CH20B012 Anish Anand Pophale

AM23S076 Omkar Mahesh Halyali

AM5640 Assignment 2

Boundary Conditions:

- The converged value of u_star which is the wall friction velocity from RSM is **0.873**.
- The y^+ of the first node away from the wall is **51.726** (Lies in the log law region, y^+ between 30 and 100). After the first node, a uniform mesh is used in the remaining domain.
- At the first node away from the wall, wall functions have been used which is a high Reynolds number formulation. For the u momentum equation, the wall shear stress is added to the source term for the first node away from the wall.
- At the wall, the velocity and Reynolds stresses are set to zero and Neumann condition is used for epsilon.
- At the channel center line, Neumann BC is used for all variables except the Reynolds shear stress uv. For uv, we have used a Dirichlet BC as uv = 0, based on the DNS data.
- For the initial conditions, we have interpolated results of the k ω model from Assignment 1.

U velocity:

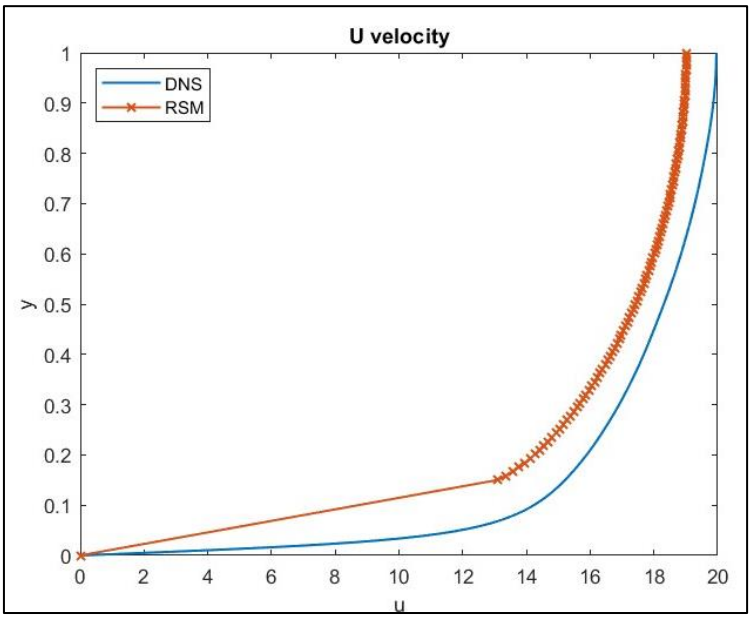

Fig 1: Comparison of u velocity for Reynolds Stress Model and DNS Data

- For all of the variables, we do not model the near wall region as we are using wall functions.
- Only the region from $y^+ > 51.726$ ($y > 0.15$) is modelled and hence we compare the results only for $y > 0.15$ for all variables.
- The trend of the u velocity from the RSM is similar to that of the DNS data but the values are a bit underpredicted.

u2 Reynolds Stress:

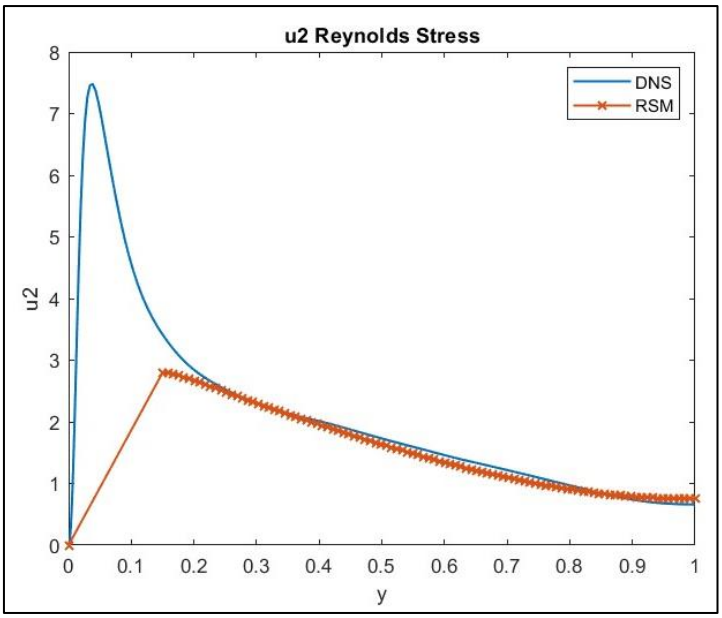

Fig 2: Comparison of u2 Reynolds Stress for RSM and DNS Data

- For u2, the results match with the DNS data.
- The value of u2 has a peak in the buffer region, but as we are not modelling any of the near wall regions below the log law region, this behaviour is not captured in the RSM.

