THE MIXING FLOW AND HEAT TRANSFER IN A POLY PIPE

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ABSTRACT

This work illustrates the setup and solution of a three-dimensional turbulent fluid flow and heat transfer problem in a mixing poly flow pipe junction by fluent under ansys 12 (finite volume). The mixing poly flow of water configuration is encountered in piping systems in power plants and process industries. It is often important to predict the flow field and temperature field in the area of the mixing region in order to properly design the junction. In this work a different Reynolds number are used to predict the better mixing in poly flow pipe. Coarse mesh type are available for more accurate and the inlet velocity and temperature of the fluid can be specified and the effect of the side stream on mixing within the poly flow pipe can be observed. Temperature dependent fluid density, viscosity, thermal conductivity, and specific heat can be specified. Pressure drop and temperature change from Inlets to the Outlet are reported. Plots of velocity distribution, pressure distribution, temperature distribution, are available also velocity vectors, temperature contours, and streamlines can be displayed in the flow domain.

Keywords: fluid flow, poly flow pipe , mixing heat

جريان الخلط وانتقال الحرارة في أنبوب متعدد

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الخلاصة

هذا العمل يظهر هيكلية وحل مسالة جريان المائع وانتقال الحرارة في امتزاج جريان متعدد في توصيلة أنبوبية ثلاثية عن طريق استخدام برنامج (Fluent). المزج في الجريان المتعدد يكون موجود في أنابيب محطات القدرة والعمليات الصناعية.حيث أنة من المهم تخمين مساحة مجال الجريان ومجال الحرارة في منطقة المزج لتصميم دقيق للوصلة حيث تم استخدام التقسيم الخشن لغرض الوصول إلى النتائج المطلوبة.كذلك السرعة الداخلة ودرجة الحرارة يتم تحديدها وتأثير الجريان الجانبي على المزج ضمن الجريان المتعدد يمكن ملاحظته و درجة الحرارة و كثافة المائع واللزوجة والموصلية الحرارية والحرارة النوعية يمكن تحديدها. تغير انحدار الضغط وتوزيع درجة الحرارة من المداخل إلى الخروج يتم تحديده. رسومات توزيع السرعة والضغط ودرجة الحرارة تكون موجودة كذلك مخططات متجهات السرعة والحرارة وخطوط الجريان.

NOMENCLATURE

Symbols	Meaning	Units	Symbols	Meaning	units
C_μ, $C_{1\varepsilon}$, and $C_{2\varepsilon}$	constants	-	ρ	Density	Kg/m^3
C_p	Specific heat	kJ/kg.K	μ	Dynamic Viscosity	Pa.s
Eij	Edge length	m	μ_t	Turbulent Viscosity	Pa.s
I	Turbulent intensity	-	ε	Turbulent Dissipation rate	m^2/s^3
V	Mean velocity	m/s	ν	Kinematics Viscosity	m^2/s
ρ	Density	Kg/m^3	σ_k, σ_ε	Turbulent Prandtl numbers	-

INTRODUCTION

Fluid flow involves the transfer of heat by the motion and mixing of "macroscopic" portions of a fluid (that is, the flow of a fluid past a solid boundary or fluid boundary). The term natural convection is used if this motion and mixing is caused by density variations resulting from temperature differences within the fluid. The term forced convection is used if this motion and mixing is caused by an outside force, such as a pump. The transfer of heat from a hot water radiator to a room is an example of heat transfer by natural convection. The transfer of heat from the surface of a heat exchanger to the bulk of a fluid being pumped through the heat exchanger is an example of forced convection. Heat transfer by convection is more difficult to analyze than heat transfer by conduction because no single property of the heat transfer medium, such as thermal conductivity, can be defined to describe the mechanism. Heat transfer by convection varies from situation to situation (upon the fluid flow conditions), and it is frequently coupled with the mode of fluid flow.(Chalida and Devahastin,2004) are study the effects of geometry and operating conditions on the mixing behavior of an in-line impinging stream mixer and they was performed a statistical analysis to indicate the best geometry of the mixer based on the data of both the mixing effectiveness and the pressure loss due to impingement of liquid streams. (Fayadh,2007) he study the numerical investigation into flow characteristics in mixing section of pipe junction and he found the effect of the side stream on mixing within the elbow is presented. Temperature, pressure, velocity and turbulence intensity were then compared for all these cases to show ifthe restrictions taken in this research will improve the mixing of hot and cold fluid in the assumed configuration or not. Comparisons can be made for different inlet temperature and velocity combinations. (Yuan et al 2010) are study features of impinging streams intensifying processes and their applications they found that impinging streams (IS) are classified into two categories: gas continuous impinging streams (GIS) and liquid-continuous impinging streams (LIS). They have individual and quite different features and thus are applicable for various occasions. All the features of IS, including GIS and LIS, have great effects on enhancing processes. One very important thing in application is that the target system has to be chosen properly according to the properties of both the specific IS and the target system.

Configuration And Fluid Properties

The geometry consists of walls, two velocity inlets, and a pressure outlet. The flow domain is shown in **Figure 1**.The water was chosen to be the referred fluid. The default properties provided in this paper accordingly represent water. Temperature dependence for material properties, including density, viscosity, specific heat, and thermal conductivity can be specified through the second order polynomial equation (Incropera,1996).

THEORY

The numerical simulation of fluid flow is achieved by solving incompressible, viscous (standard k-ε model)with three dimensional. In general, basic equations of fluid flow are known, therefore in the current paper we emphasized on the solution of the three-dimensional turbulent fluid flow and heat transfer in a mixing junction.

