	STRESS TENSOR
σ	TURBULENT PRANDTL NUMBER
∇	MATERIAL DERIVATIVE
@	AT THE RATE OF
Δ	DIFFERENCE
β	ANLGE OF INCLINATION
η	ETA
∈	EPSILON
$\sqrt{\ }$	UNDER ROOT
%	PERCENTAGE
=	EQUALS TO
≈	APPROXIMATELY
M	METER
m/s	METER PER SECOND
Kg/s	KILOGRAM PER SECOND
W/m^2	WATT PER METER SQUARE
CFD	COMPUTATIONAL FLUID DYNAMICS
V/S	VERSUS
ANSYS	ANalysis SYStem SOFTWARE

no.	NUMBER
RANS	REYNOLDS AVERAGED NAVIER STROKES
R.H.S.	RIGHT HAND SIDE
L.H.S.	LEFT HAND SIDE
e.g.	FOR EXAMPLE
w.r.t	WITH RESPECT TO

1. INTRODUCTION

The most important sign of the phases of development of countries and partly standards cohabitation shows the energy consumption. Reduction of natural assets, the increase in global warming and the price of fossil fuels is an actual human anxiety. The most important requirements in a building construction and design of the ventilation air and light. The air flows through the structure of naturally or mechanically. Today because of easy access to fossil fuels and electricity and technological development, as well as air conditioning in the building will be through device by electrical and mechanical activation. Grow with regard to environmental issues and energy crises in our global world, natural aeration has been covered by many investigators and planners.

Solar chimney and air/wind receiver are devices that are used to provide by thermal fluctuations as the driving forces of natural ventilation. Throughout history, a porch was introduced as an architectural device that reaches the thermal relief in buildings. Apart from the obvious kind in the Muslim and Arab architectural ideologies, buildings were marked by a conceptual structure of work that develops an understanding of conscious responses to environmental conditions, urban and social existence. In hot, dry region of Pakistan as Southern Punjab, Sindh and Baluchistan Southwest in particular the form of traditional buildings of the available energy were by the natural source marked, helps to reduce the moisture and provide natural air circulation. Therefore it is important for countries such as Pakistan, the energy crisis through to efficient resource ventilation instead of mechanical devices or electrical concentrate conventional.

One way to make a building with relaxed inside environments, to detect the principles of natural air circulation. This tends to lower power consumption and the discharge of unsafe emissions in the surrounding space. Natural aeriation methods, innovative as wind gripper arrangement have simplified the efficient use of natural aeration in a variety of buildings to increase the speed of the air supply.

This construction extracted and supplies air to the buildings air circulation principles of reflexive stack and wind tower each. It cools the occupants in the interior to increase directly through the heat transfer by convection, radiation and evaporation of interior surfaces and indirectly to remove stored heat within the building structure. Wind collector systems in various formations are different types and requirements, such as to meet, for example, the incorporation of lightweight Suns chimneys and pipes for driving the building chimney effect.

The effect of this work find focuses on the field of fluid mechanics, the main mass flow rate and the heat transfer in terms.

1.1 OBJECTIVE:

To investigate the effect on natural ventilation of a building by installing a vertical chimney at inlet and heated bend at outlet.

Following are the specific objectives:

- Grid independence study
- Insight of Turbulence model used.
- Effect of temperature on flow rate.

2. LITERATURE REVIEW

The perception of a solar chimney to induce wind catcher natural aeration has been studied analytically in [1]. Aero structure fundamentals such as wind catchers were used in Iran and countries bordering to it for natural aeration and reflexive chilling for hundreds of years. The wind catcher is planned to capture the air at higher altitudes and to straight to the living space warm air gradients and pressure. The air catcher comprises of a vertical shaft, with a plurality of openings to aerate the catcher to the rooms to connect. The effects of wind on the high tower cause the growth of positive pressure. As the air circulating the structure flows occurring flow separation at the windward edge and created a negative pressure on the leeward edge of the structure. There is a differential pressure, between the tower and the inlet openings on the leeward side of the spaces. Accordingly, the wind stream exits the tower entrance to the openings of the rooms, the swept area of the space, and finally passes through the openings of the leeward side room. Thus, the space is ventilated by means of the effect of wind towers.

Wind catcher generates an exciting system for incorporation into a building to provide a large area of solar collector natural ventilation for the variable wind speed available.

The presentation of a vacant solar duct for heat recovery in naturally aerated buildings was studied using CFD technology [2]. The conclusions are made that glazed solar chimney to reduce condensation with risk factor and project down (low power) air, triple-glazed solar chimney is the best solution to reduce condensation and the air thrown down. Even through the heat pipes in solar chimney for heat recovery installation increasing pressure drop, reduces the thermal fluctuation, reducing ventilation rates. And the stack height can also significant for the best results.

Wind tunnel and smoke imagining test experimentally and applying analytical and CFD modeling was performed to examine both sides of the output of a wind catcher. This type of wind manifold is internally divided into 2 halves for the purpose of supply and exhaust air. In [3]

Wind catcher as a natural aeration system will highly minimizes in modern buildings non-renewable energy consumption and reduces harmful emissions. Height, cross section of the ducts and also set the number of windows the main factors that influence the aeration performance of a wind catcher. In [4], the experimental tests were carried out in a wind tunnel subsonic open circuit. For these options, the air flow rate was measured vented to the testing room at various angles of incidence of the air. Numerical solutions were used for all of these configurations, in order to confirm the projected measuring method and the results in the wind duct. The results show that the number of windows is a significant reason in the presentation of the wind catcher systems.

The conclusions are that the induced air flow velocity increases with the increase of the opening, front and back catcher Wind induced the highest level of indoor air in the wind angle of zero degrees. In addition, the windscreen induced with a rectangular cross-section side or front and rear more airflow than the wind collector circular cross section. And pressure coefficient depends on the windscreen shape

Wind duct and smoke visualization test and CFD modeling were conducted to examine the result of air flow control mechanism and a heat source in rooms Wind Catcher / towers presentation [5]. To this end, a windscreen on a large scale was connected to a test room and centrally placed open border in a wind tunnel. Pressure coefficient (CP), the established around the hook wind and air flow to the test room. The wind collector performance depends strongly on the wind speed and direction. Reduced the incorporation of damping grid box, and the ceiling height eggs and regulates the flow of air at an average pressure loss coefficient of 0.01. The Catcher Wind in the existence of heat causes potentially lower indoor temperatures in accordance with the outside temperature works.

Wind catcher / towers systems were used in buildings in the gulf for hundreds of years and they are recognized by various names in various parts of the region. They were conventionally wooden structure of strengthened masonry with windows at a height above the roof of the building 2 to 20 m in the area. At higher wind towers catch the air at higher speeds and with less dust. Its application in the hot, dry region of the gulf is natural ventilation / passive cooling and comfort, therefore, thermal, in particular to explore the night aeration strategy.

Concern about worldwide temperature increment has naturally led to a renaissance of interest in aerated houses. Natural aeration is increasing in modern public houses to minimize non-renewable energy utilization. It is an actual amount to improve the quality of internal air. [6]. the openings may in several cases be sufficient to cool the houses. Although the use of a window opening for aeration of a room, seems to be very simple. The amount of air flows through the openings will depend on various aspects, such as size, type and location of the opening. Wind catchers are found to be an efficient way of fresh air into the room. The work context was to improve the use of natural ventilation systems in buildings.

The traditional architecture of different region of mid Asia and the gulf east is the product of the country, the local weather and culture of the people. Human needs and the environment represent the most important factors in their projects are taken into account. The traditional and indigenous architecture of the region led many solutions and realistic devices for local environmental problems such as the wind-catcher, which has become a common feature of the architecture of buildings. The windscreen is based on a regional Iranian construction device that was used to create natural aeration in buildings. In recent decades there has been a growing consciousness of these regional conservational institutions and their impending for probable future construction. However, traditional architecture and the needs of people and the environment are considered for the latest modern environmental problems facing many realistic solutions discussed in [7]. This work shows the wind collectible value and gives an insight use of natural aeration systems as a substitutive to modern inadequate cooling in hot climates. The aim is to analyze the theoretical state of the wind catcher and to identify their specific function, its use in the context of constructional practice, in the old age, present and forthcoming. It can be concluded that this research of the significance of the catcher increase awareness regional wind and helped extend opportunities to improve the performance and capability of wind catchers. It will also bring new chances for the use of passive cooling system of the old heritage in the world today. And the combination of technological knowledge and progress traditional can develop a revolution in the field of architecture.

A new module was developed in Energy Plus program for the simulation and calculation of energy implemented effects of thermal ducts. [8] Describes the basic principles, conventions and applied in Energy program algorithms to predict the performance of thermal ducts.

3. DESIGN MODEL AND GRID GENERATION

3.1 SINGLE ROOM WIND CATCHER WITH SOLAR DUCT:

In this study, the exemplary is used as a single room with solar chimney and wind catcher. The overall analysis with one room is vague and velocity, solar irradiance V/S mass flow rate results were not clear so far.

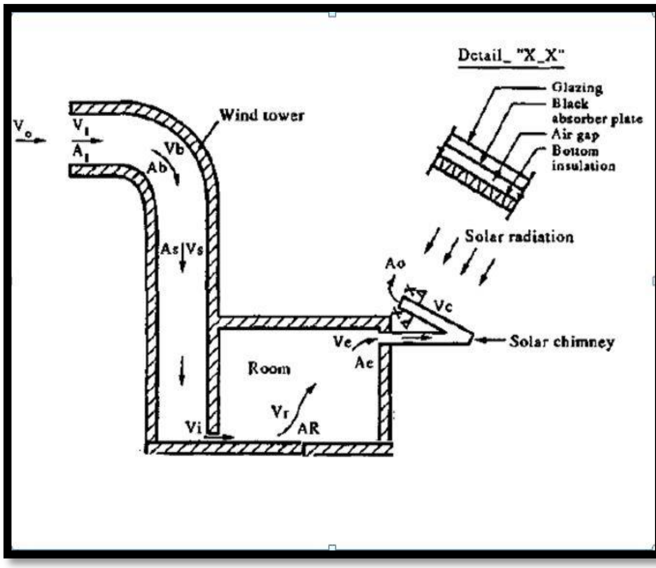

Figure 1: One schematic room was considered for initial case

In this thesis, *Figure 1* is used as a design model, wind catcher inlet height is 2m, room air inlet is 0.14m, room area is 4m x 4m and chimney outlet is 0.225m from *Figure 1*. Initially, only one room was considered for the entire work but no significant results were found and then *Figure 12* was considered for significant results. It was the courtesy of Bansal N.K., Mathur R., Bhandari [1]

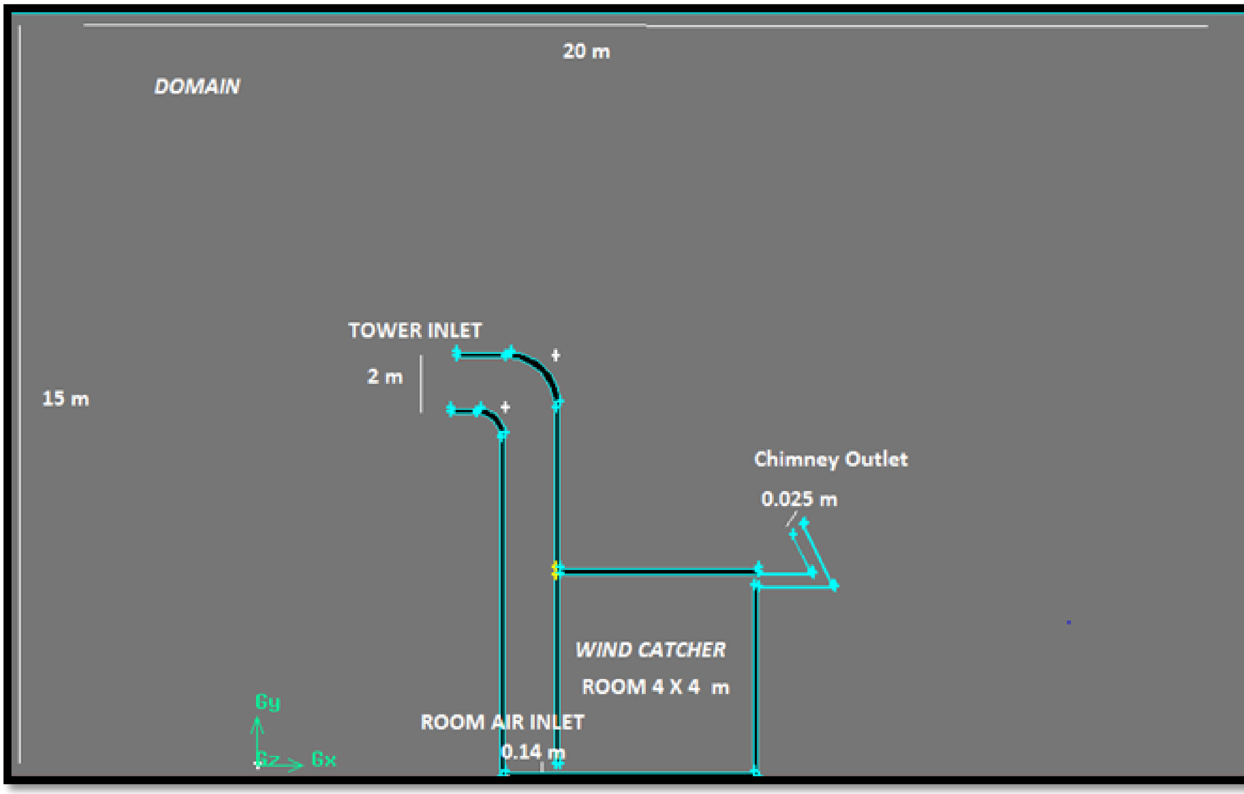

Figure 2: Schematic design of wind catcher system

This *Figure 2* is designed in the gambit for initial results. The domain in x-direction is 20m wide, in y-direction 15m tall. Chimney inlet is 2m, room inlet is 0.14m. Solar chimney outlet is 0.225m and room area is 4m x 4m.