v2 Reynolds Stress:

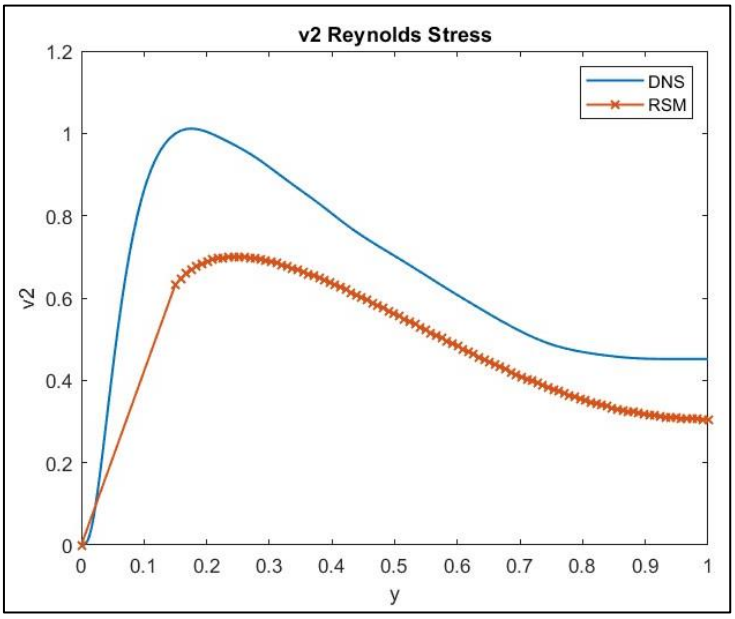

Fig 3: Comparison of v2 Reynolds Stress for RSM and DNS Data

- For the v2 Reynold stress, the values from the RSM are lower than the DNS data.
- But the variation of v2 with y is similar to the DNS data.

w2 Reynolds Stress:

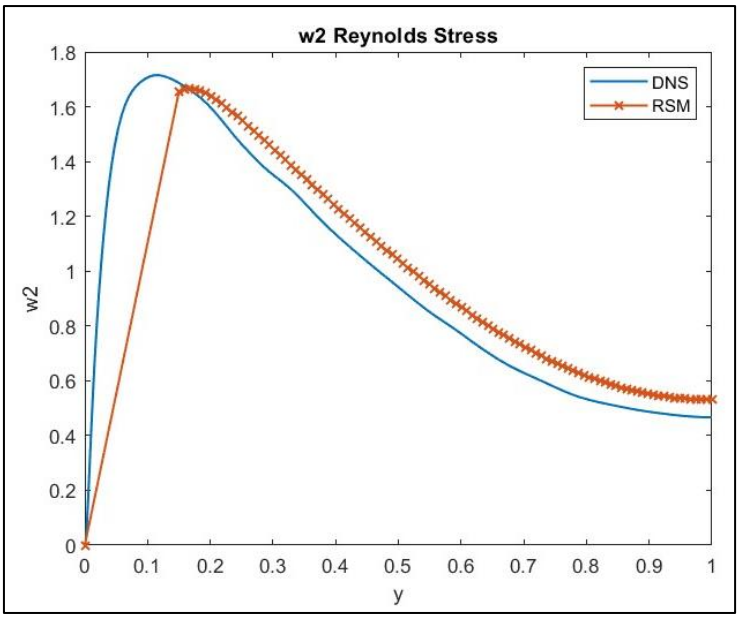

Fig 4: Comparison of w2 Reynolds Stress for RSM and DNS Data

- The values of w2 from the RSM model are slightly larger than the DNS data, but the trend in values is same
- From the above 3 plots for the normal Reynolds stresses, we can see that the RSM captures the anisotropy of these turbulence quantities.