Transport Equation For The Standard K-E Model

The standard k-ε model is a semi-empirical model based on model transport equations for the turbulent kinetic energy (k) and its dissipation rate (ε) (Anderson,1990) *k* and ε are obtained from the following semi empirical transport equations, as equation (1&2) (Choudhury,1993):

$$div\left(\rho KV\right) = div\left\{\left(\mu_t / \sigma_k\right) gradk\right\} + 2\mu_t E_{ij} E_{ij} - \rho\varepsilon \quad (1)$$

$$div\left(\rho\varepsilon V\right) = div\left\{\left(\mu_t / \sigma_\varepsilon\right) grad\varepsilon\right\} + C_{1\varepsilon}\frac{\varepsilon}{k} 2\mu_t E_{ij} E_{ij} + C_{2\varepsilon}\rho\frac{\varepsilon^2}{k} \quad (2)$$

Modeling The Effective Viscosity

The “eddy" or turbulent viscosity, μ_t is computed by combining k and ε as $\mu_t = c_\mu \rho f_\mu k^2/\varepsilon$.

Model Constant

The standard turbulence model coefficients are as follows in **table 1**: (Tennekes, 1972)

Problem Description

The problem to be considered is shown schematically in **Figure 1.** A cold fluid at 20_C flows into the pipe through a x-coordinate inlet, and mixes with a warmer fluid at 40_C that enters through a z-coordinate inlet located at poly flow pipe. The pipe dimensions are in millimeters , and the fluid properties and boundary conditions are given in SI units. The Reynolds numbers for the flow at the inlets are (1000,2000,5000,10000) so a laminar and a turbulent flow will be happened. The turbulent intensity (I) can be found by equation **(3) (Fayadh, 2009)**:

$$\mathbf{I=0.16*Re^{-0.125}} \quad (3)$$

RESUULETS AND DISSCUTION

The Reynolds number at both inlets is calculated based on the specified boundary conditions and material properties. The change in Reynolds number of any mixing unit is considered effective if the fluid at the outlet is thermally mixed such that the temperature across the outlet approached uniformity. The assumed Reynolds numbers of the current mixing pipe were tested by this research using CFD to evaluate the mixing performance of each set of assumptions in the poly flow pipe.

Iterations and Residuals:

There are three indicators that convergence has been reached in **Figure 2** for varies Reynolds number:

• The residuals have decreased to a sufficient degree. The solution has converged when the convergence criterion for each variable has been reached. The default criterion is that each residual will be reduced to a value of less than 10−3, except the energy residual, for which the default criterion is 10−6.

• The solution no longer changes with more iterations. Sometimes the residuals may not fall below the convergence criterion set in the case setup. However, monitoring the representative flow variables through iterations may show that the residuals have stagnated and do not change with further iterations. This could also be considered as convergence.

• The overall mass, momentum, energy, and scalar balances are obtained.

Velocity Distribution:

It can be seen from the **Figures 3** and **4**, that the highest velocity is distributed in the region that has the dimensions from (0 to -0.003) for the outlet y (region of red color). The lowest velocity distribution is in the region that has the dimensions from (0 to 0.003)for the outlet (region of blue color). With the mixture of the cold water coming from the inlet x pipe and the hot water coming from the inlet z pipe, the velocity distribution develops gradually. In order to examine this result, the velocity distribution was plotted in the outlet of the large pipe as shown below in **Figure 3**. It shows that the velocity change is more clearly due to changing in Reynolds numbers**.**

Temperature Distribution

The temperature distributions shows much of what can be expected from the velocity distributions as explained above. There is also no heat transfer assumed from the system presented in these results. The results of temperature data are presented in **Figures 5** and **6** shows the effects of the change of the Reynolds numbers from the hot and cold pipe on the mixing process. Because of the equal the velocity of the hot pipe and cold pipe, there are a definite high temperature zone, low temperature zone and a small transition area. According to what are shown above, it could be seen that as the velocity profile begins to become more magnitude and uniform, the transition area will begin to grow until the entire fluid exiting the system . In the small Reynolds numbers, this transition area appears to shrink lead to a longer distance before the transition area spreads to even out the temperature distribution. **Figures 5** and **6** shows the large Reynolds numbers causes, this phenomenon reverses and increases the transition zone between the two fluids. This could be as a result of the change in magnitude of the velocity of the cold fluid and hot fluid, as mentioned above in the velocity discussion. This allowed the cold fluid to mix more efficiently with the hot fluid and that leads to increase the transition zone and decrease the hot fluid zone.

Dynamic Head

In the **Figure 7** which shows the contours of the dynamic head (equal to $\rho V^2/2$) for different values of Reynolds numbers that the distribution of the pressure is similar to all effects of velocity profile and absolutely different in the values because of different in the values of the Reynolds numbers which effects on the velocity of the hot and cold flow. So the loses in the dynamic head becomes more with increase of the values of the Reynolds numbers.

CONCOLUSION

In our study the results refer to some points that must take in our future work which are:

1. ANSYS FLUENT, it is good practice to use your first-order solution as a starting guess for a calculation that uses a higher-order discretization scheme and, optionally, an adapted mesh.
2. In this problem, the flow field is decoupled from temperature, since all properties are constant. For such cases, it is more efficient to compute the flow-field solution first (i.e. without solving the energy equation) and then solve for energy (i.e., without solving the flow equations).

