IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Flow through transition duct

[1]Upendra Kumar Shukla

[1]Assistant Professor,
[1]Department of Chemical Engineering,
[1]Institute of Engineering and Technology, Lucknow, India

Abstract: Forced air circulation become more important for heating and cooling of the place of living for more comfortable life. There are several types of Duct namely circular and rectangular used for different purposes. Heating, ventilation and air conditioning (HVAC) system designs require good understanding of variation of velocity, pressure and energy throughout the duct in three dimensions. In this paper theoretical analysis has been performed using Ansys-CFX. The physics of the turbulent air flow in duct has been captured by analyzing variation of velocity, pressure, turbulent kinetic energy and wall shear stress in terms of contour plots and graphical plots.

***Key words* – Duct, Turbulent flow, HVAC, Transition.**

I. Introduction

Flow through duct became important because induced drag and enhanced mixing [1]. Transitional flow in the duct encountered in many industrial applications [2]. So the correct prediction of flow transition plays an important role in Duct design either circular or rectangular or combination of both. In this study turbulent flow through the duct has been studied. Different contour plots and graphs related to velocity, pressure, turbulent kinetic energy, wall shear stress and turbulent viscous dissipation has been drawn using k-ε model.

II. Mathematical Formulation

Governing Equations:

Continuity equation: $$\frac{\partial \rho}{\partial t} + \nabla.(\rho\vec{v}) = 0$$

Momentum Equation: $$\frac{\partial(\rho\vec{v})}{\partial t} + \nabla.(\rho\vec{v}.\vec{v}) = -\nabla p + \nabla.\overline{\overline{\tau}} + \rho\vec{g}$$

For turbulent kinetic energy: $$\frac{\partial k}{\partial t} + \mathbf{u_j}\frac{\partial k}{\partial x_j} = -\frac{1}{\rho}\frac{\partial u_i' p'}{\partial x_i} - \frac{1}{2}\frac{\partial u_j' u_j' u_i'}{\partial x_i} + \nu\frac{\partial^2 k}{\partial x_j^2} - u_i' u_j'\frac{\partial u_i}{\partial x_j} - \nu\frac{\partial u_i'}{\partial x_j}\frac{\partial u_i'}{\partial x_j} - \frac{g}{\rho}\rho' u_i'\delta_{i3}$$

k-ε model has been used for fluid flow modeling.

III. GEOMETRY AND MESH

Prismatic and tetrahedral mesh has been used with maximum skewness 0.64 and aspect ratio 11.2 as shown in figure 1.

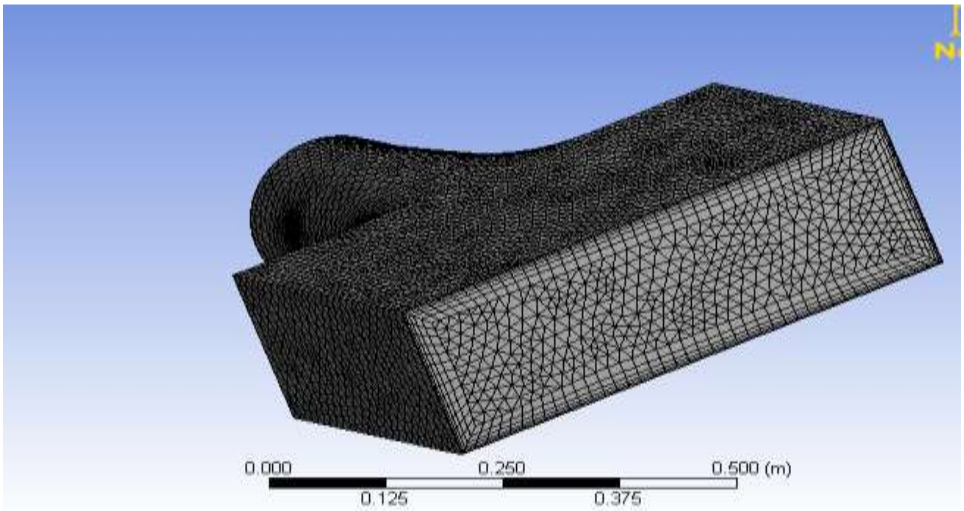

Figure 1: Meshing of the Duct

IV. Results and discussions

Figure 2 shows velocity contour, it is clear that velocity is higher along the central region of the duct.