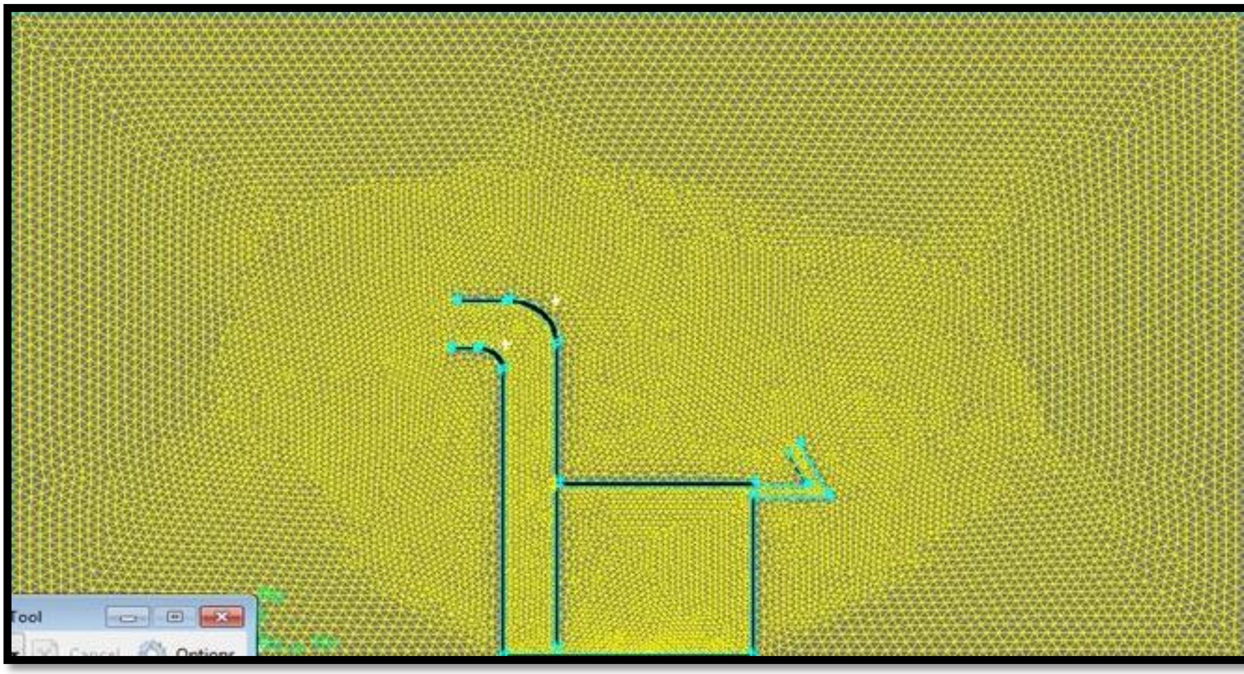

Figure 3: Unstructured Tri mesh

Figure 4 illustrates us the concept of tri meshes, the results of tri meshes are not so good that is why we use quadrilateral meshes

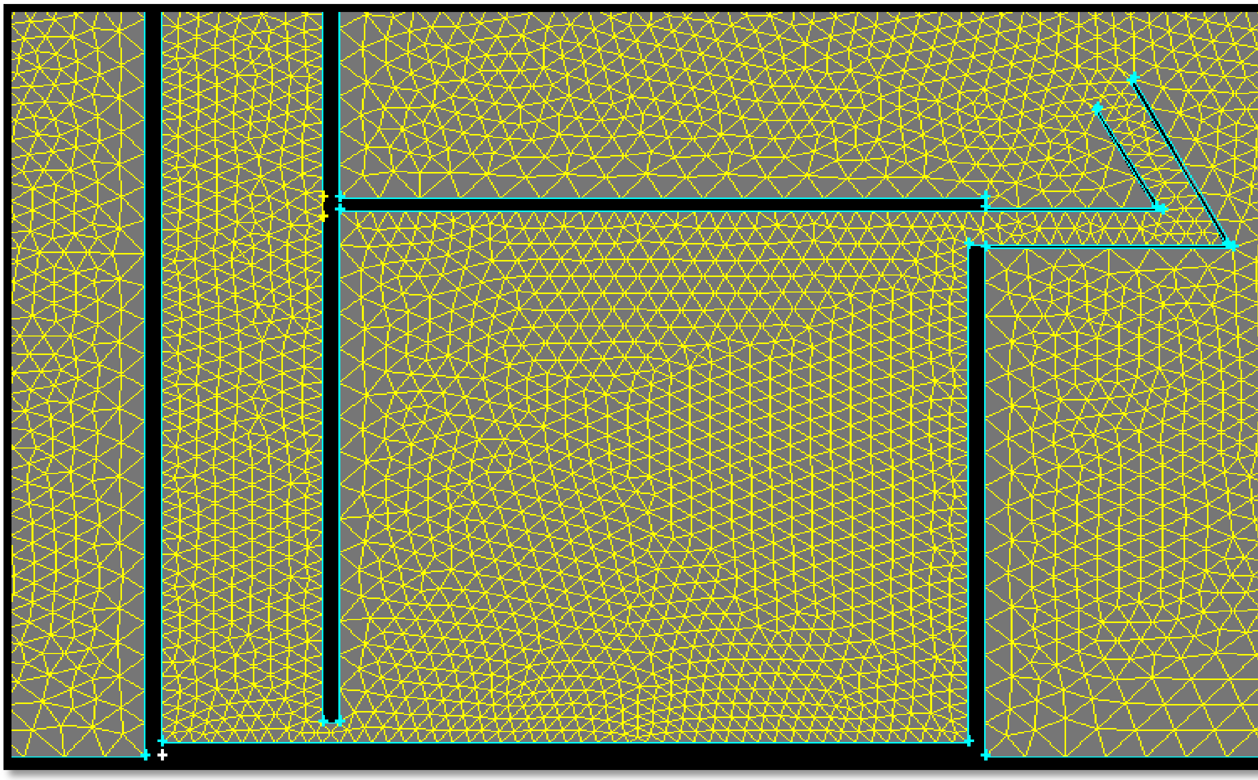

Figure 5: Close view of tri mesh

In *Figure 4* unstructured tri mesh are generated. Non cleared vague results, the closest view of *Figure 6*

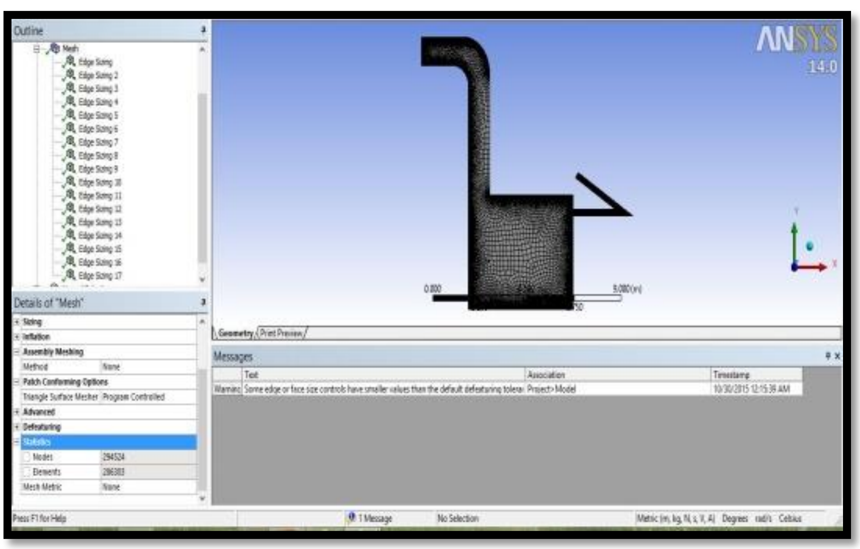

Figure 7: Unstructured mesh in ANSYS work bench

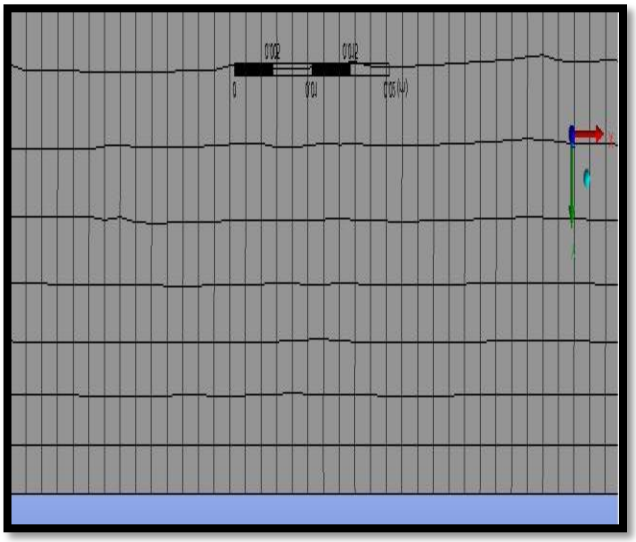

Figure 8: Grids on edges

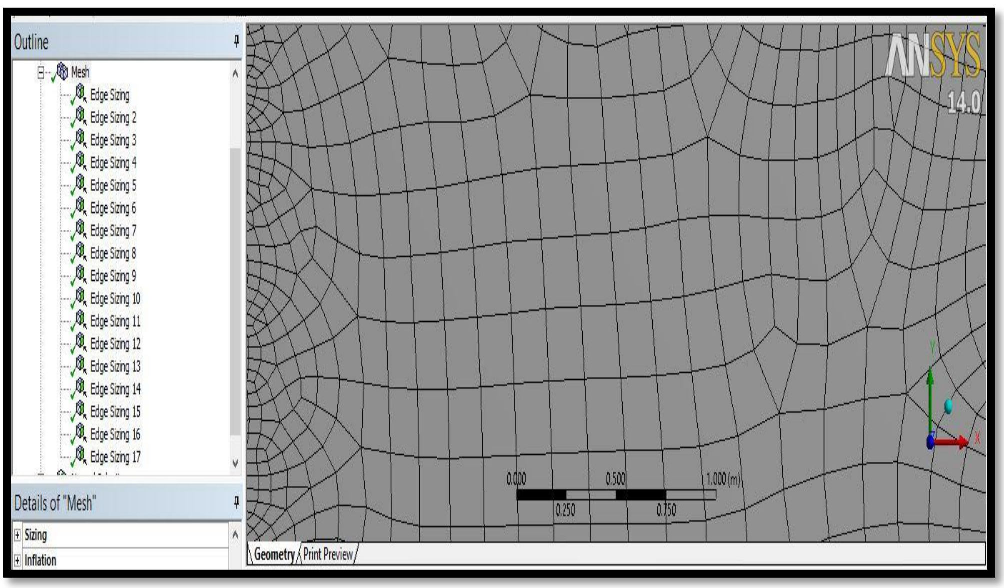

Figure 9: Grids on interior surface

In above figures, *Figure 5, Figure 6 and Figure 7* mesh are generated as unstructured mesh with no. of elements being 15,050 initially, but results are vague, and in each number of iteration contain reverse flow on many faces.

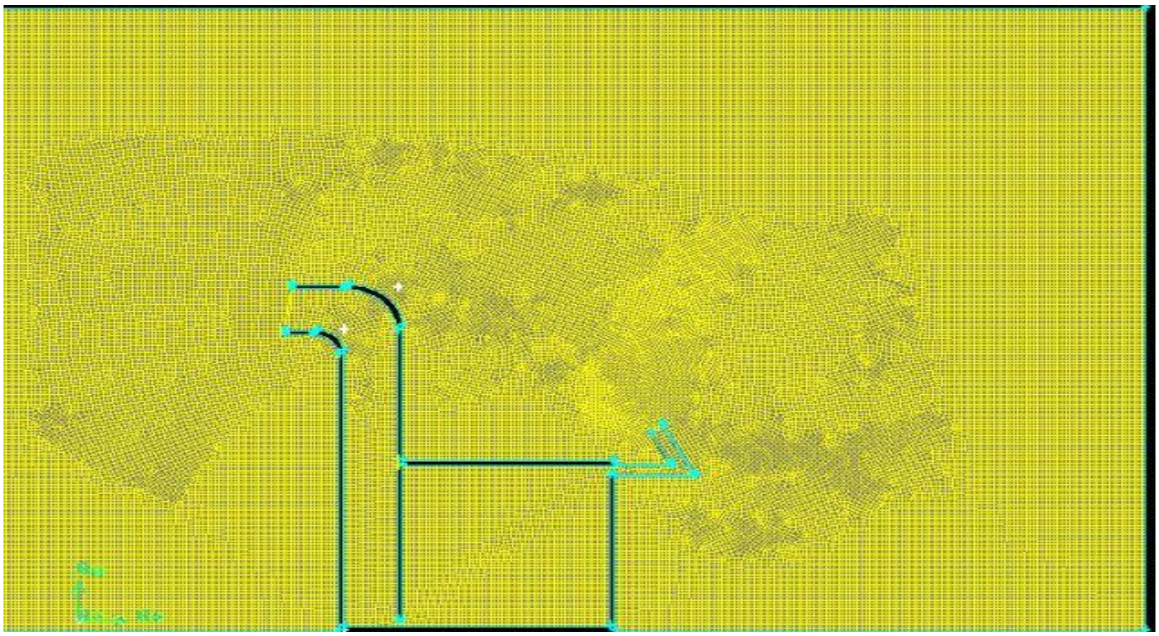

Figure 8: Grids on entire domain

In *Figure 8:* Mesh was generated and with quad elements with no. of elements being 80000.

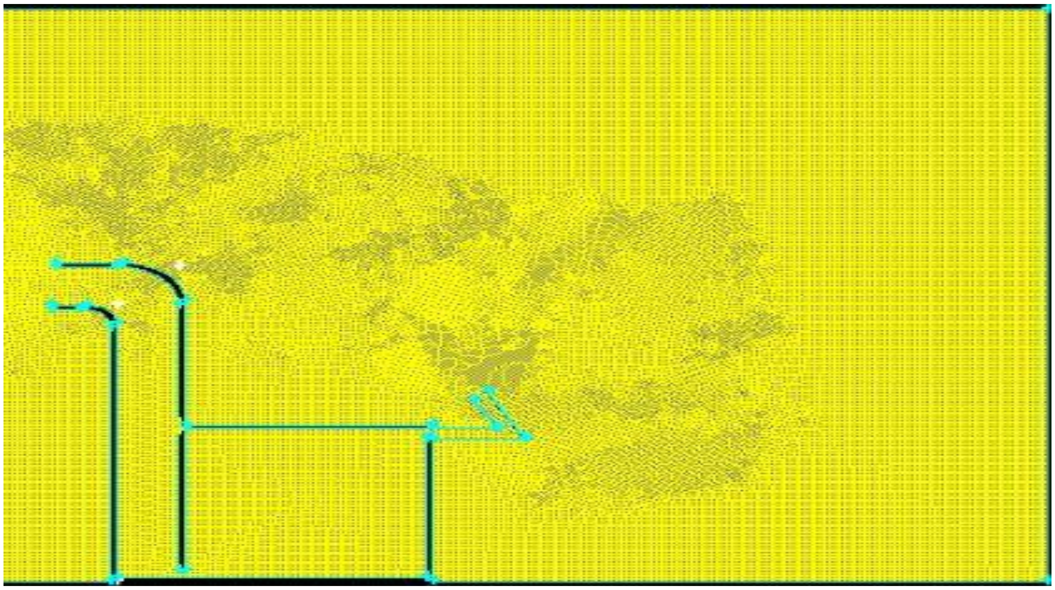

Figure 9: Grids on interior surface

In *Figure 9:* Mesh was generated and with quad elements with no. of elements being 125390.