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Table 1. The standard turbulence model coefficients

Coef.	σ_k	σ_ε	$C_{1\varepsilon}$	$C_{2\varepsilon}$	C_μ
value	1.0	1.30	1.44	1.92	0.09

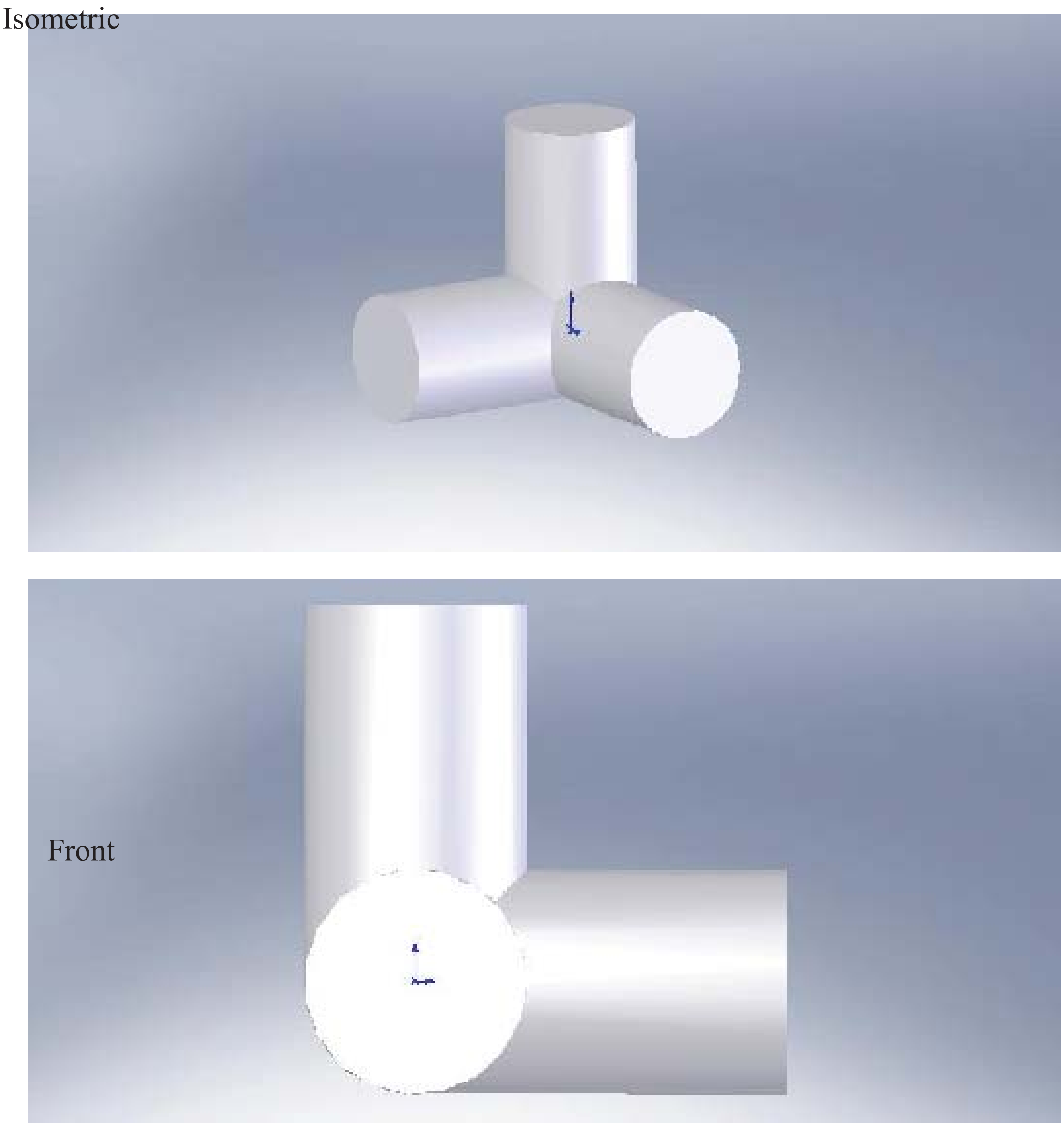
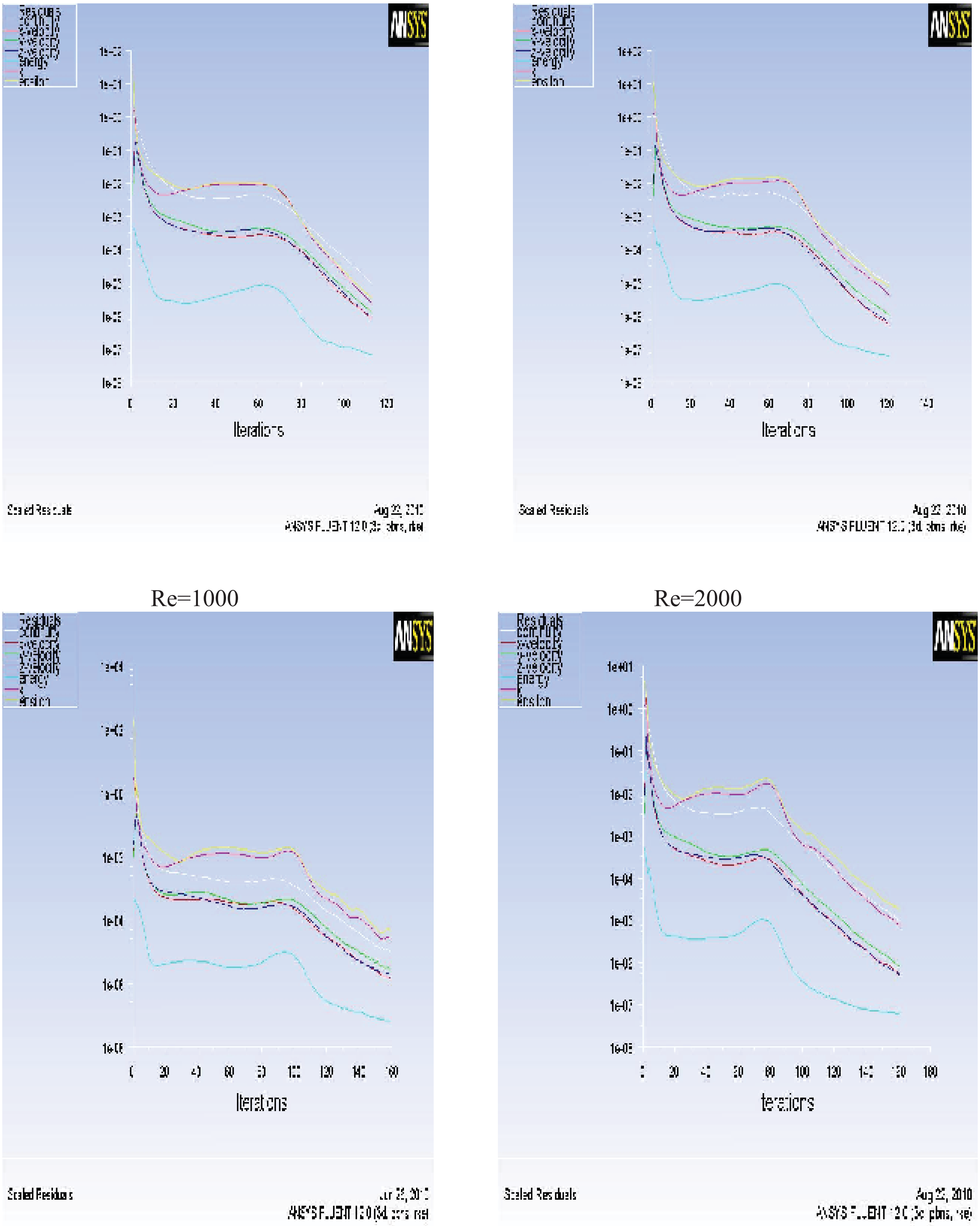