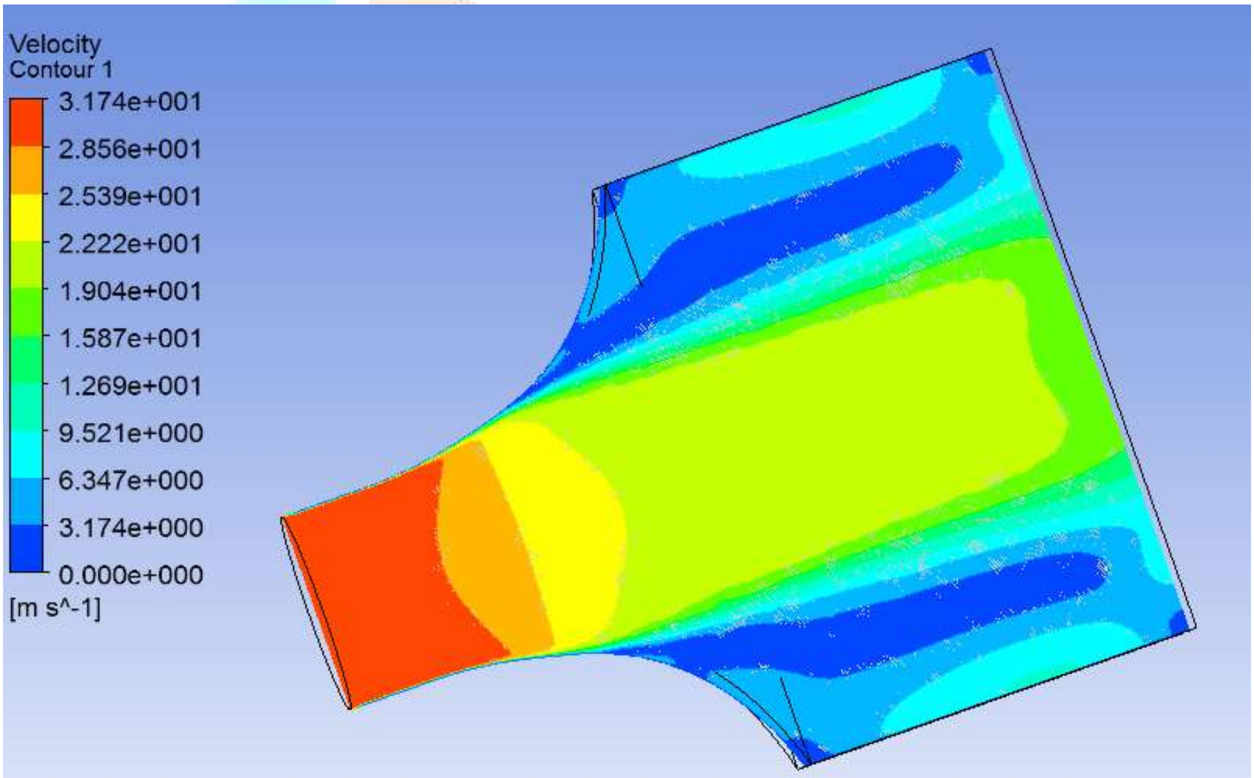

Figure 2: Velocity Contour

Figure 3 shows turbulent kinetic energy in the duct.