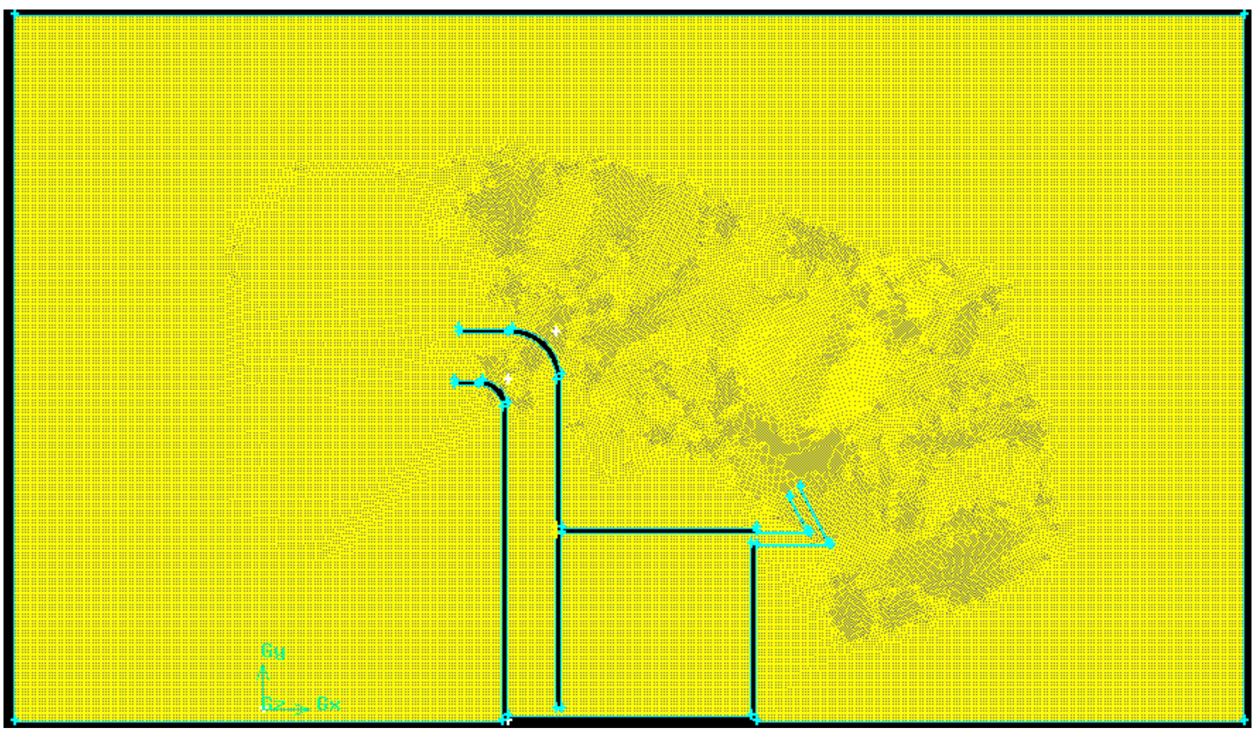

Figure 10: Structured quadrilateral mesh

In *Figure 8* Structured Mesh was generated with quad element with no. of elements being 152,585. In between 125,000 & 150,000 elements, results of the ANSYS Fluent were getting same. So this was assumed that the independency of grid achieved

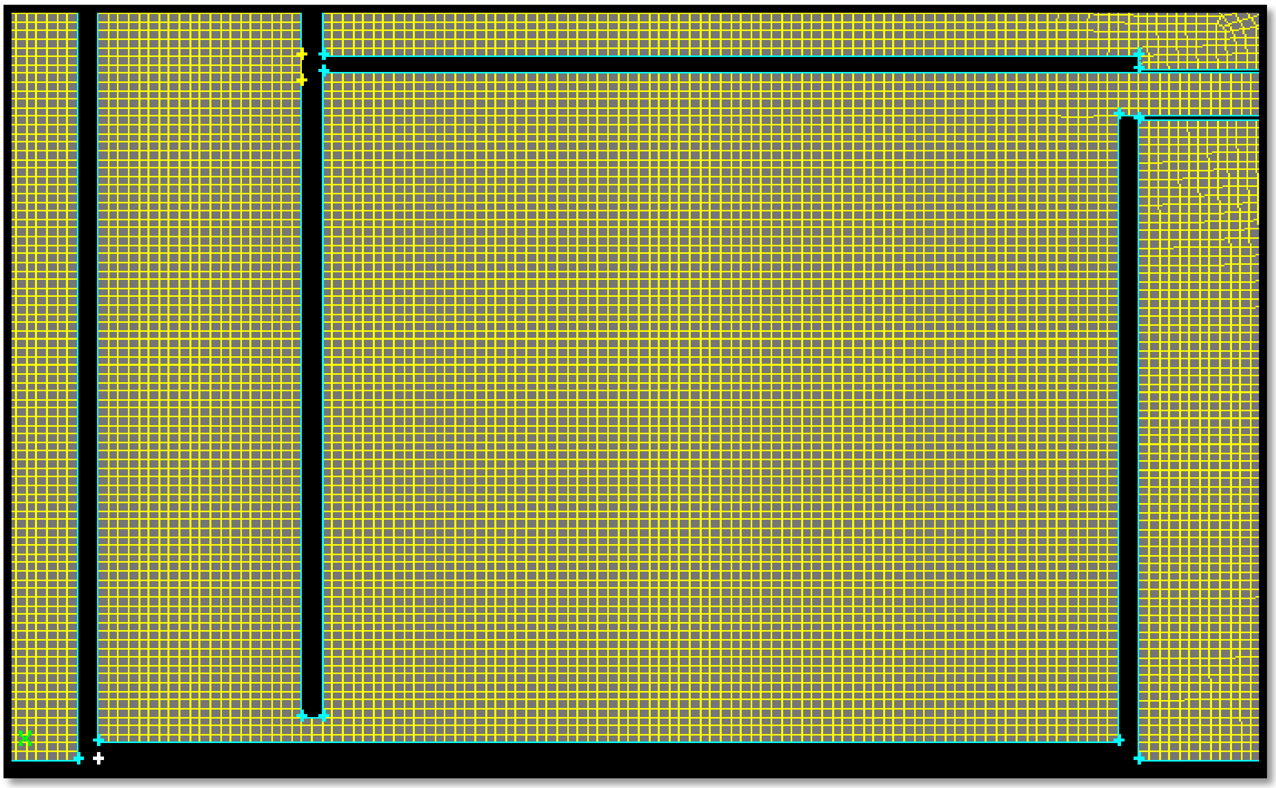

Figure 11: Structured mesh were generated near walls

Figure 10 is the microscopic view of *Figure 8* fine structured quadrilateral mesh are generated inside the room and the results generated from these mesh are precise

3.2 THREE ROOMS WIND CATCHER WITH SOLAR CHIMNEYS:

In this case three rooms are designed for better results, using one inlet of wind catcher with 2m wide opening; with each room inlet is 0.14m for air flow and each solar chimney outlet is 0.225m wide, small exit is provided for greater air velocity.

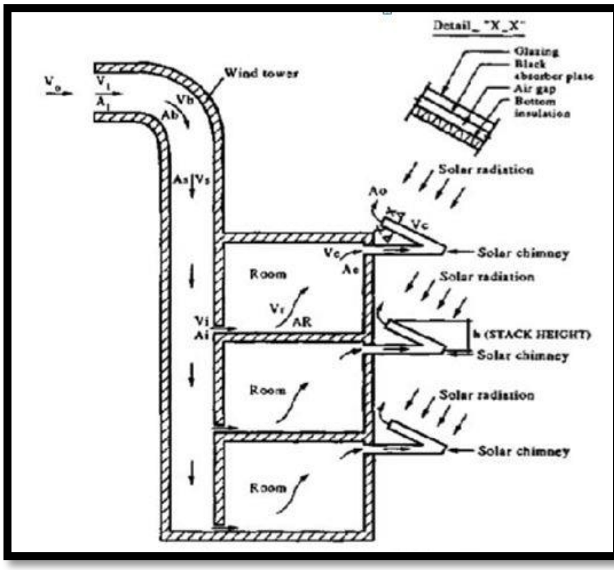

Figure 12: Schematic of wind tower solar-chimney system

Figure 10 is three room figure which is under consideration for the calculation of mass flow rate against the inlet to the outlet velocity. It was the courtesy of Bansal N.K., Mathur R., Bhandari [1]

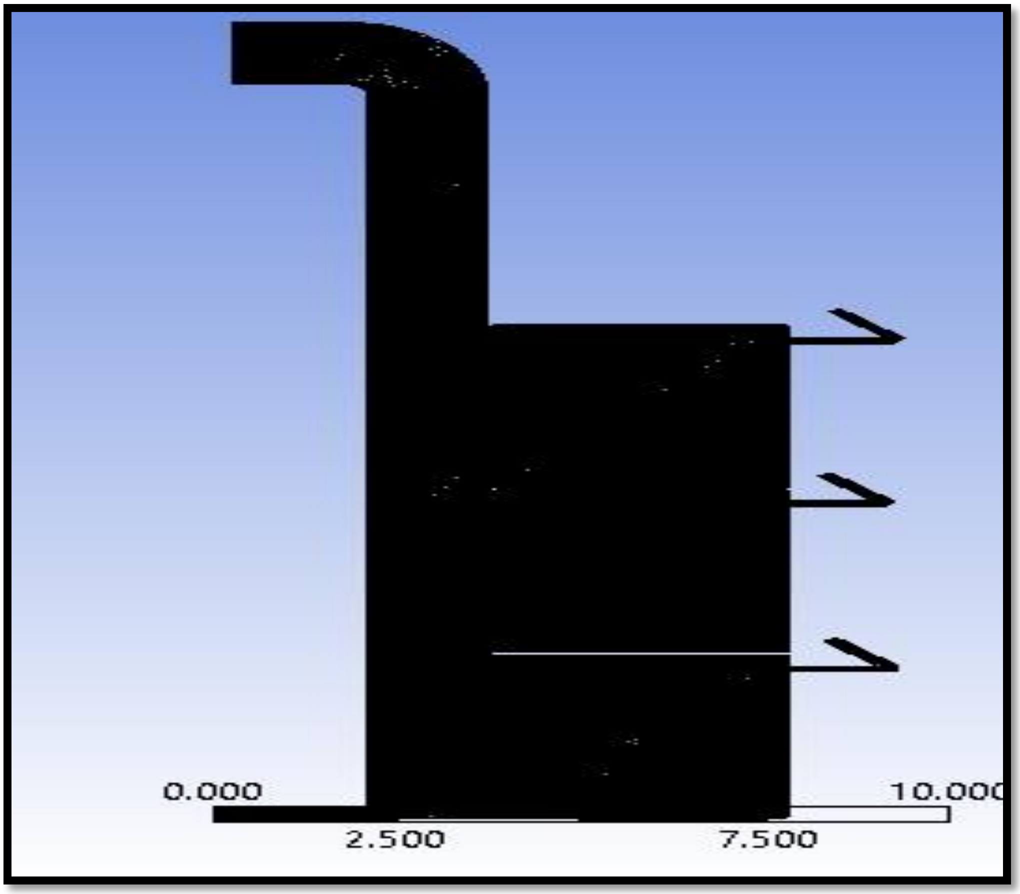

Figure 13: Mesh generated design of 3 rooms with solar chimneys and wind catcher

Figure 11 is designed in the ANSYS workbench for analysis. Chimney inlet is 2m, room inlet is 0.14m. Solar chimneys outlet is 0.225m and each room area is 4m x 4m.

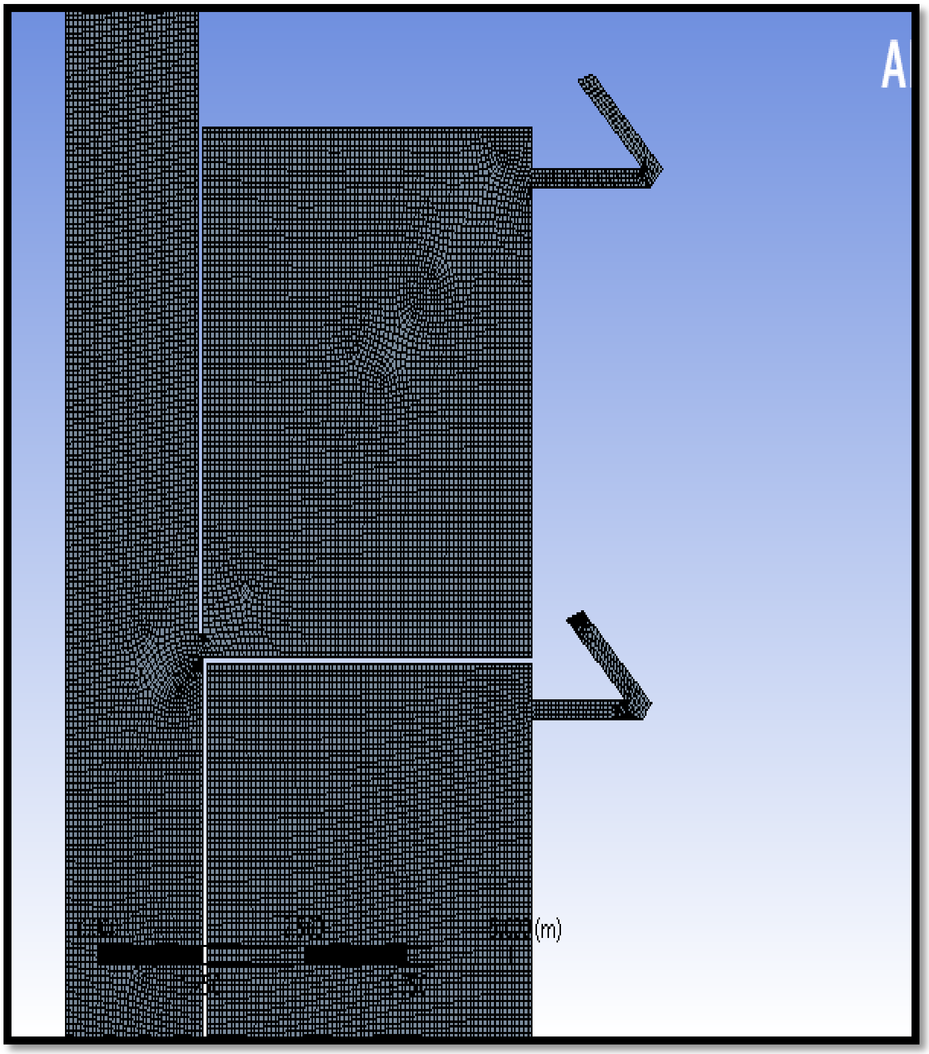

Figure 14: Structured Mesh was generated with quad element

In *Figure 12,* Structured Mesh was generated with quad element with no of elements being 152,585.

4. MATHEMATICAL MODEL

4.1 GOVERNING EQUATIONS:

Reynolds Averaged Navier Stokes Equation (RANS) also known as momentum equation and Continuity Equation are the two basic governing equations regarding this thesis work. The equations are mathematically represented as:

RANS Equation:

$$\rho\left(\frac{\partial u}{\partial t} + u\,\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z}\right) = -\frac{\partial p}{\partial x} + \mu\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2}\right) + \rho g_x \qquad (1)$$

$$\rho\left(\frac{\partial v}{\partial t} + u\,\frac{\partial v}{\partial x} + v\,\frac{\partial v}{\partial y} + w\,\frac{\partial v}{\partial z}\right) = -\frac{\partial p}{\partial y} + \mu\left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} + \frac{\partial^2 v}{\partial z^2}\right) + \rho g_y \qquad (2)$$

$$\rho\left(\frac{\partial w}{\partial t} + u\,\frac{\partial w}{\partial x} + v\,\frac{\partial w}{\partial y} + w\,\frac{\partial w}{\partial z}\right) = -\frac{\partial p}{\partial z} + \mu\left(\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} + \frac{\partial^2 w}{\partial z^2}\right) + \rho g_z \qquad (3)$$

Continuity Equation:

$$\frac{\partial \rho}{\partial t} + \nabla.(\rho U) = 0 \qquad (4)$$

Where,

ρ = density of the mixture,

p = pressure,

g = gravitational acceleration and

μ = fluid viscosity

U = velocity composed of velocity components

4.2 PERSISTENT FLOW:

$$\Delta P_W = \Delta P_t \tag{5}$$

P_w is the change of inlet and outlet pressure flows and P_t = pressure loss throughout the system.

Pw is given by:

$$\Delta P_w = \frac{1}{2} X \rho V_o^2 + \frac{1}{2} K_i P_i V_i^2 \tag{6}$$

$$V_o = \sqrt{2gh \frac{\Delta \rho}{\rho}} \tag{7}$$

Where,

X = pressure coefficient with respect to on blowing wind,

K_i = solar chimney coefficient,

V_o = outdoor wind velocity,

V_c = velocity in solar chimney.