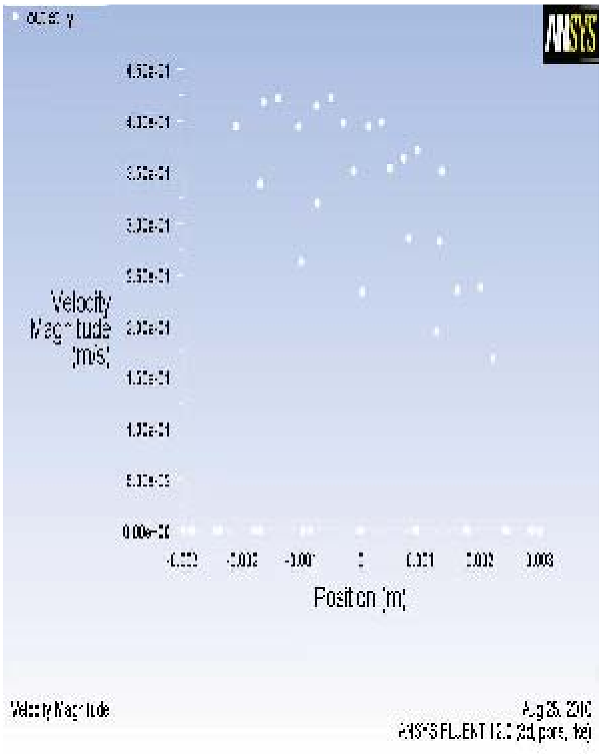
Figure (1). Configuration of poly flow pipe.