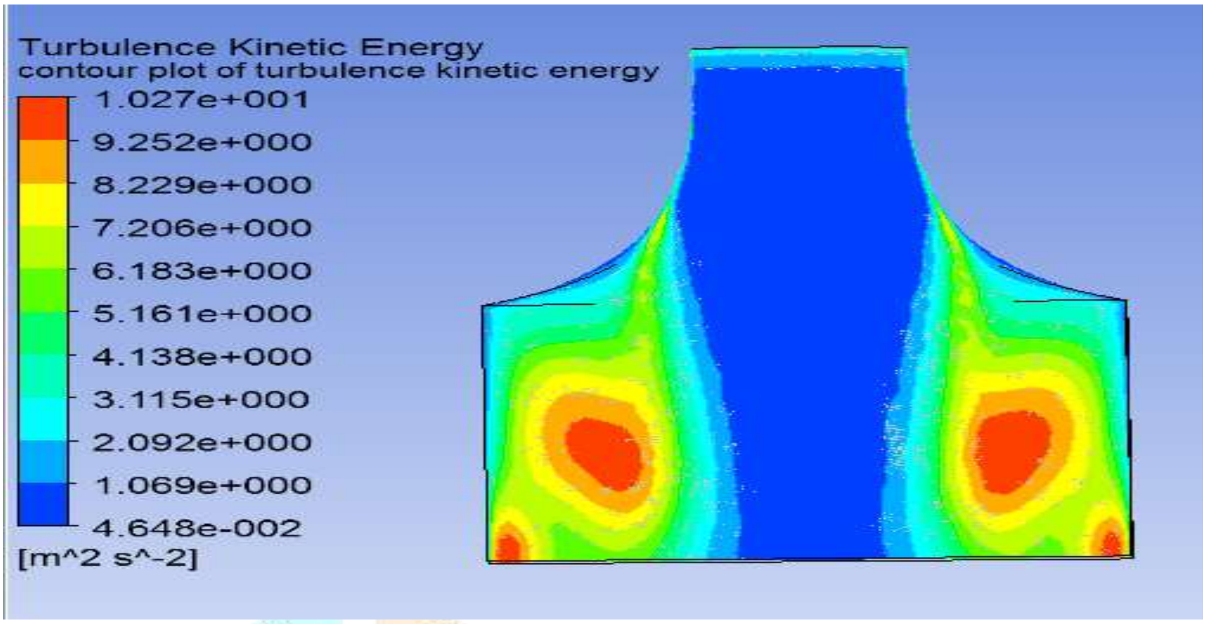

Figure 3: Turbulent Kinetic Energy Contour Plot

Figure 4 shows velocity streamline along the duct, tangent at any point of the streamline gives the velocity at that point.