ρ = atmospheric air density,

ρ_i = air density in solar chimney,

H = height.

$$Q = K_i A \sqrt{2gh \frac{\Delta \rho}{\rho}} \tag{8}$$

β = inclination of solar chimney w.r.t horizontal. *Equation (8)* can be written as:

$$Q = K_o A \sqrt{\frac{2gh \ \sin\beta \left(\frac{\Delta T}{T}\right)}{(1 + A_r^2)}} \tag{9}$$

Conservation of mass, or continuity equation:

$$\frac{\partial \rho}{\partial t} + \nabla \,.\, \rho V = Sm \tag{10}$$

For 2D axisymmetric geometries, continuity equation:

$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x} \,(\rho V_x) + \frac{\partial}{\partial r} \,(\rho V r) + \frac{\rho V_r}{r} = Sm \tag{11}$$

Conservation of momentum will be:

$$\frac{\partial \rho}{\partial t} + (\rho V) + \nabla\,(\rho. v. v) = -\nabla \mathrm{p} + \nabla.(\tau) + \rho g + F \tag{12}$$

Stress tensor τ is given by

$$\tau = \mu \left[(\nabla. \mathrm{v} + \nabla v^T) - \frac{2}{3}\, \nabla. \mathrm{vI} \right] \tag{13}$$

Where,

μ = molecular viscosity,

I = is the unit tensor,

The second term on the right hand side is the effect of volume dilation.

4.3 BOUSSINESQ BUOYANCY MODEL:

Natural-convection flows, faster convergence done with the Boussinesq model by setting up the problem with fluid density as a function of temperature, In this model fluid density is a constant value:

$$(\rho - \rho_o)g \approx \rho_o \beta (T - T_o) g \qquad (14)$$

Where,

ρ_o = air density

T_o = ambient temperature,

β = coefficient of thermal expansion.

4.3.1 LIMITATONS OF THE BOUSSINESQ MODEL:

If the temperature differences of the domain are large then Boussinesq model is not be applicable. Species calculations like, combustion and reaction on fluid are not be applicable in Boussinesq model.

ANSYS Work bench 14.0

4.4 THE REALIZABLE k-∈ TURBULENCE MODEL:

The realizable k-∈ model having a new origination for the turbulent viscosity. It satisfies Reynolds stresses that is why it is known as realizable. It is realizable than k-ω and ordinary k-∈. The realizable k-∈ model precisely work on co-planner and circular model. It accurately works under strong pressure gradients, separation and recirculation.

The modeled transport equations for k and ∈ in the realizable **k-**∈ model are:

$$\frac{\partial}{\partial t}(\rho k) + \frac{\partial}{\partial x_j}(\rho k u_j) = \frac{\partial}{\partial x_j}\left[\left(\mu + \frac{\mu_t}{\sigma_k}\right)\frac{\partial k}{\partial x_j}\right] + G_k + G_b + \rho \in + Y_M + S_k \quad (15)$$

and,

$$\frac{\partial}{\partial t}(\rho \in) + \frac{\partial}{\partial x_j}(\rho \in u_j) = \frac{\partial}{\partial x_j}\left[\left(\mu + \frac{\mu_t}{\sigma_{\in}}\right)\frac{\partial \in}{\partial x_j}\right] + \rho C_1 S_{\in} - \rho C_2 \frac{\in^2}{k + \sqrt{v \in}} + C_{1\in}\frac{\in}{k} C_{3\in} G_b + S_{\in} \qquad (16)$$

Where,

$$C_1 = \max\left[0.43, \frac{\eta}{\eta + 5}\right], \eta = S\,\frac{k}{\in}, S = \sqrt{2S_{ij}S_{ij}} \qquad (17)$$

4.5 2ND ORDER UPWIND SCHEME:

The 2nd order upwind scheme is usually referred as high resolution scheme, to increase the order of accuracy from 1st order upwind scheme, we use 2nd order upwind scheme. The upwind scheme is one of the most stable and simplest discretization schemes; it is more dissipative according to the flow simulation.

Basically, it uses the values the of upstream to evaluate the property on the boundaries of the grid and then use them to compute the value at the center of the cell it is the upstream value, it takes into account the flow direction. The main difference between 1st order and 2nd order is the no. of points, 1st order upwind uses one point to evaluate and 2nd order upwind uses two points to evaluate.

5. RESULTS AND ANALYSIS

5.1 ASSUMPTIONS:

The results of the designed wind catchers are based on the assumptions given below:

- The system is at steady state.
- The air is frictionless at the entrance in the Solar Chimney to the outlet and leakages.
- The roof insulator temperature is same as the ambient temperature.
- Boussinesq buoyancy model was kept on to account for change in density w.r.t temperature
- The realizable $k{-}\varepsilon$ turbulence model was used

5.2 BOUNDARY CONDITIONS:

- The x and y components of velocity are 0 on the walls of the solar duct and the absorber.
- The pressure at the outlet of the Solar Chimney is same as the atmospheric pressure.
- The entrance velocity of flow in the x and in the y direction is zero for case1, Velocity at inlet was increased sequentially for other cases.
- Pressures, temperatures and densities are at standard to the atmospheric conditions
- Wall temperature was given to the plate of the collector

5.3 SINGLE ROOM ANALYSES:

The single room was considered for initial results and analysis whose descriptions are given below:

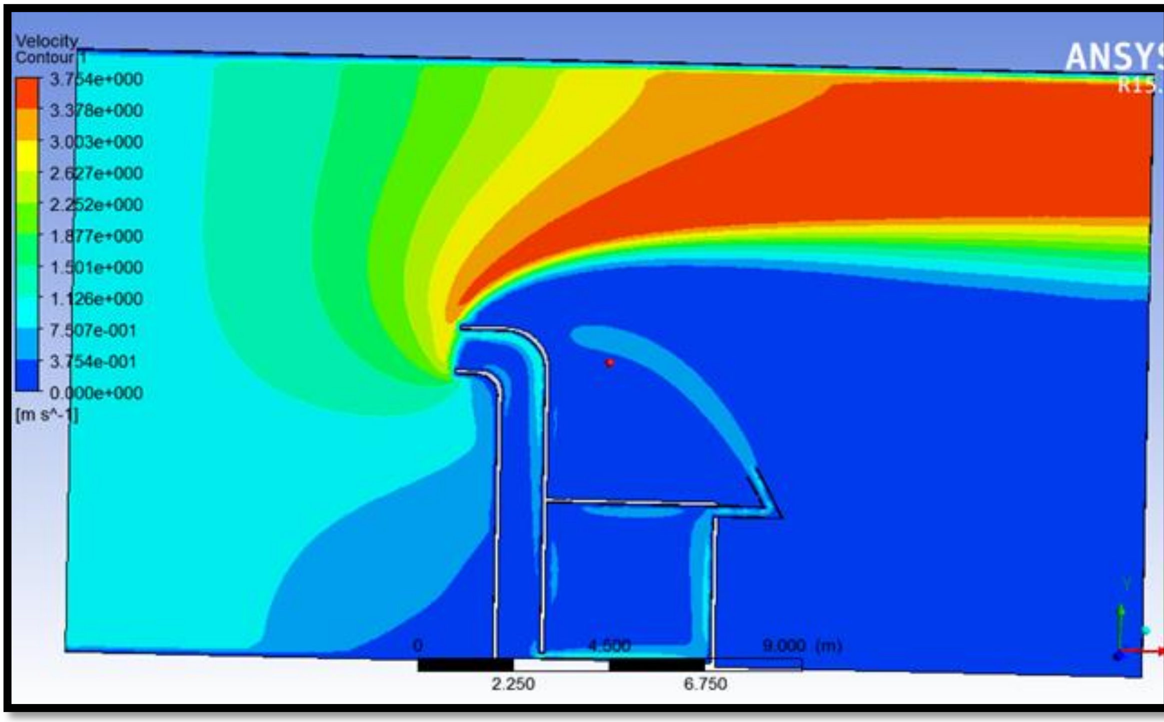

Figure 15: vague results

Consequence vague results were obtained during the analysis of unstructured mesh, here inlet velocity is 0 and solar chimney exit velocity in between 0.375 to 0.750, inside the room the velocity of air was supposed to be 0. The maximum velocity is 3.75 m/s from the above edge of the wind catcher to the domain, the dark red region is maximum velocity of the domain.

5.3.1 CASE 1 NATURAL CONVECTION:

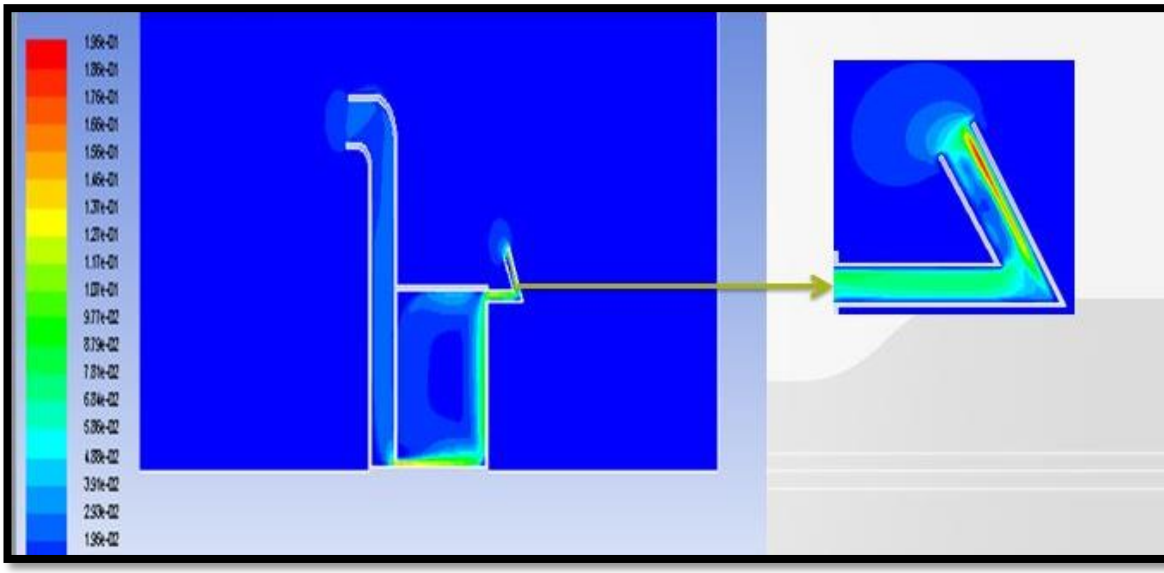

Figure 16: Natural convection

The upstream velocity for natural convection was set as 0; the maximum velocity was obtained near solar chimney, i.e. 0.19 m/s. An increment of 200% almost.

Solar Irradiance Watt/m^2	Temperature of Plate ºC
800	63.8
700	57.8
600	48.9
500	41.9

Table 1: Change in Temperature at different Solar Irradiance

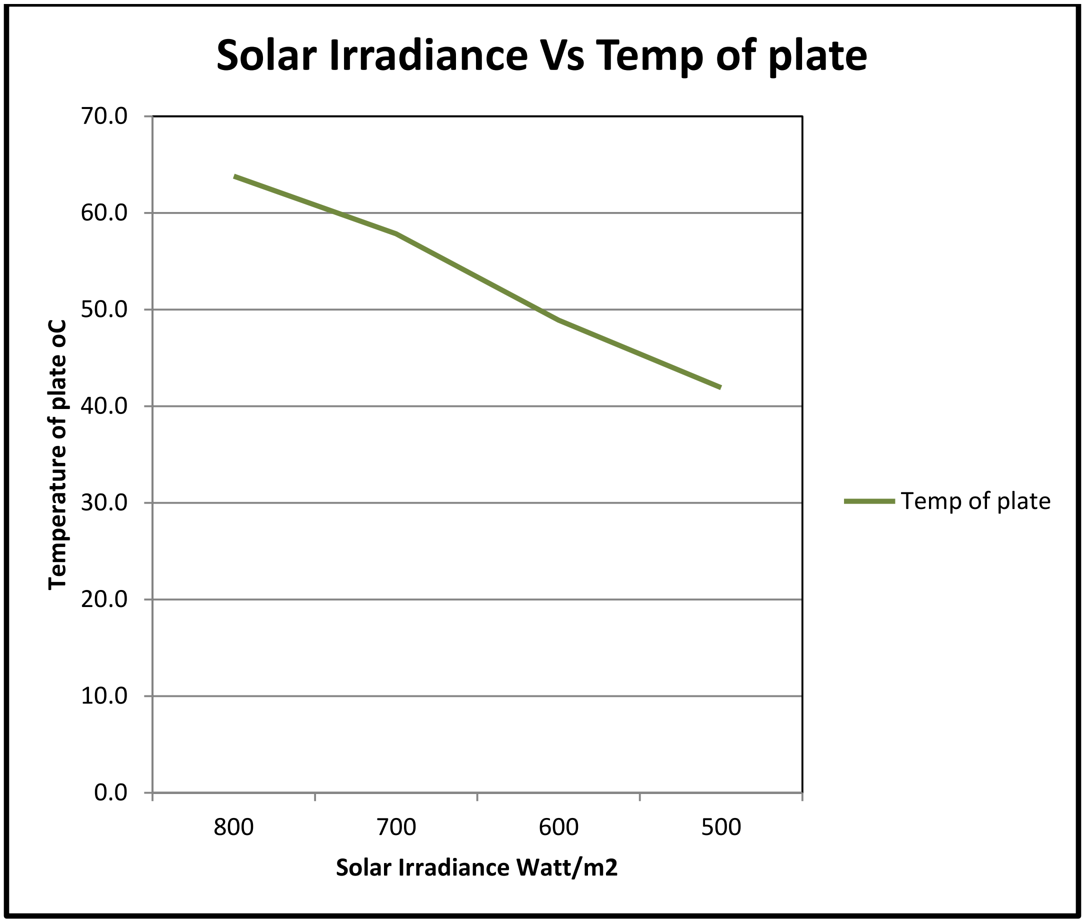

Figure 17: Solar irradiance V/s Temperature of plate

Naturally ventilated solar chimney's different solar collector plate temperatures were calculated at different Solar Irradiance.

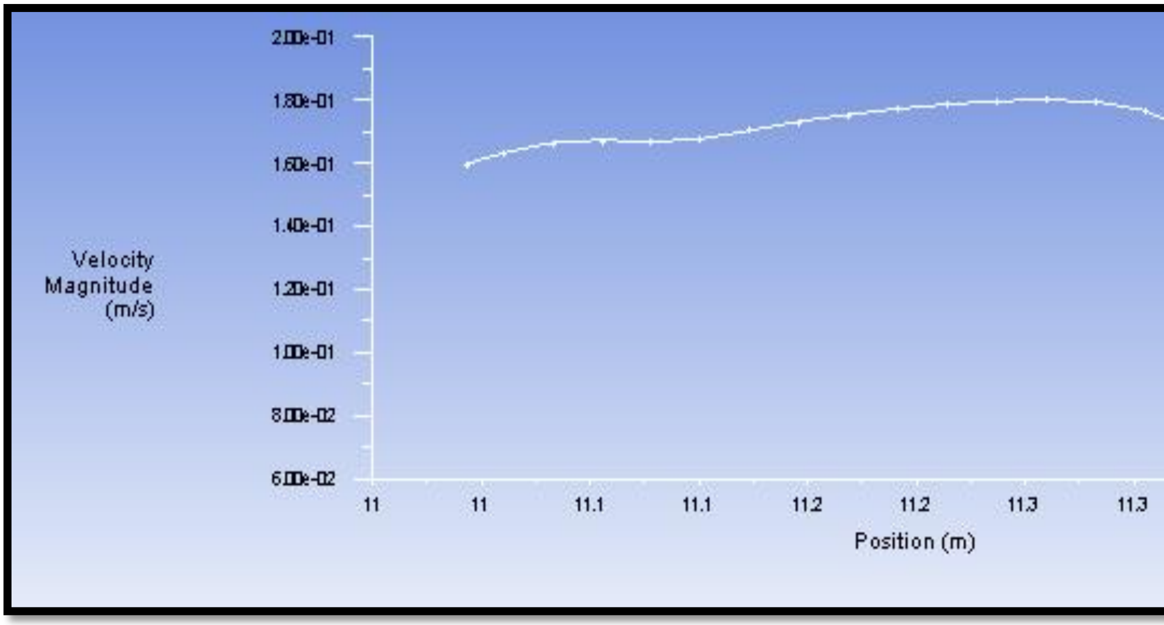

Figure 18: Velocity Profile for Natural convection

In *Figure 16*, naturally ventilated solar chimney's velocity magnitude graph along the length of solar chimney.