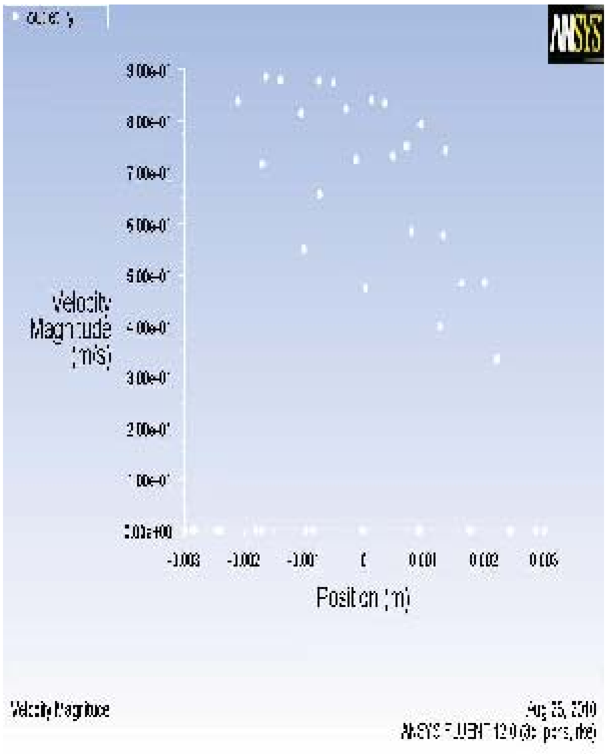
Re=1000 Re=2000

Re=5000 Re=10000

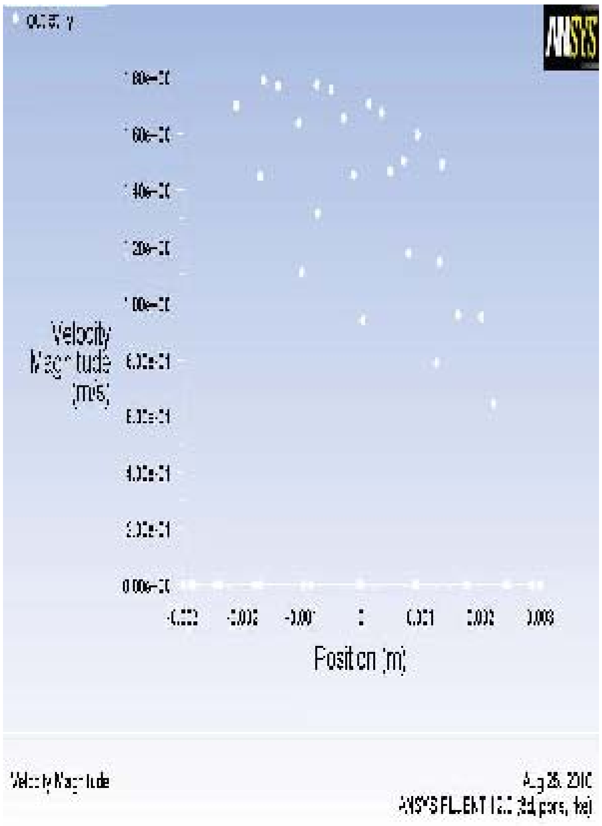
Figure (2) scaled residuals for different Reynolds numbers.



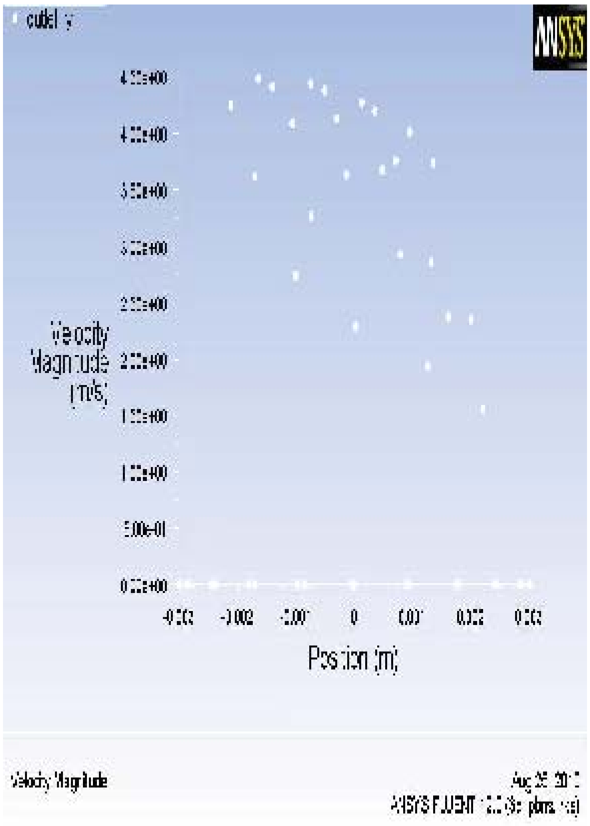
Re=1000



Re=2000



Re=5000



Re=10000

Figure (3) . Velocity magnitude for outlet.