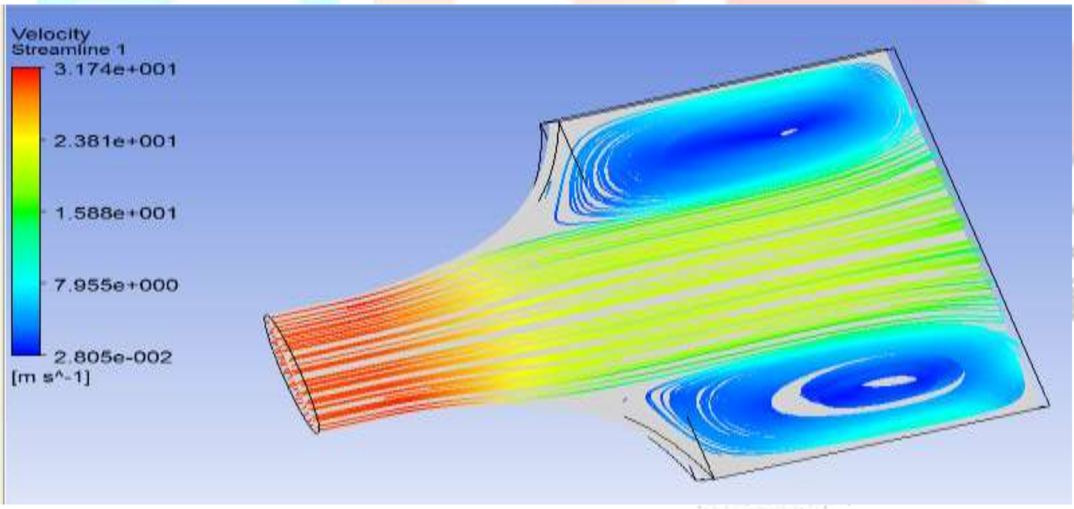

Figure 4: Velocity streamline

Figure 5 shows Pressure contour plot, it can be seen that pressure is higher at the outlet of the duct.

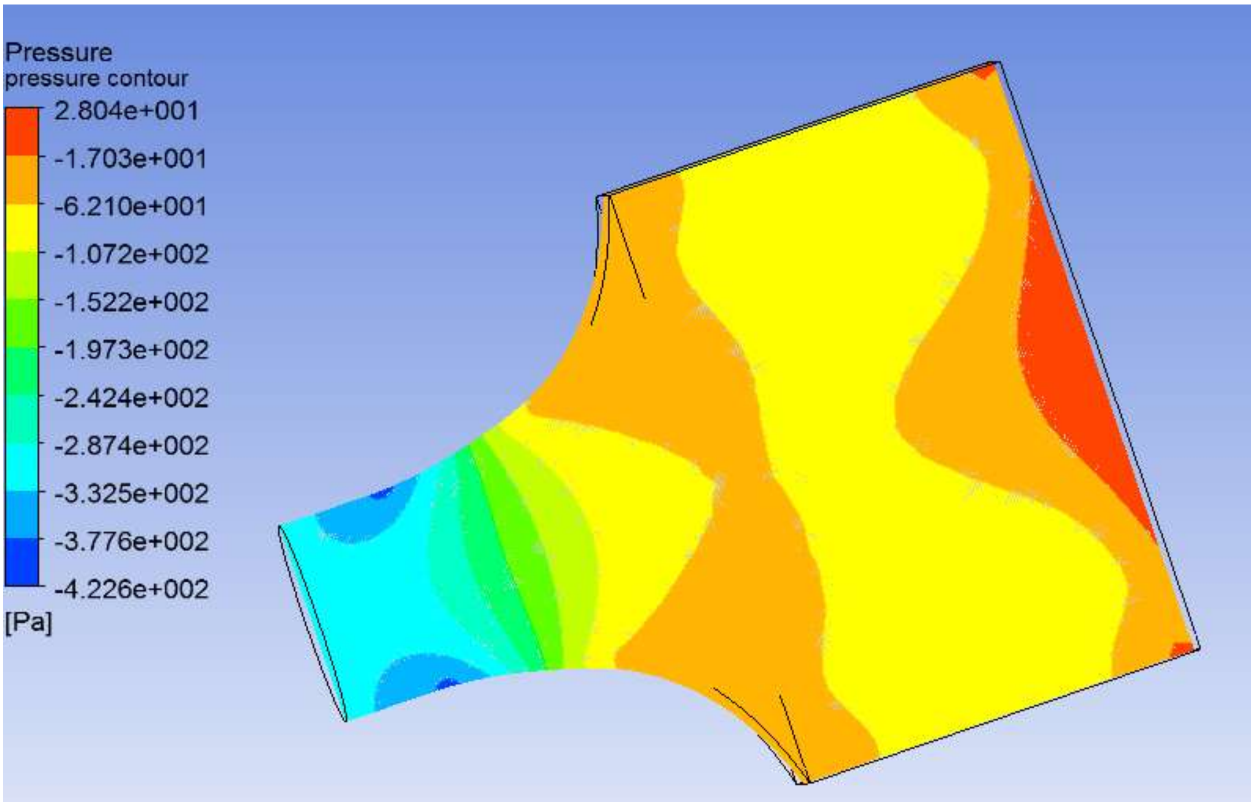

Figure 5: Pressure Contour Plot

Figure 6 shows the Wall shear stress contour plot.