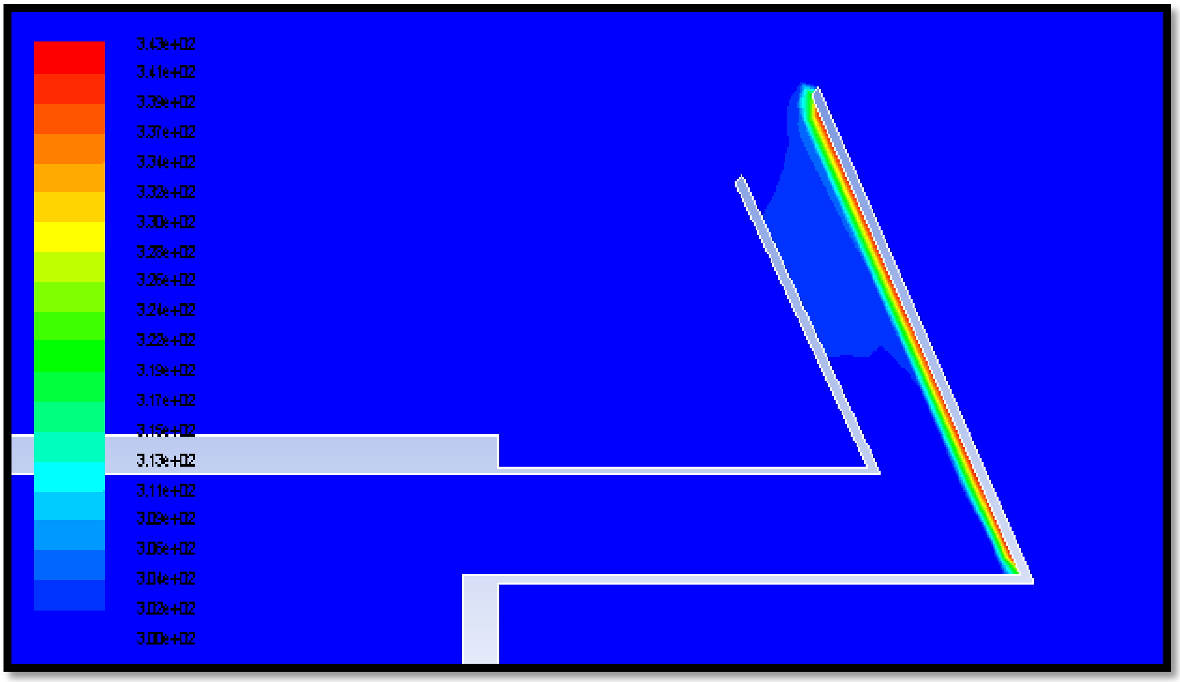

Figure 19: Temperature at the Solar Plate

Maximum temperature occurred at the fluid near the solar collector plate

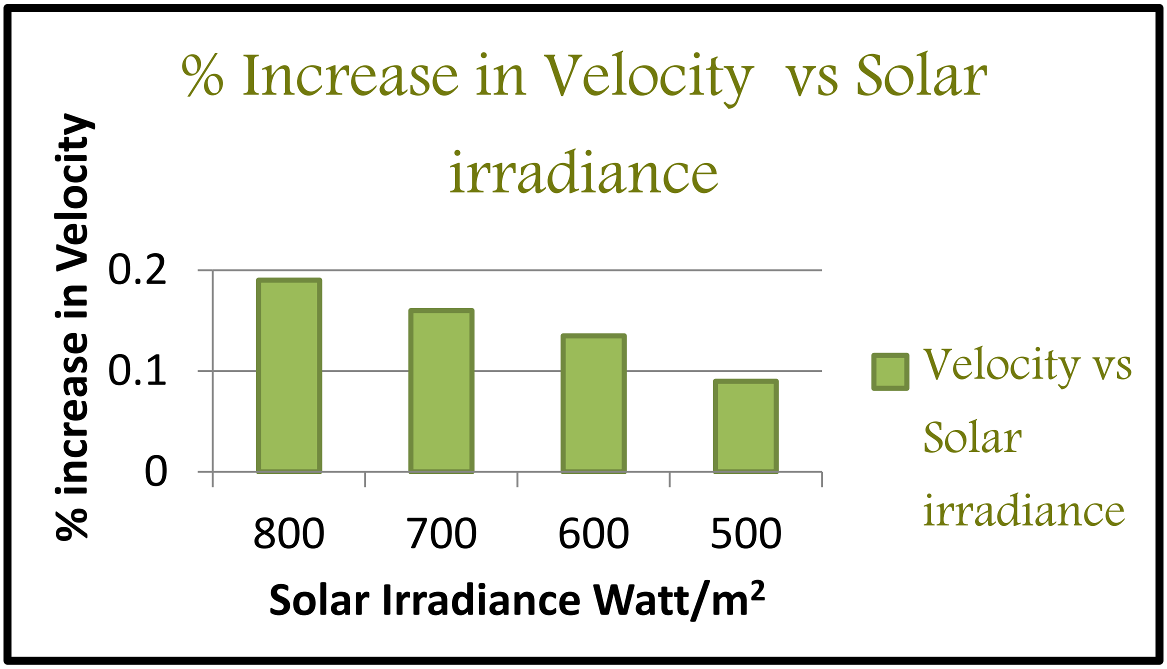

Figure 20: Velocity V/s Solar Irradiance Chart

Percentage Variation of Maximum Velocity at the solar chimney outlet with respect to solar irradiance.

5.3.2 CASE 2 DOMAIN VELOCITY 1 m/s:

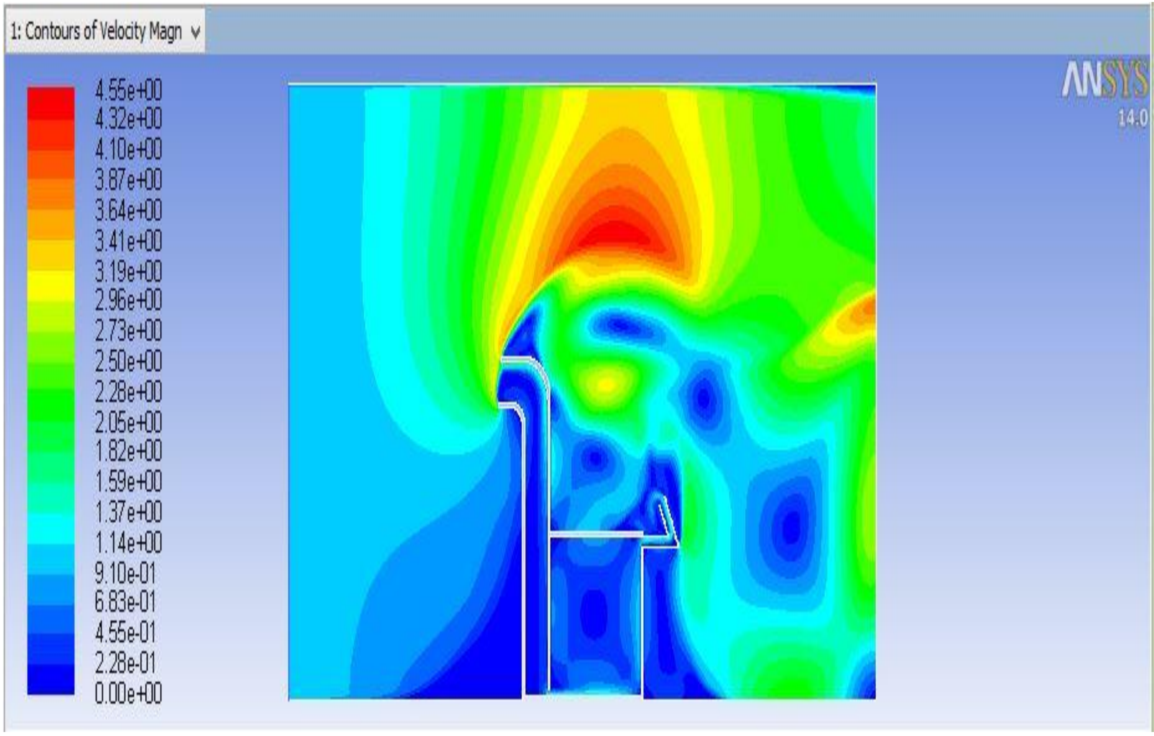

Figure 21: Velocity Contours at 1 m/s with the no. of elements being 80,000 in the grids

Domain inlet velocity is set to be 1 m/s at the outlet the velocity is found in between 0.9 m/s to 1.6 m/s. Maximum velocity was found in the domain and is to be 4.55 m/s. above velocity contours were received at 80,000 numbers of elements.

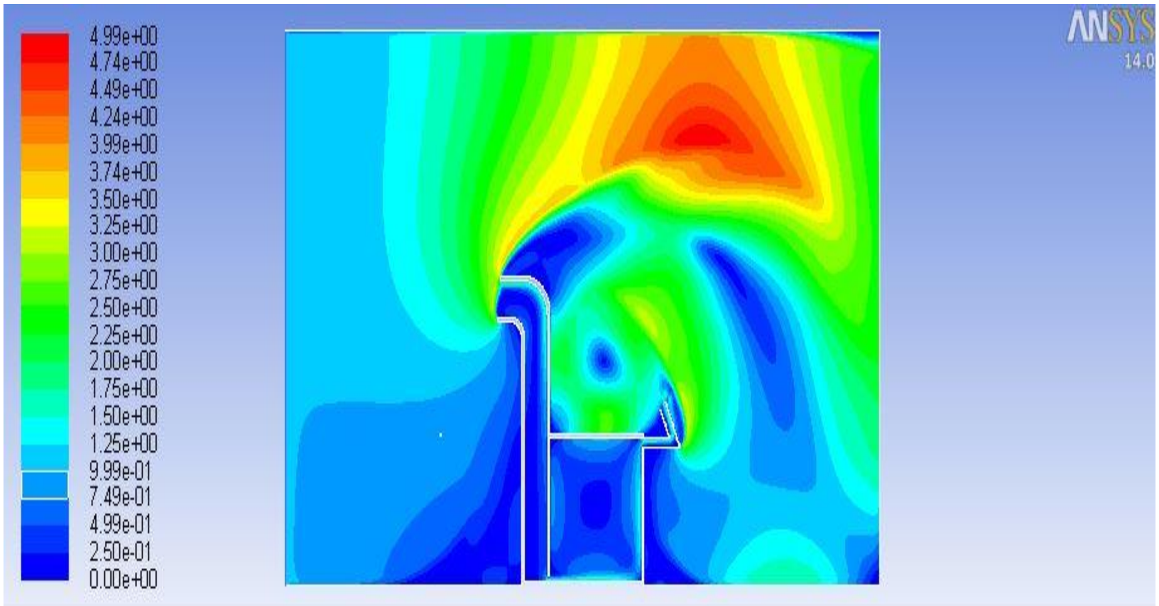

Figure 22: Velocity Contours at 1 m/s with the no. of elements being 125490 in the grids

Domain inlet velocity is set to be 1 m/s at the outlet the velocity is found in between 1.8 m/s to 2.88 m/s. Maximum velocity was found in the domain and is to be 5.0 m/s. above velocity contours were received at 125490 numbers of elements.

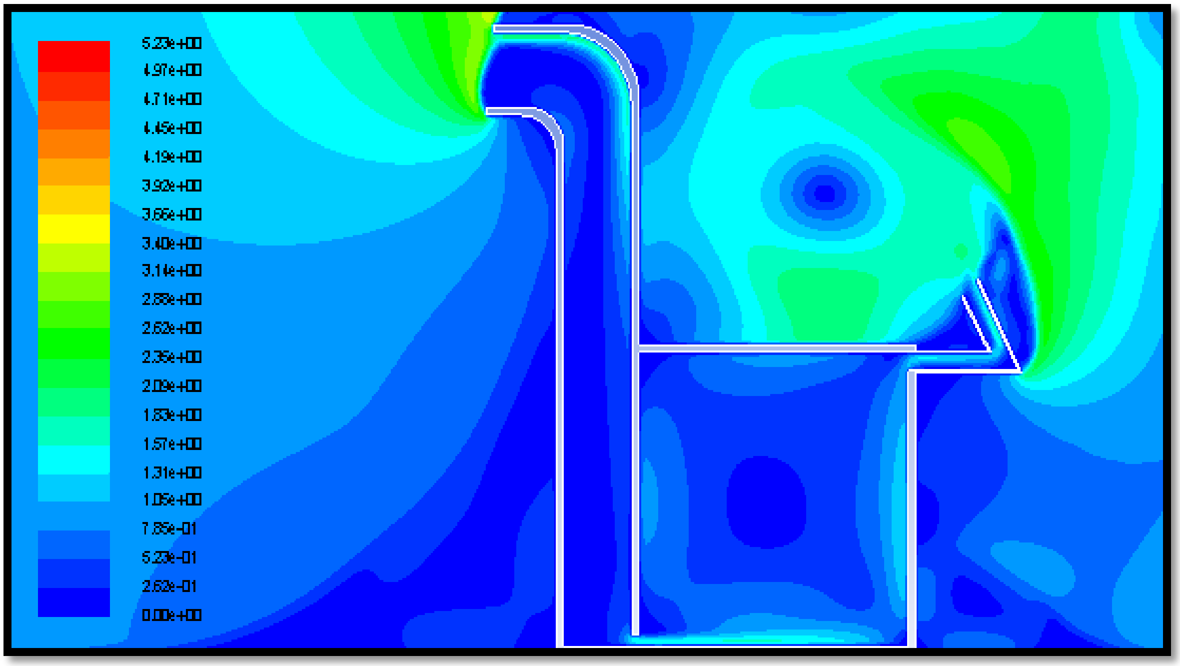

Figure 23: Velocity Contours at 1 m/s with the no. of elements being 152585 in the grids

Domain inlet velocity is set to be 1 m/s at the outlet the velocity is found in between 1.8 m/s to 2.88 m/s. Maximum velocity was found in the domain and is to be 5.23 m/s. above velocity contours were received at 152585 numbers of elements. It was assumed that the results are getting same between 125,000 and 150,000 elements.