-uv Reynolds Shear Stress:

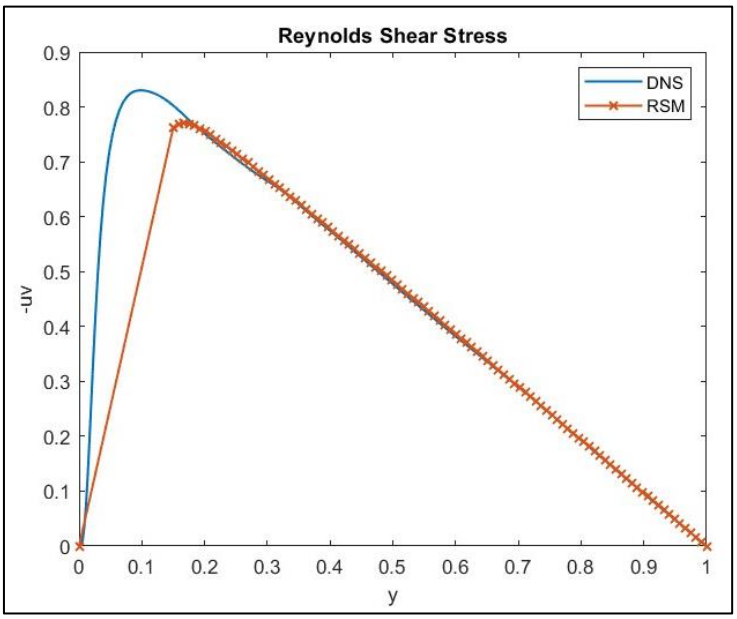

Fig 5: Comparison of -uv Reynolds Stress for RSM and DNS Data

- The RSM values match well with the DNS data for the region of $y^+ > 50$ or $y > 0.15$.

Turbulence Kinetic Energy:

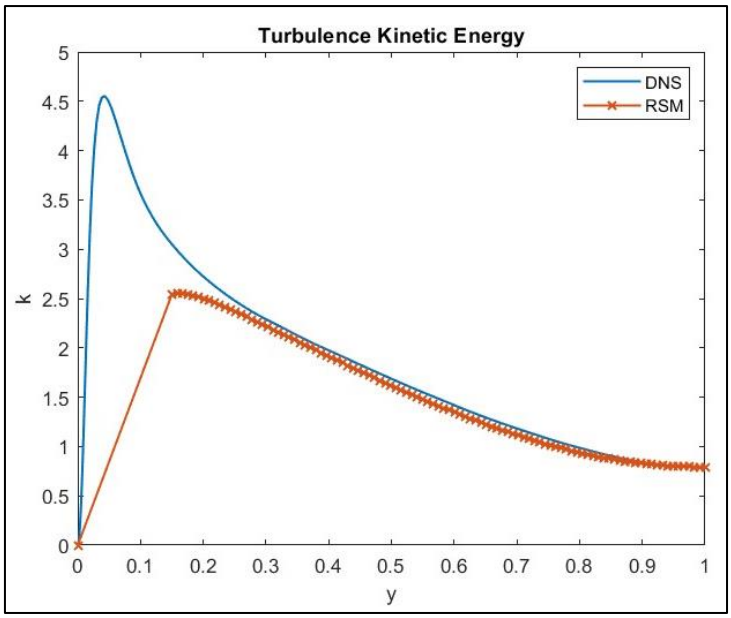

Fig 6: Comparison of TKE for RSM and DNS Data

- The data from the RSM matches well with the DNS data.
- Again, the TKE has maximum production in the buffer layer, but as we are not modelling that region with the wall functions, the near wall behaviour is not captured in the RSM.