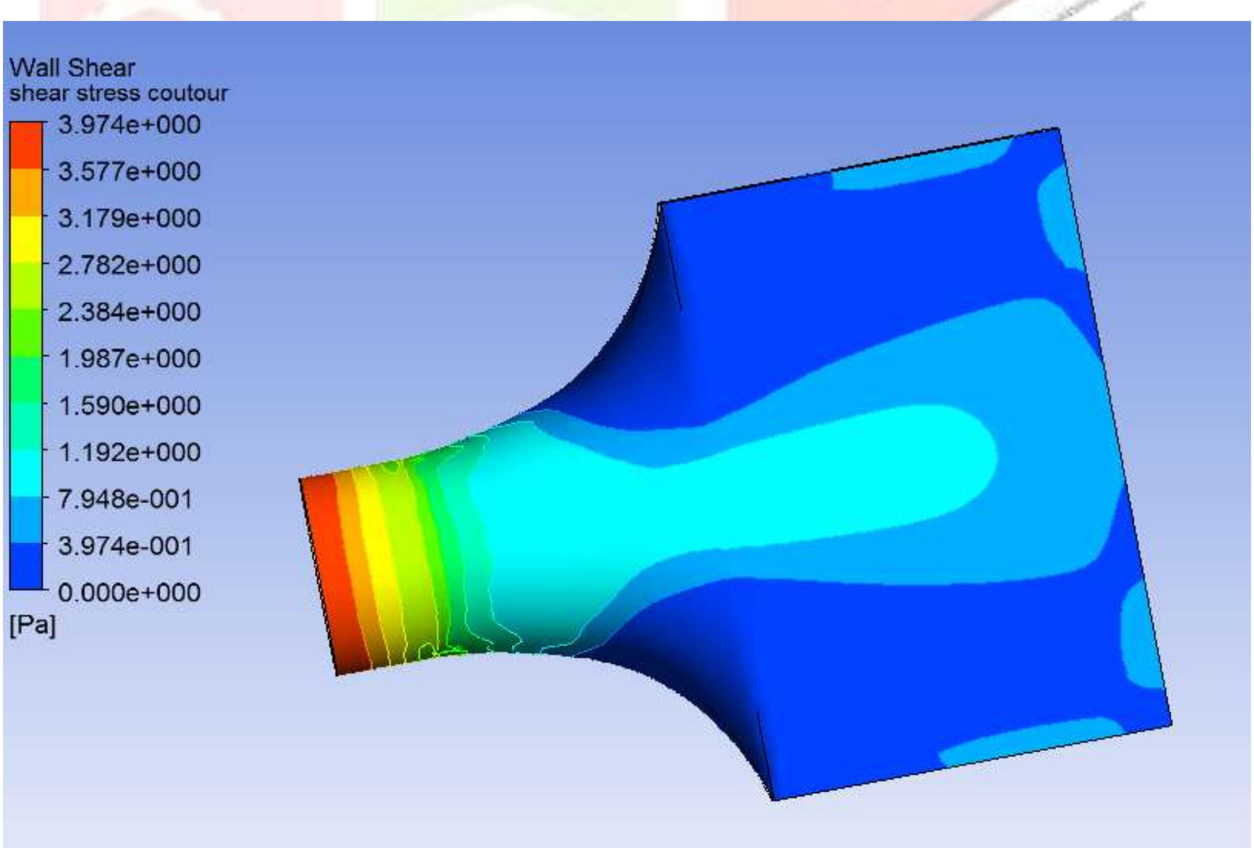

Figure 6: Wall Shear Stress Countour

Figure 7 shows the turbulent eddy dissipation along the central line of the duct. It is clear from the graph that turbulent eddy dissipation increases along the central line.