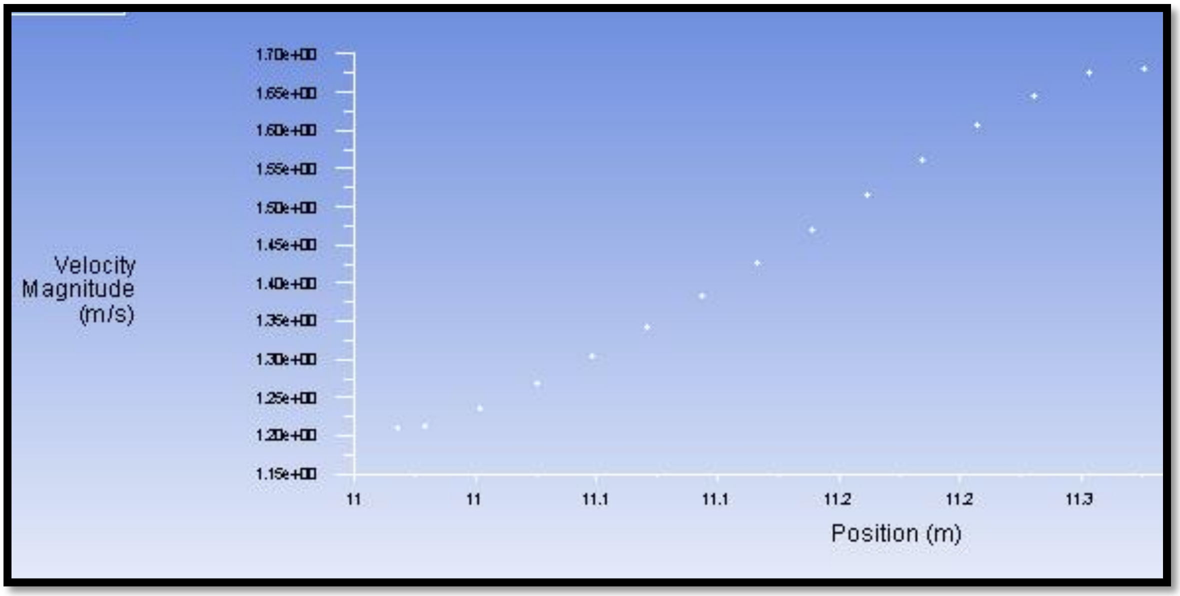

Figure 24: Velocity magnitude profile vs solar chimney length at 1 m/s

At domain inlet velocity 1 m/s, solar chimney outlet flows augmented velocity, maximum velocity increased by almost 70% at 800 watt/m^2 solar irradiance.

5.3.3. CASE 3 DOMAIN VELOCITY 2 m/s:

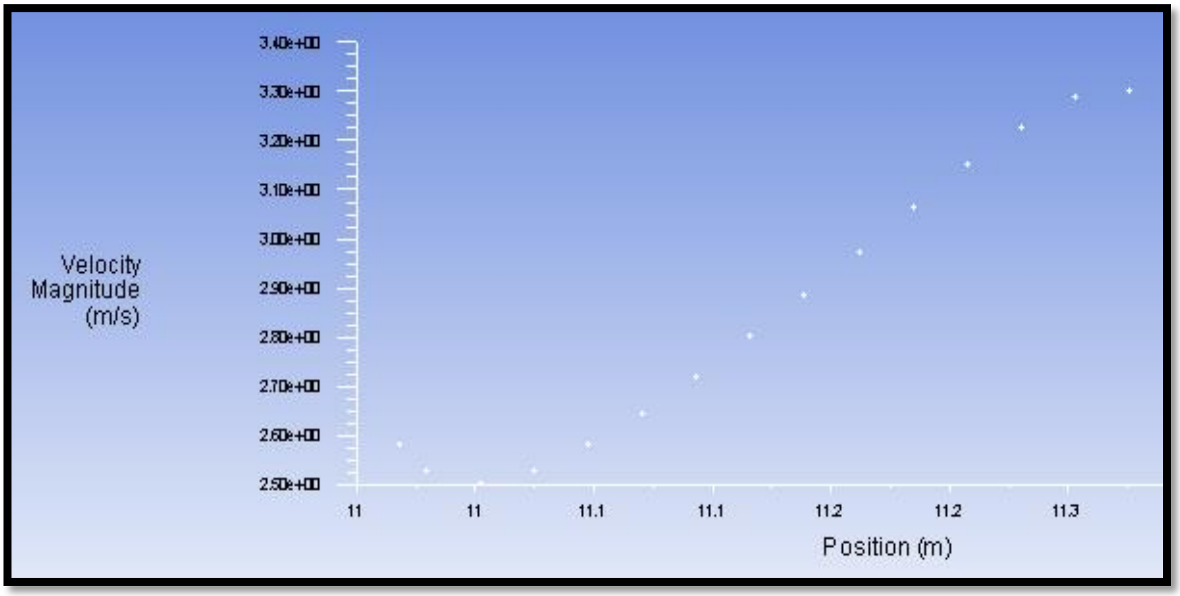

Figure 25: Velocity magnitude profile vs solar chimney length 2 m/s

At domain inlet velocity 2 m/s, solar chimney outlet flows augmented velocity, maximum velocity increased by almost 65% at 800 watt/m^2 solar irradiance.

5.3.4 CASE 4 DOMAIN VELOCITY 3 m/s:

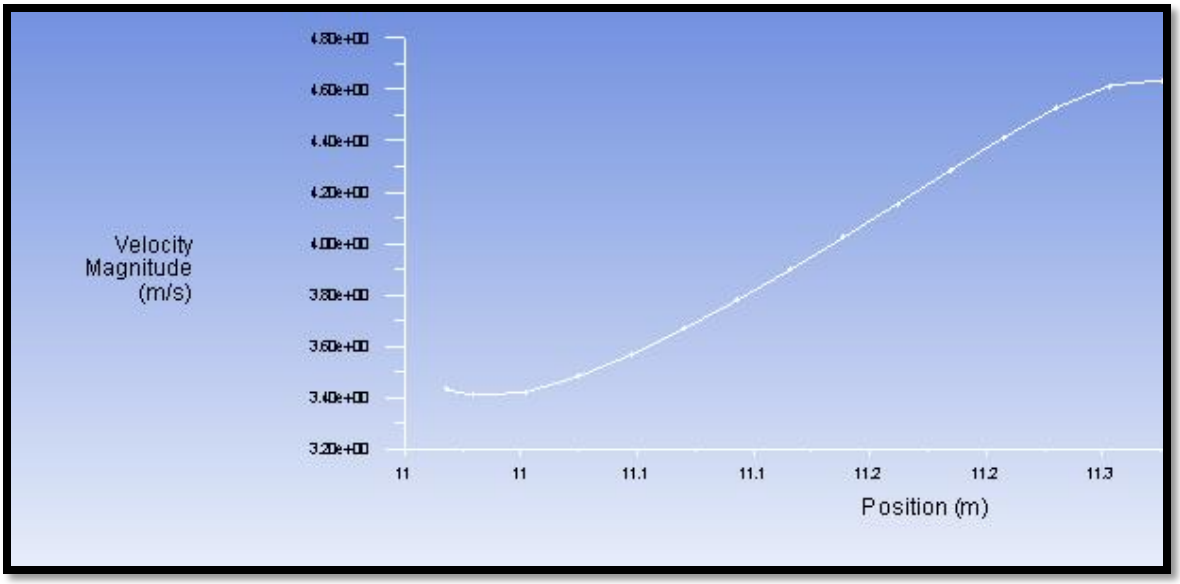

Figure 26: Velocity magnitude profile vs solar chimney length 3 m/s

At domain inlet velocity 3 m/s, solar chimney outlet flows augmented velocity, maximum velocity increased by almost 53% at 800 watt/m^2 solar irradiance.

5.3.5 CASE 5 DOMAIN VELOCITY 4 m/s:

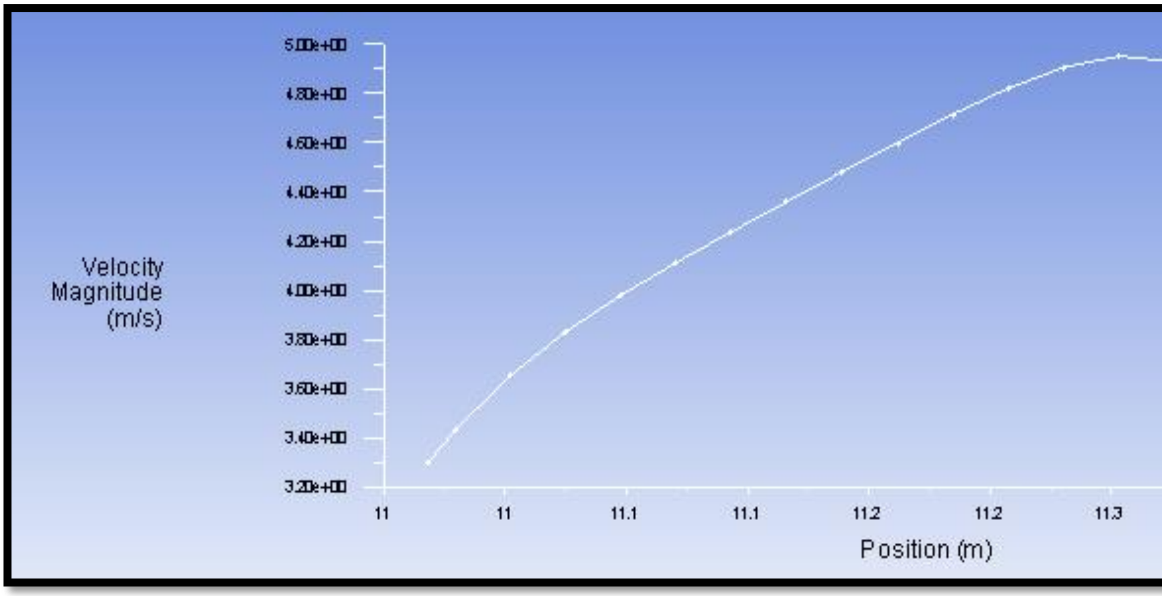

Figure 27: Velocity magnitude profile vs solar chimney length 4 m/s

At domain inlet velocity 4 m/s, solar chimney outlet flows augmented velocity, maximum velocity increased by almost 25% at 800 watt/m^2 solar irradiance.

Figure 20, 21, 22 and 23 represents the velocity profile at the chimney outlet as shown in *Figure 17*. It was observed that at 1, 2 & 3 m/s velocity at the inlet gives same velocity profile at the chimney exit while when set the velocity at 4 m/s the velocity profile curve's behavior changed from the position 11.2 m to 11.3 m. Here 11.2 m to 11.3 m is the inclined surface of the solar chimney.

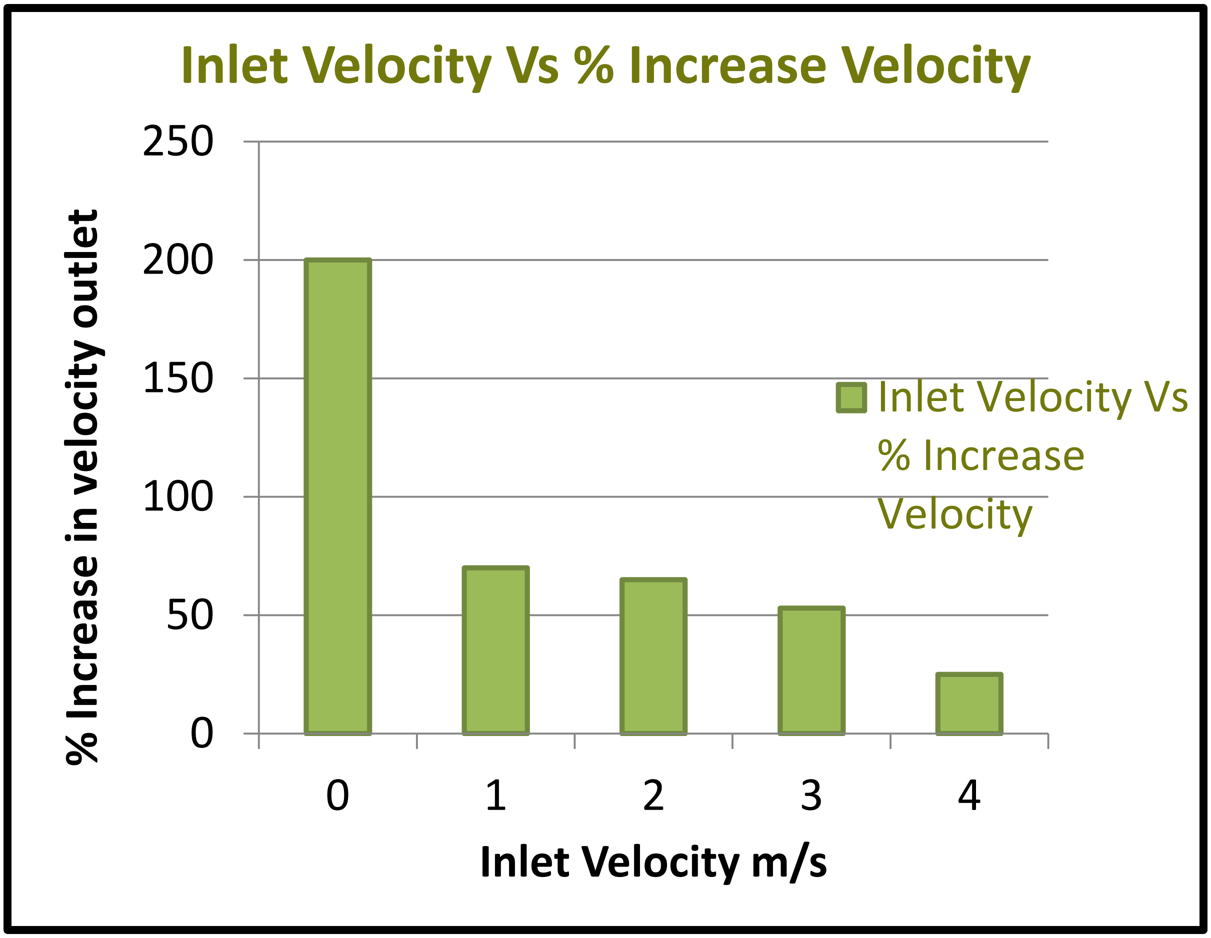

Figure 28: Inlet Velocity Vs % increase in velocity at the out let of the solar chimney

% Increase in Velocity with respect to Inlet Velocity. It can be concluded for the same amount of solar radiation, the % increase in velocity decreases with the increase in inlet velocity.

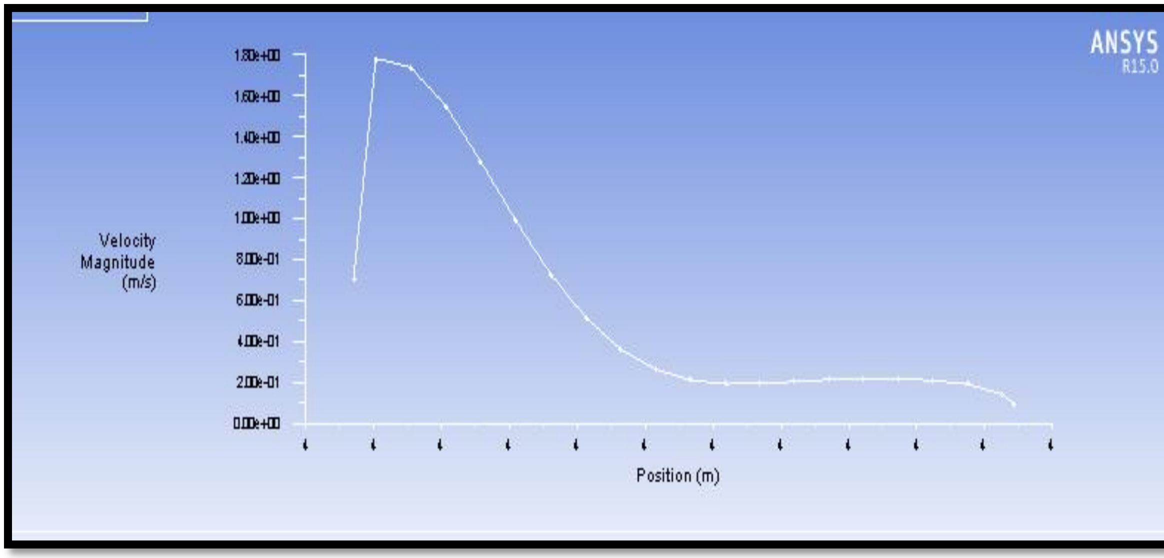

Figure 29: Velocity Profile at Wind tower inlet

The wind velocity is calculated at the wind catcher inlet @ 1 m/s inlet velocity the average wind velocity at the inlet being 0.6 m/s. almost the profiles of all the cases are same that’s why only one profile is discussed in this slide.