Dissipation Rate of TKE (Epsilon):

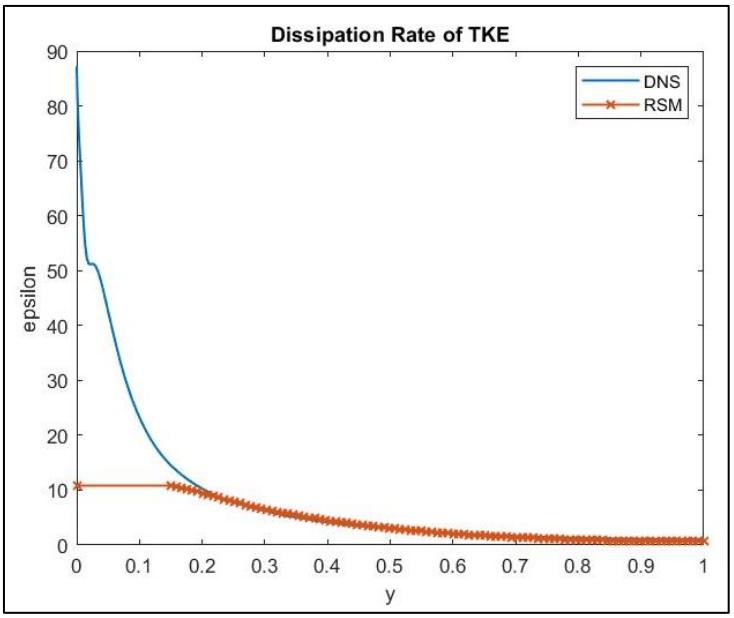

Fig 7: Comparison of Epsilon for RSM and DNS Data

- The dissipation rate of TKE also matches with the DNS data.
- Here also the near wall region where epsilon goes to a maximum value is not captured in the high Reynolds number formulation using wall functions.

Comparison of velocity profile with log law:

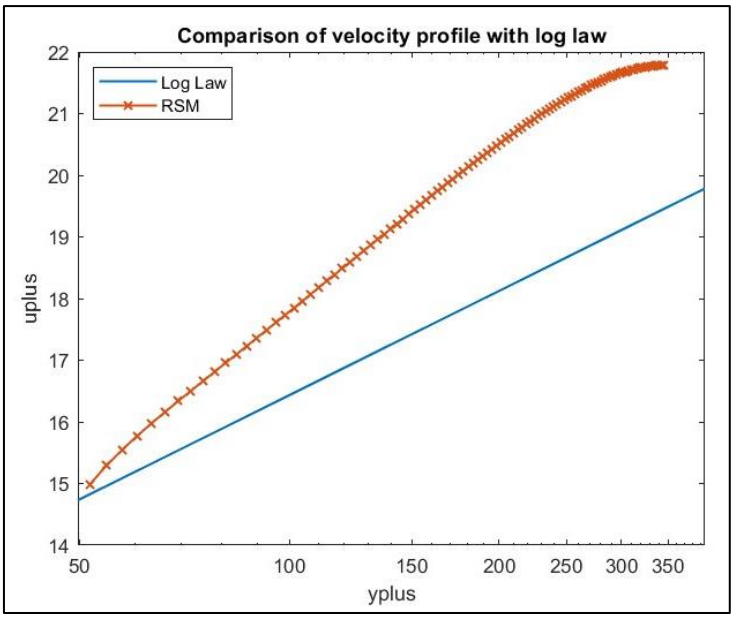

Fig 8: Comparison of velocity profile with log law

- The log law is plotted from y^+ 50 will the end of the channel.
- The RSM data for u^+ vs y^+ shows a linear variation in the log scale plot, hence it does show a logarithmic variation.
- Comparing the RSM and DNS data, the intercept of the lines is close to each other but the slope of the log law is less than that of the RSM data.

We also simulated the given flow in Ansys using the Low Reynolds number formulation of the RSM (Enhanced Wall Treatment in Ansys) to compare how well it captures the near wall variation which is not modelled using the MATLAB code which uses wall function.

For the Ansys simulation, we use a 2D domain with the entire channel including the 2 walls and apply a periodic boundary condition for the left and right boundaries of the domain.