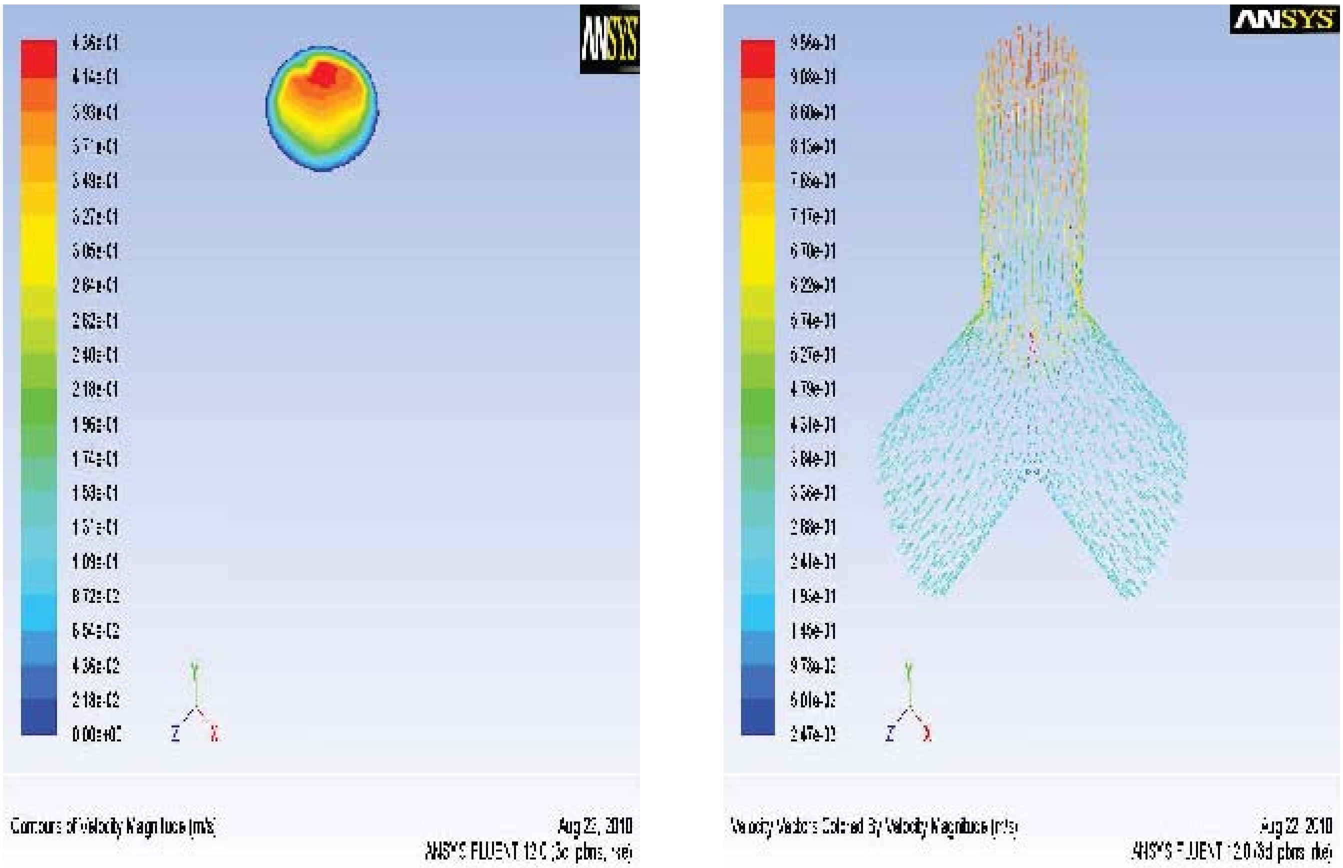
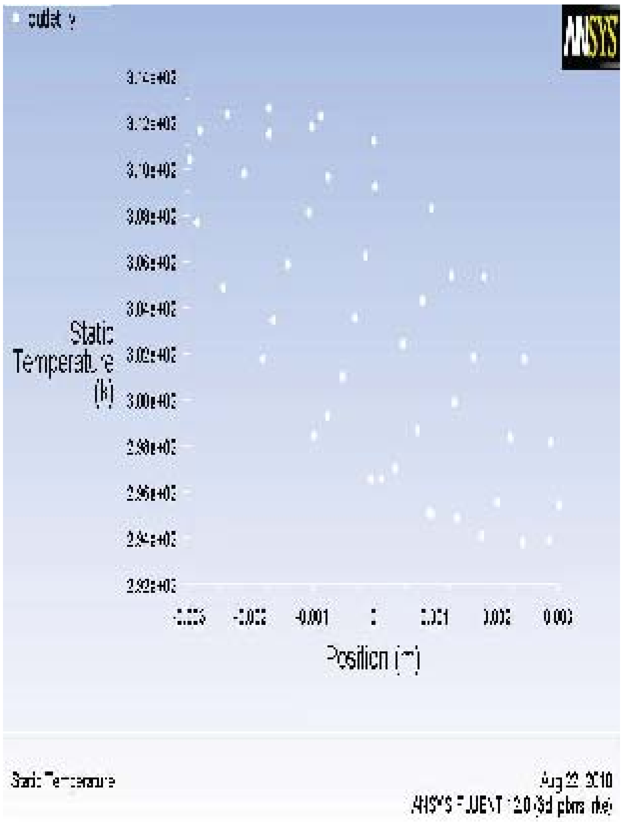
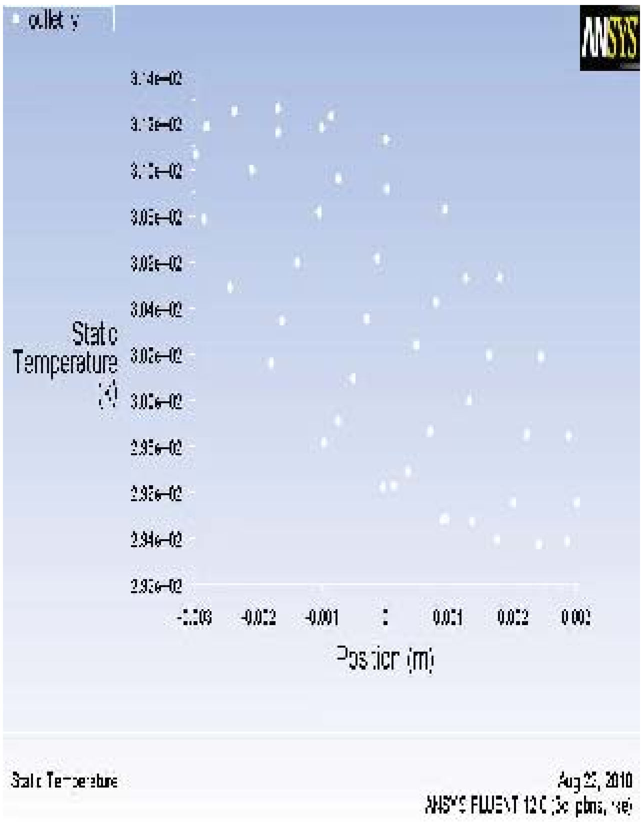