5.4 VELOCITY V/S MASS FLOW RATE:

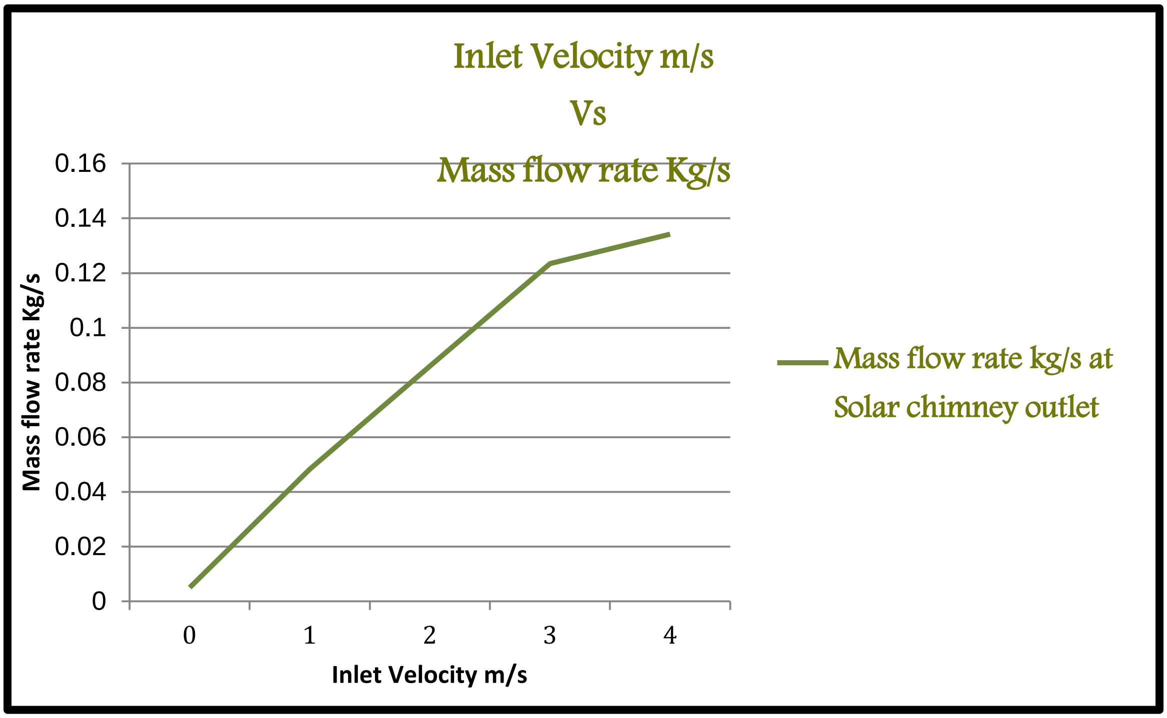

Figure 30: Inlet velocity V/s Mass Flow Rate

Mass flow rate increases as inlet velocity of the domain increases but not in a linear trend at constant heat flux of 800 W/m^2.

5.5 VELOCITY V/S VOLUME FLOW RATE:

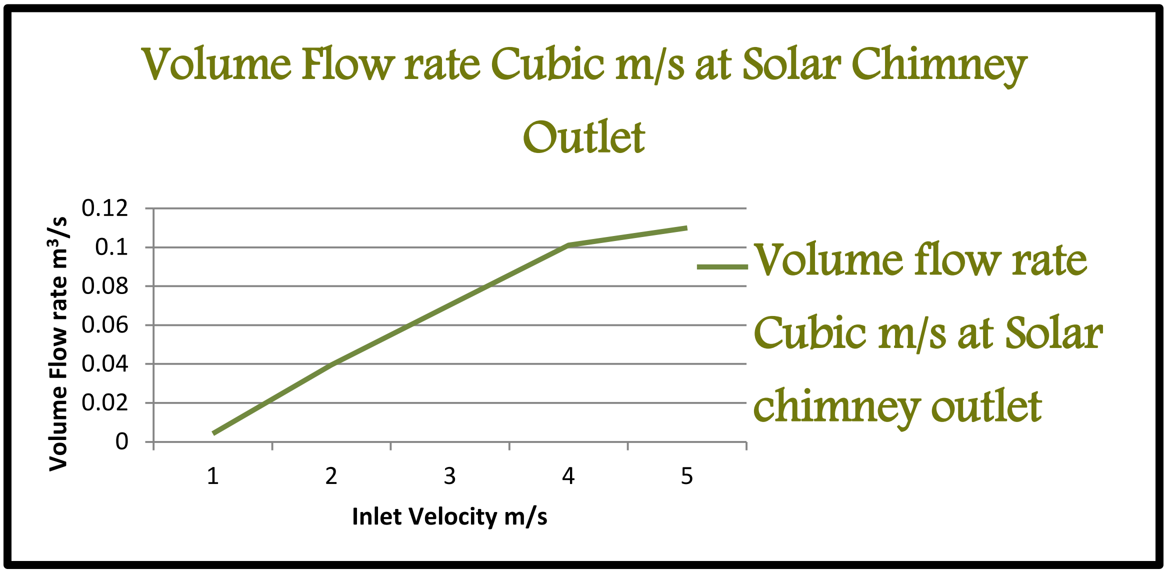

Figure 31: Inlet velocity V/s Volume Flow Rate

Volume flow rate increases as inlet velocity of the domain increases but not in a linear trend at constant heat flux of 800 W/m^2.

5.6 MASS FLOW RATE Vs SOLAR IRRADIANCE:

At 800 W/m^2

```
  Mass Flow Rate                    (kg/s)
------------------ ---------------------
            line-6              0.14455433
```

At 700 W/m^2

```
  Mass Flow Rate                    (kg/s)
------------------ ---------------------
            line-6              0.13567415
```

At 600 W/m^2

```
  Mass Flow Rate                    (kg/s)
------------------ ---------------------
            line-6              0.13014872
```

At 500 W/m^2

```
  Mass Flow Rate                    (kg/s)
------------------ ---------------------
            line-6              0.12853411
```

5.6.1 MASS FLOW RATE V/S SOLAR IRRADIANCE AT 1 m/s AT INLET:

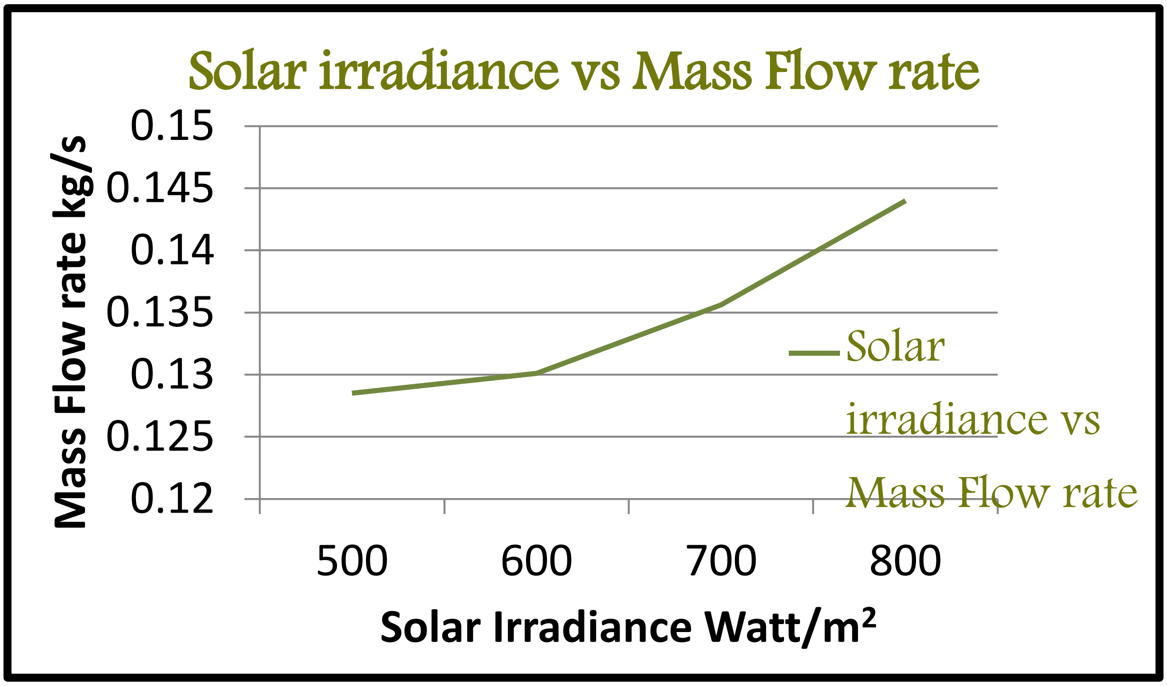

Figure 32: Solar Irradiance V/s mass flow rate at 1 m/s

Mass flow & Volume flow rate increases as Solar irradiance increases in a parabolic manner.

5.6.2 MASS FLOW RATE V/S SOLAR IRRADIANCE AT 2 m/s AT INLET:

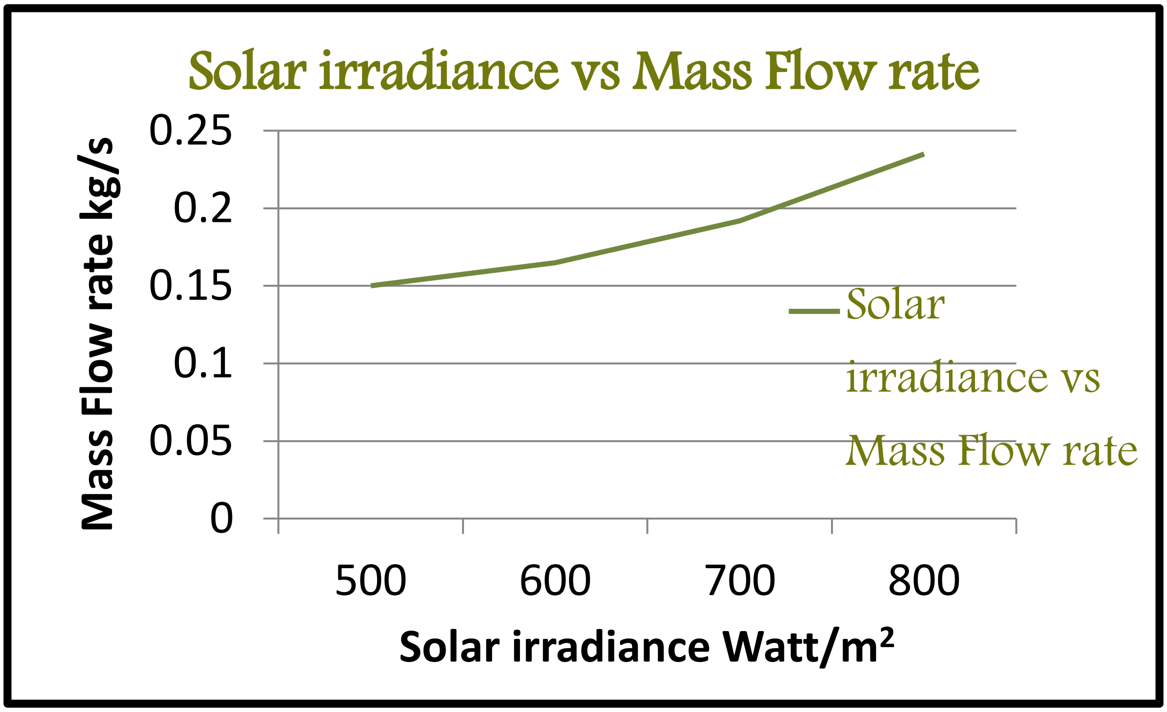

Figure 33: Solar Irradiance V/s mass flow rate at 2 m/s

Mass flow & Volume flow rate increases as Solar irradiance increases in a parabolic manner.

5.6.3. MASS FLOW RATE V/S SOLAR IRRADIANCE AT 3 m/s AT INLET:

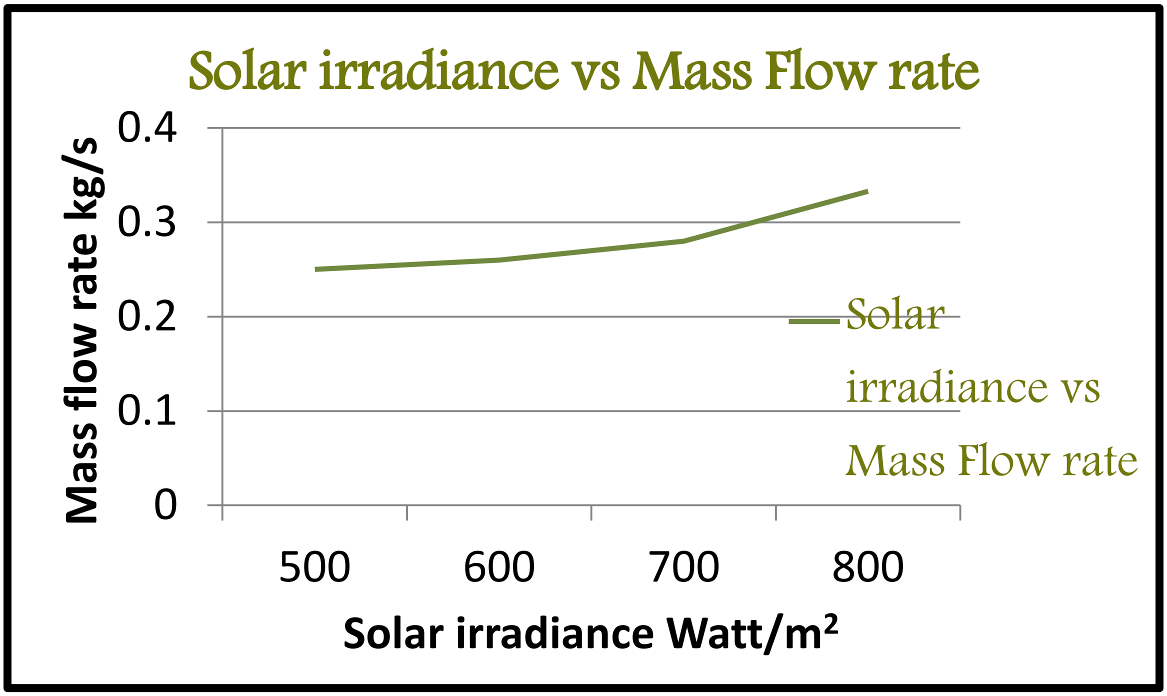

Figure 34: Solar Irradiance V/s mass flow rate at 3 m/s

Mass flow & Volume flow rate increases as Solar irradiance increases in a parabolic manner.