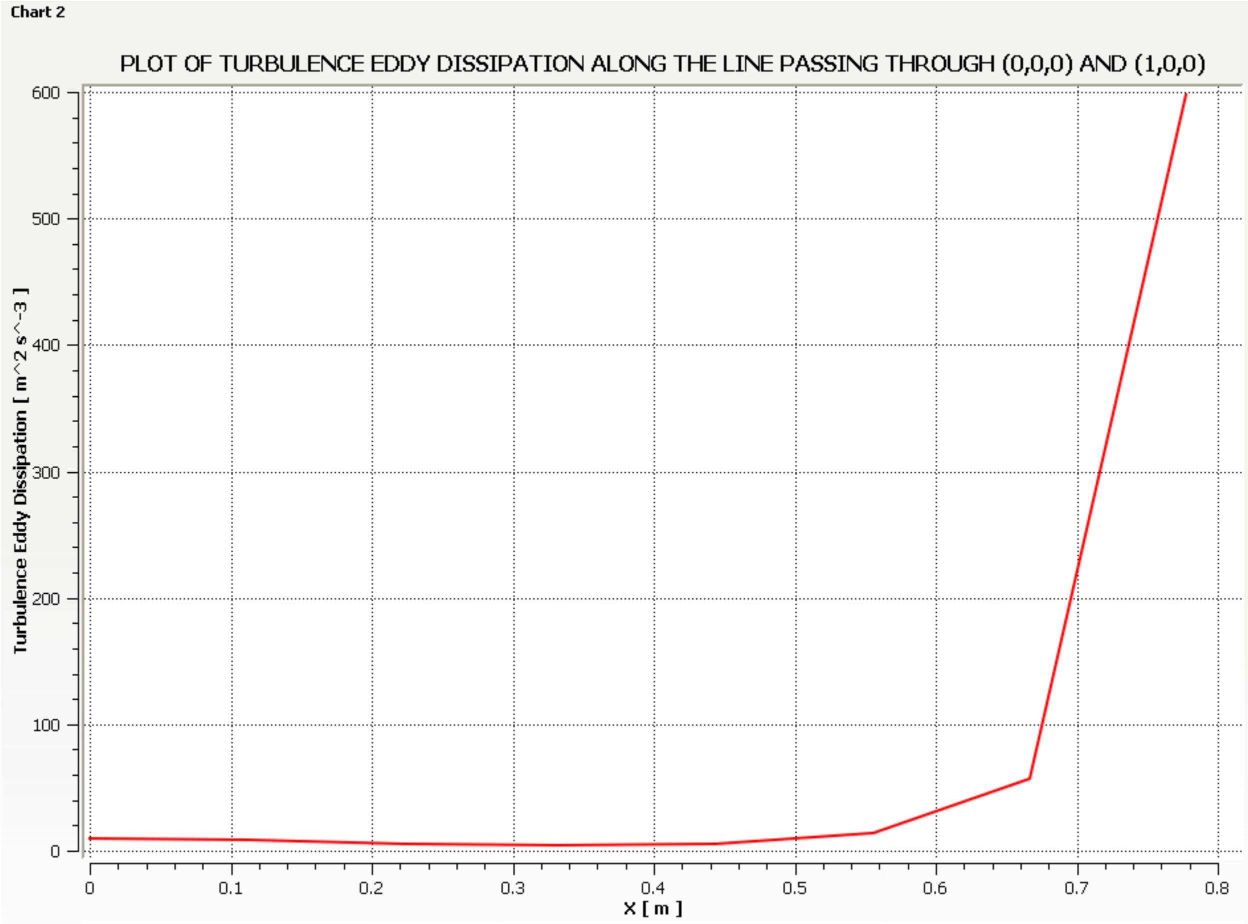

Figure 7: Turbulent Eddy Dissipation

Figure 8 shows velocity along central line. It is clear from the graph that velocity increases along the central line.