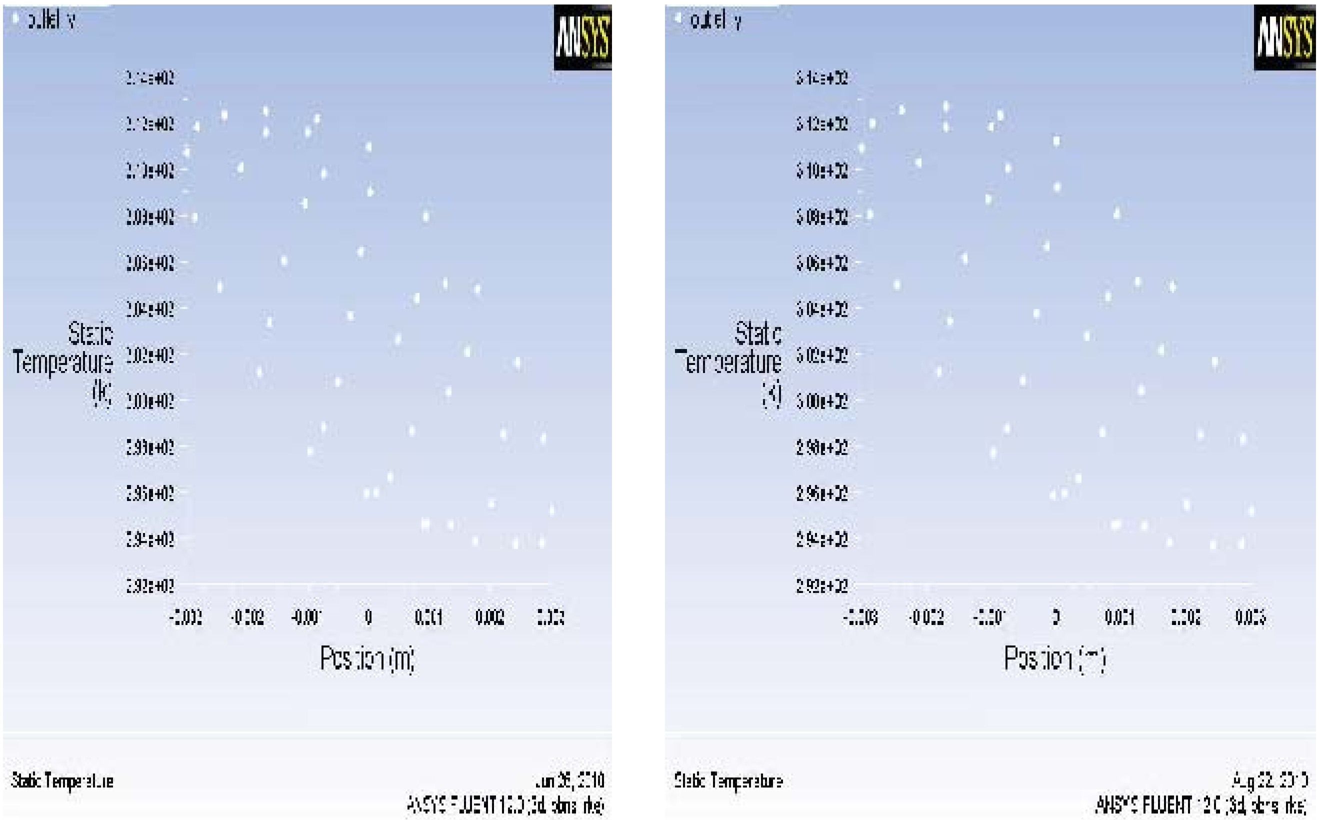
Figure (4). Contours of velocity magnitude and vector for outlet (Re=1000).