5.6.4 MASS FLOW RATE V/S SOLAR IRRADIANCE AT 4 m/s AT INLET:

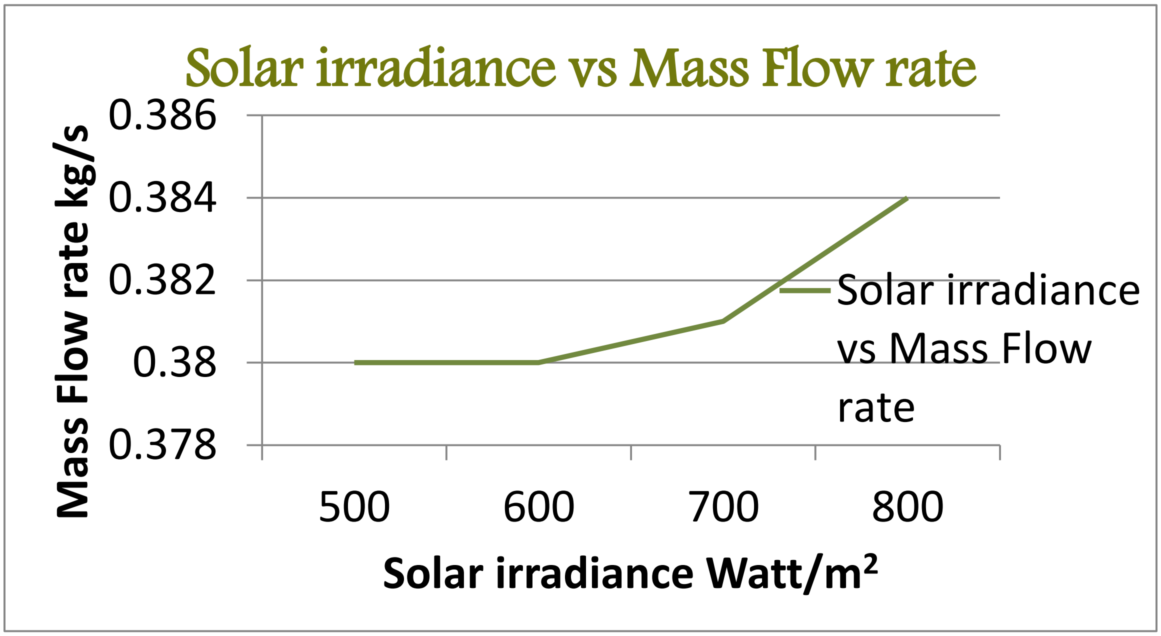

Figure 35: Solar Irradiance V/s mass flow rate at 4 m/s

Mass flow & Volume flow rate increases as solar irradiance increases in a parabolic manner.

5.7 THREE ROOMS ANALYSES:

5.7.1 PRESSURE CONTOURS @ 1m/s:

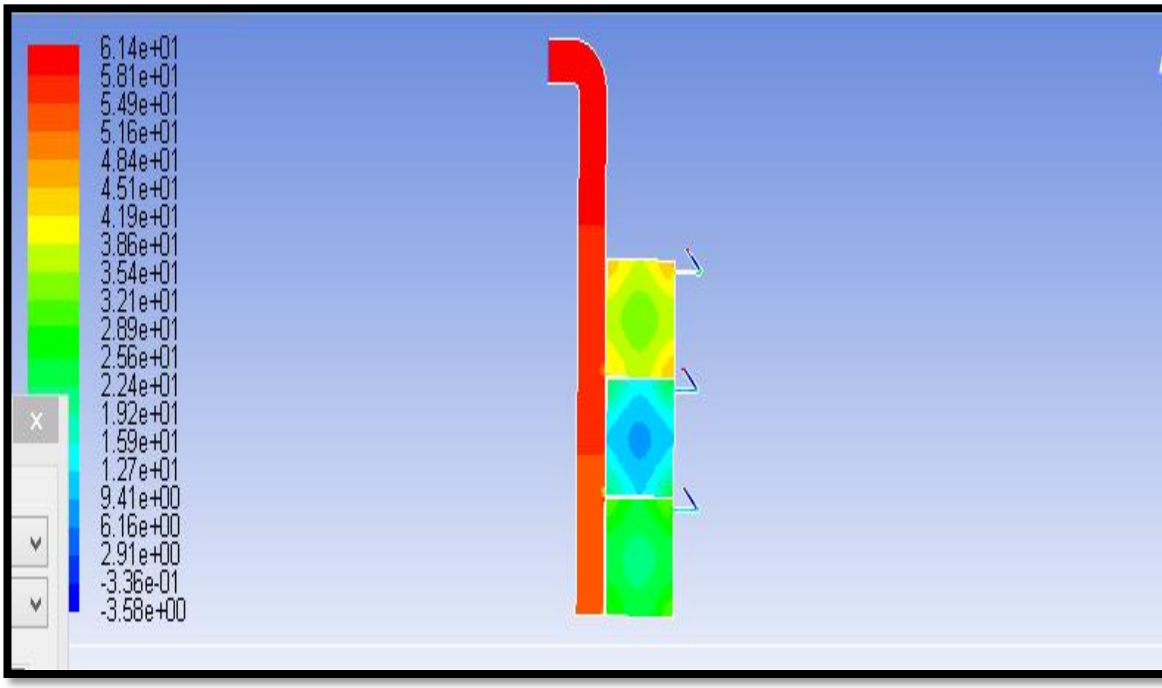

Figure 36: Pressure Contours @ 1m/s

Pressure is maximum at vertical shaft of wind catcher and at the outlet of solar chimney which value is 61.4 KPa. And inside the room the pressure is low and the room is comfortable zone.

5.7.2 VELOCITY CONTOURS @ 1m/s:

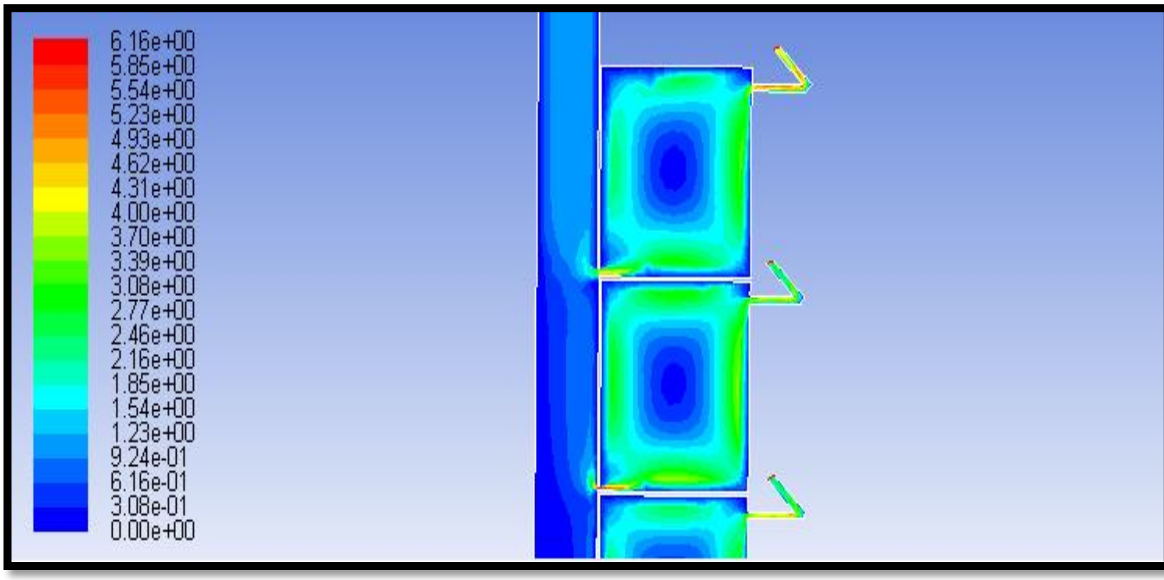

Figure 37: Velocity Contours @ 1m/s

Velocity is maximum at the outlet of the solar chimney which is 6m/s approximately. And inside the room the value of the velocity is ranges from 0 m/s to 3.08 m/s, inside the room the velocity is maximum at the edges of the wall and 0 at the center.

5.8 CONVERGENCE:

The solution converges at 230 iterations, the continuity is 9.9 x 10^{-4} kg/s, x velocity is 3.46 x10^{-4} m/s, y velocity 3.71 x 10^{-4} m/s, energy is 1.91 x 10^{-7} KJ, the value of k is 1.60 x 10^{-4}, and the value of epsilon is 1.503 x 10^{-4}.

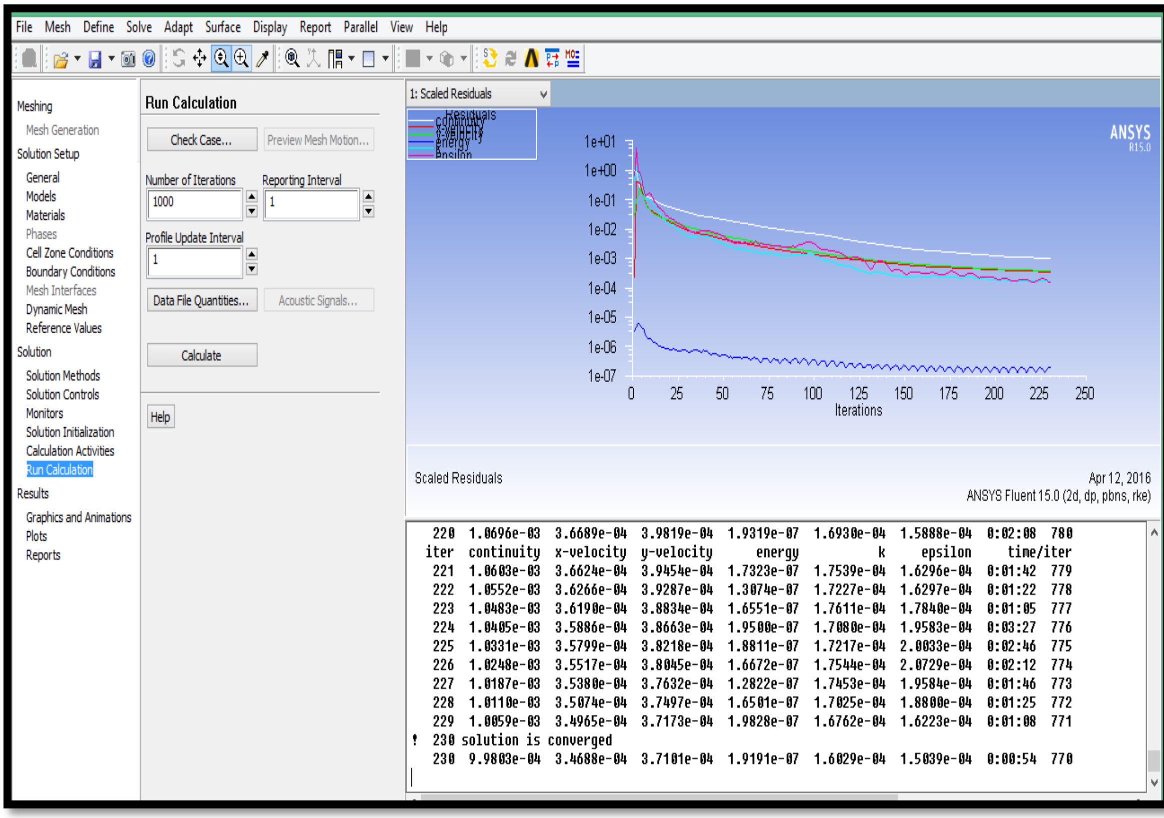

Figure 38: Convergence

Convergence of each solution takes 250 numbers of iteration with convergence criteria 500 numbers.

5.9 MASS FLOW RATE FROM 3 OUTLETS:

Mass flow rate from outlet 1	=	0.74094489 Kg/s
Mass flow rate from outlet 2	=	0.54064276 Kg/s
Mass flow rate from outlet 3	=	0.54466039 Kg/s
Net mass flow rate	=	1.826248 Kg/s

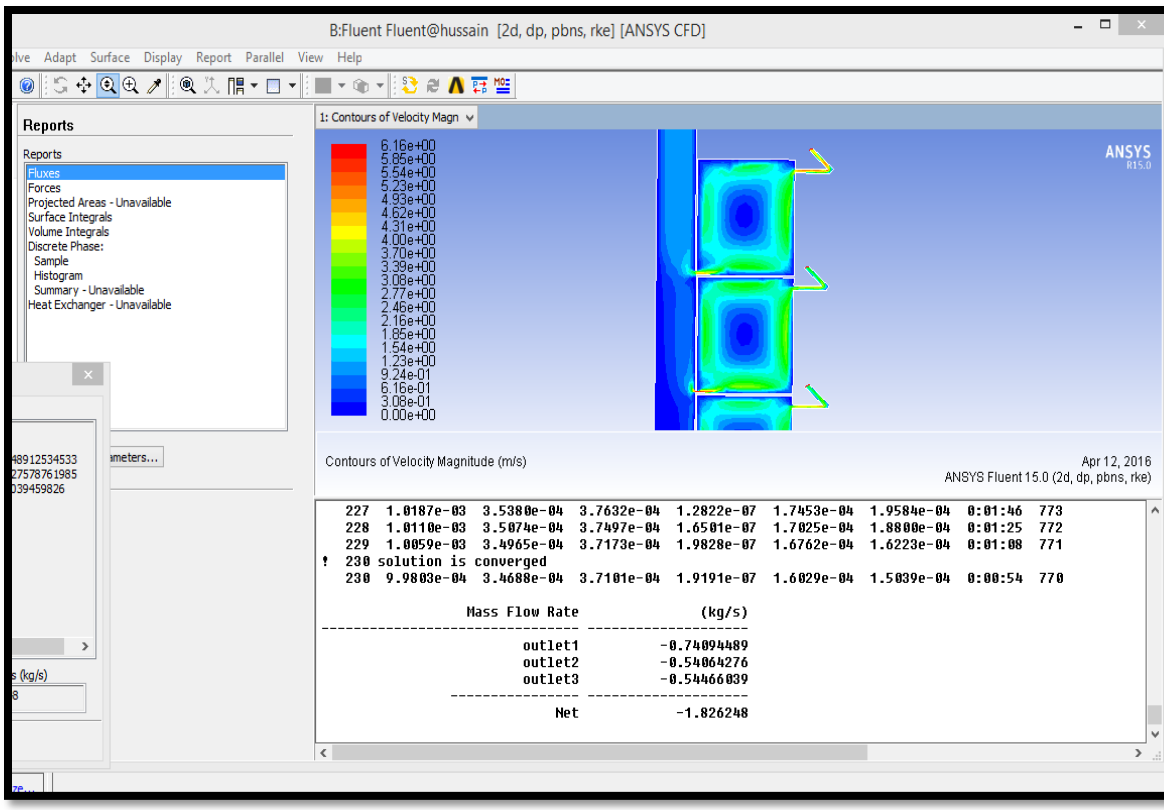

Figure 39: Mass flow rate

6. CONCLUSION

The combination of passive instruments such as wind and solar chimney scavenger used in this study. CFD techniques were used, and the model Boussinesq buoyancy Achievable k ∈ model is used for natural convection, used for different speeds. Percentage increase in velocity increases with field input speed is increased. It is observed that with increasing surface and higher solar radiation input speed the mass flow rate and a large number of environments and wind catcher height increases also growth the mass flow rate. The design philosophy and function of mentioned important foundations can be detected and tracked the entrance for air of existing structures. The working of a natural aeration system is highly dependent on the design and frontage open spaces that allow outside air to enter and stale air to flow out. Wind collectors have been neglected in the modern construction industry today. There exist two kinds of driving forces with the porch mechanism; is thrust and external wind, which each described in Boussinesq model and model k ∈ reachable. Buoyancy effect has its physical occurrence which is stimulated by the presence of indoor and outdoor heating difference. The collector Wind height raises increments in the mass flow rate. The larger the area of the solar collector plate, the higher its absorption of heat will be through which the solar radiation, which increases the exhaust flow rate from the inside to the outside. A large number of stacks increases the volume flow. This creativity is very useful and innovative in saving a large amount of energy, it involves to operate a very high-tech electrical control. The discussion so far increased sentience of the significance of the traditional porch and helped open opportunities to improve performance and extend the applicability of wind catchers. This brings wide range of opportunities for the use of passive cooling system of the old heritage in the world today. The presence of such similar examples constructed in various regions of the world delivers a starting point for research practical guidelines to develop wind collectors for all types of buildings with different designs.

6.1 RECOMMENDATION FOR FURTHER STUDIES:

Aerodynamic wind collector, phase change material, the structure of wind catchers under the technical issues are that need to be covered in forthcoming studies. Louver arrangement is another theme that changes wind collector efficiency. Evaporative cooling technology, either directly or indirectly, there’s another topic for study recommended.

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