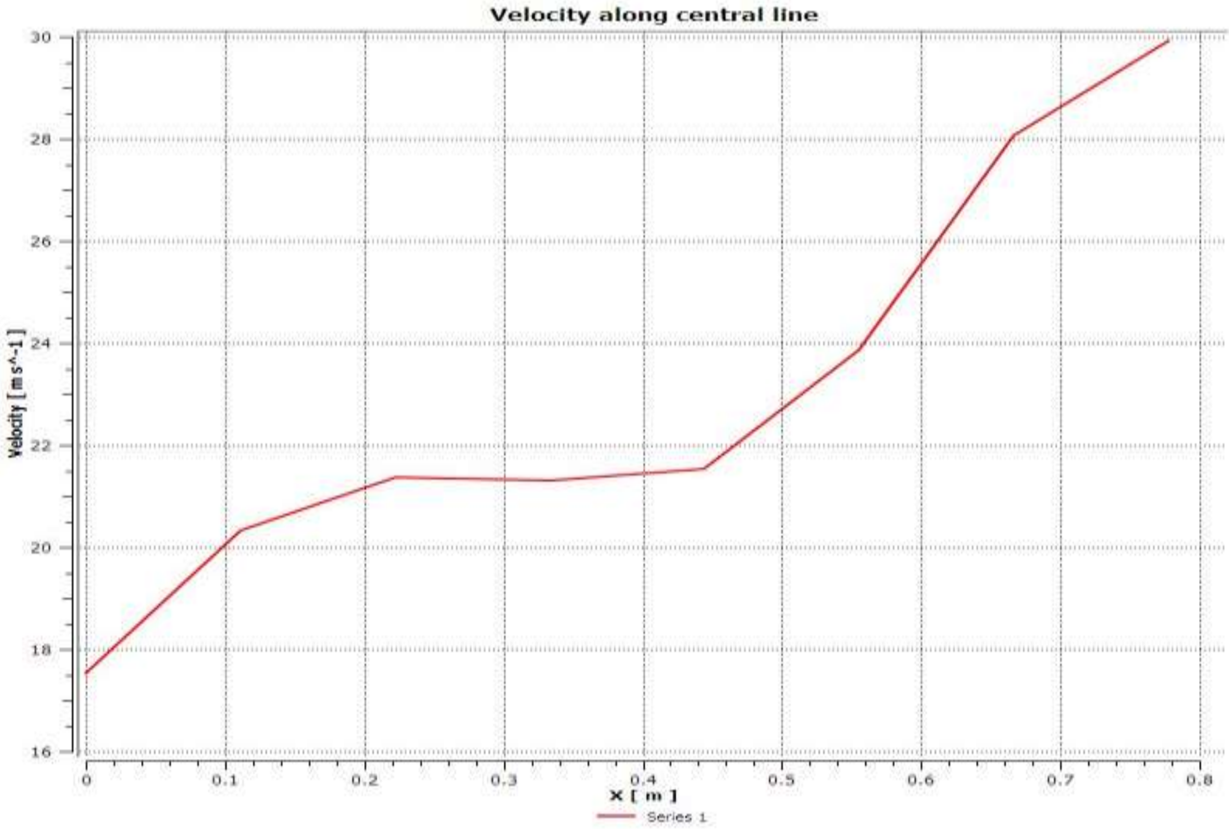

Figure 8: Velocity along central line

Figure 9 shows the total pressure plot along the central line. It is clear from the graph that total pressure first decreases and then increases .