Re=1000



Re=2000



Re=5000 Re=10000

Figure (5). Static temperature for the outlet

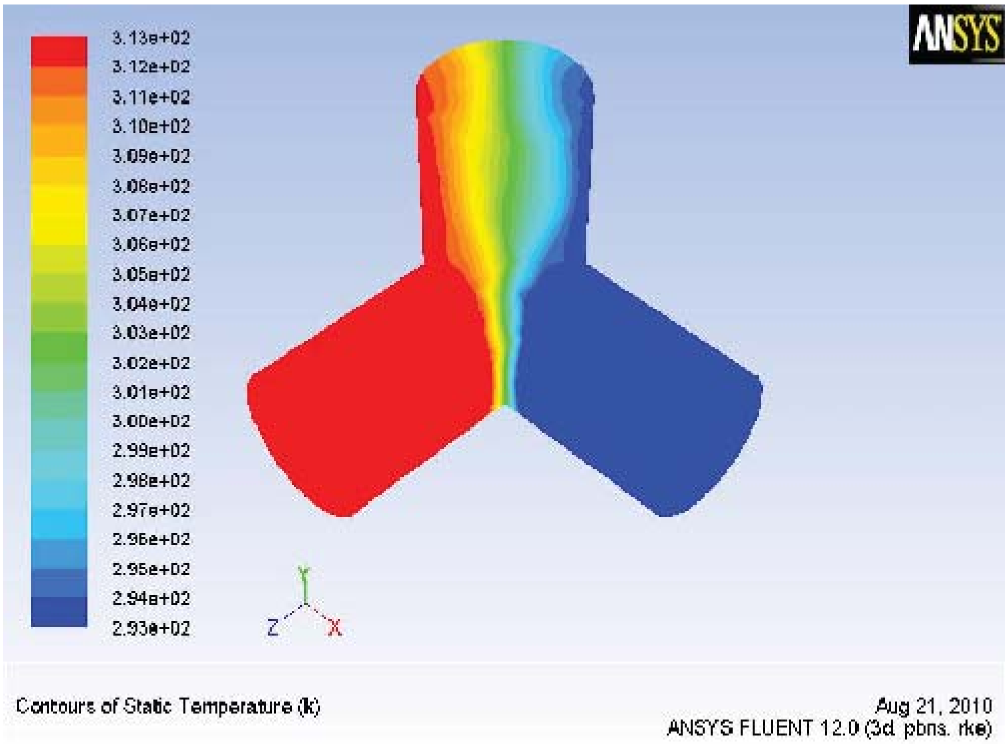
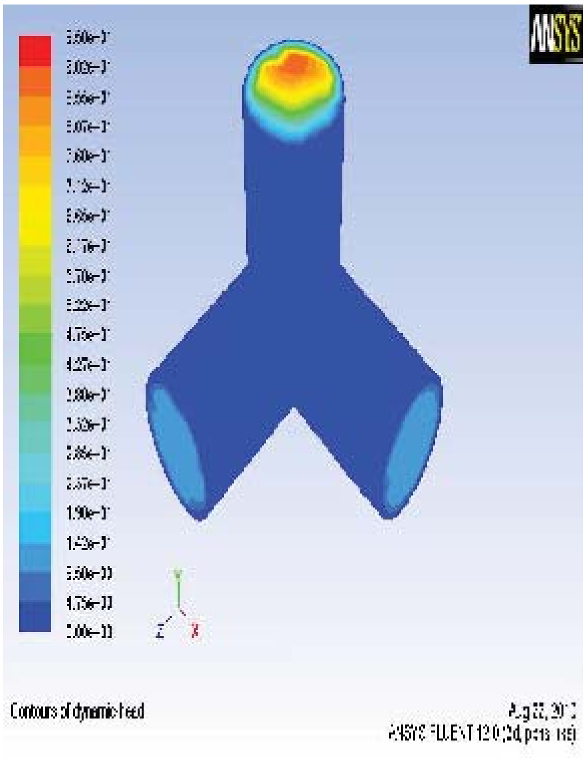
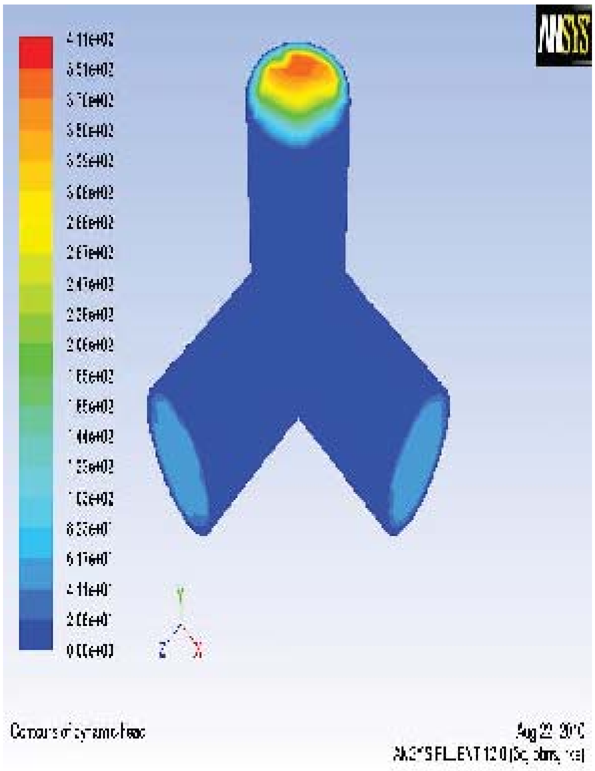
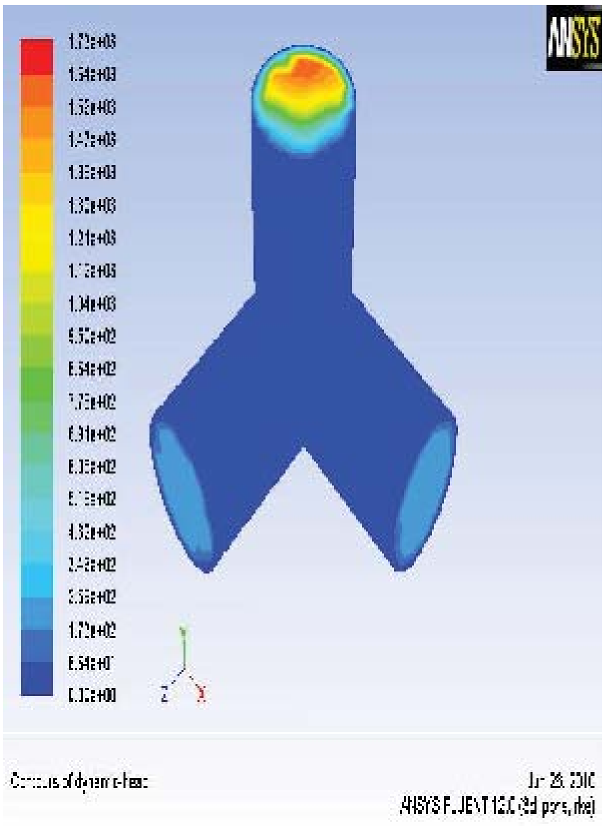


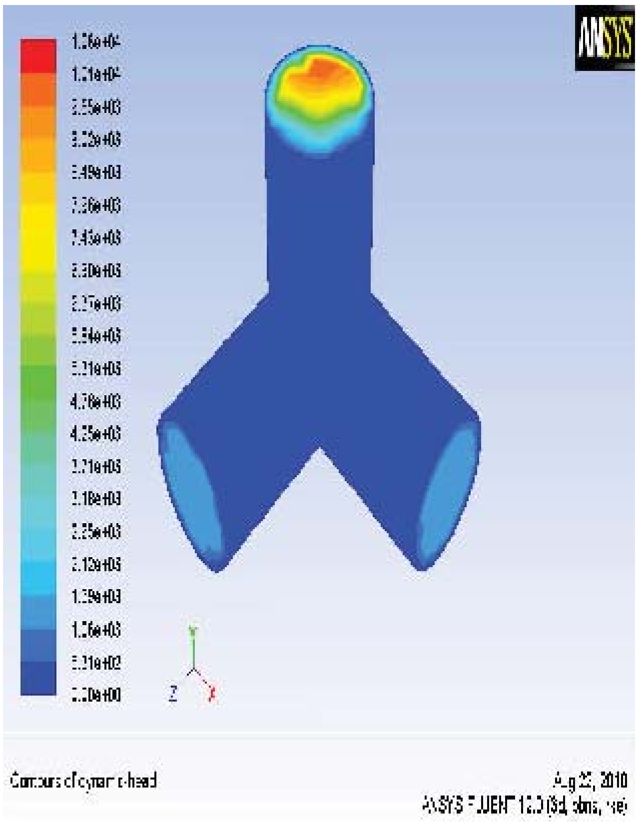
Figure (6). Contours of static temperature for the body (Re=10000).





Re=2000





Re=5000

Re=10000

Figure (7). Contours of dynamic head for the poly flow pipe