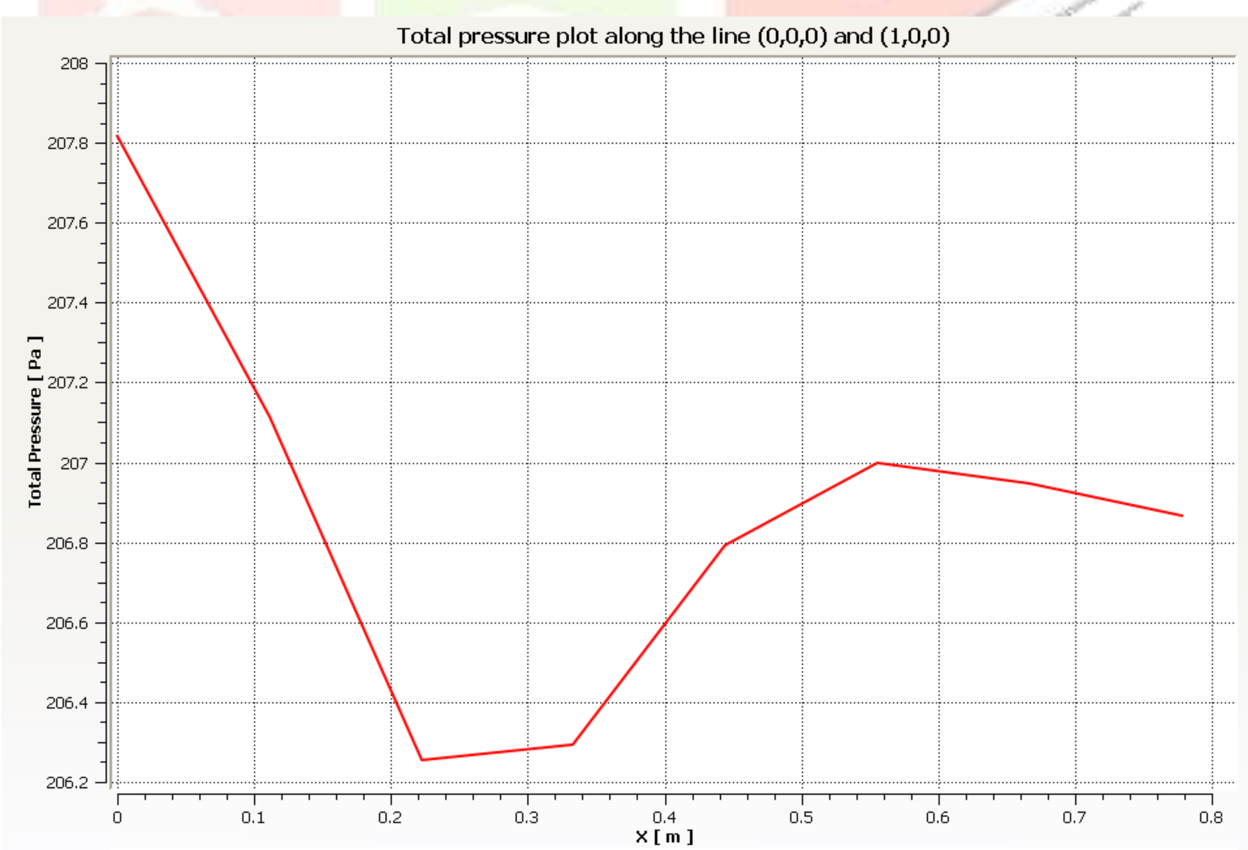

Figure 8: Total Pressure Plot along central line

V. CONCLUSION

The different parameter like velocity, pressure, turbulent kinetic energy, and turbulent eddy dissipation has been analyzed using Ansys CFX software. It has been found that velocity increases along central line and pressure decreases along central line. Unsymmetrical nature of the streamline plot shows flow is unsymmetrical though geometry is symmetrical.

VI. NOMENCLATURE

V_j=velocity component

Xj=coordinate x,y,z

ρ=density

k= turbulent kinetic energy

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[2] A Study on Flow Transition and Development in Circular and Rectangular Ducts, Journal of Fluid Engineering ,June 2009

[3] Ansys CFX manual