We have used 194 nodes along with a stretching factor making the nodes finer towards the wall to discretize the domain so that there are sufficient number of nodes close to the wall

Following are the plots comparing the Low Reynolds number RSM with the given DNS data:

U velocity:

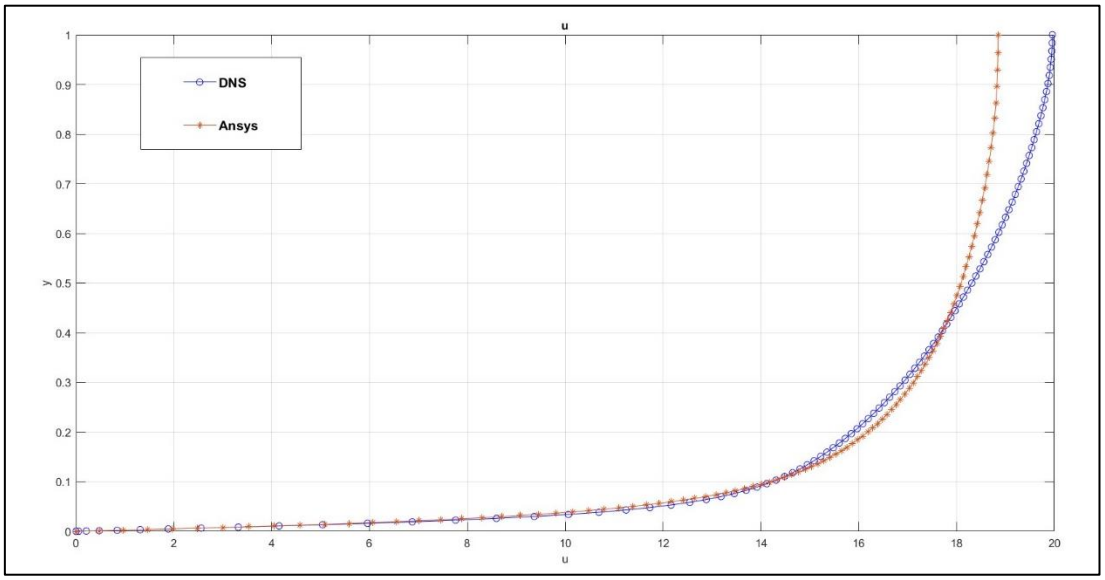

Fig 9: Comparison u velocity profiles

u2 Reynolds Stress:

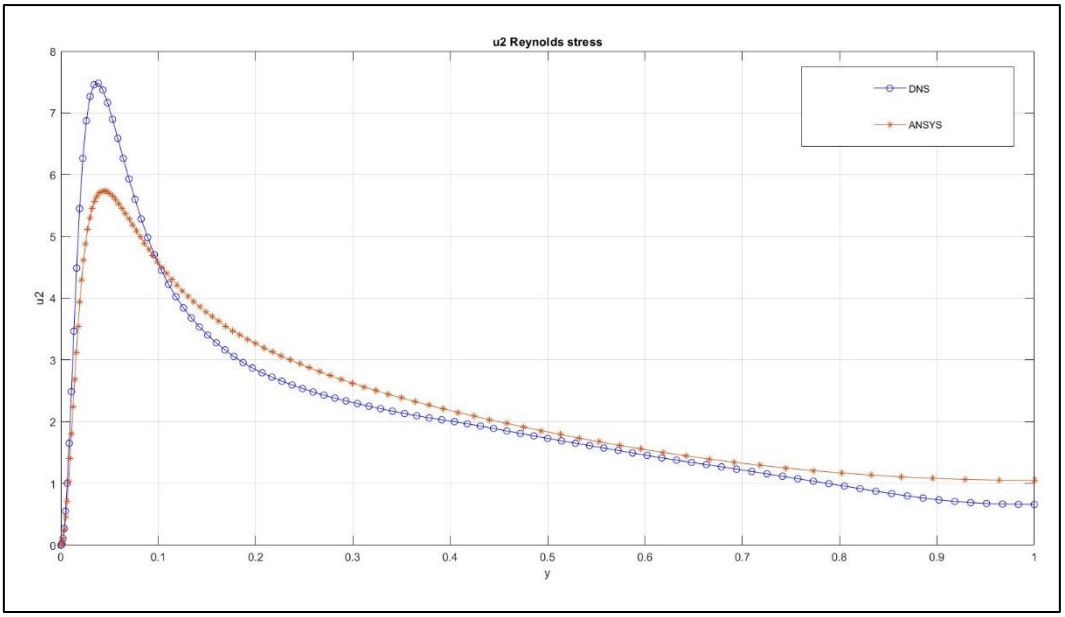

Fig 10: Comparison u2 Reynolds Stress profiles

v2 Reynolds Stress:

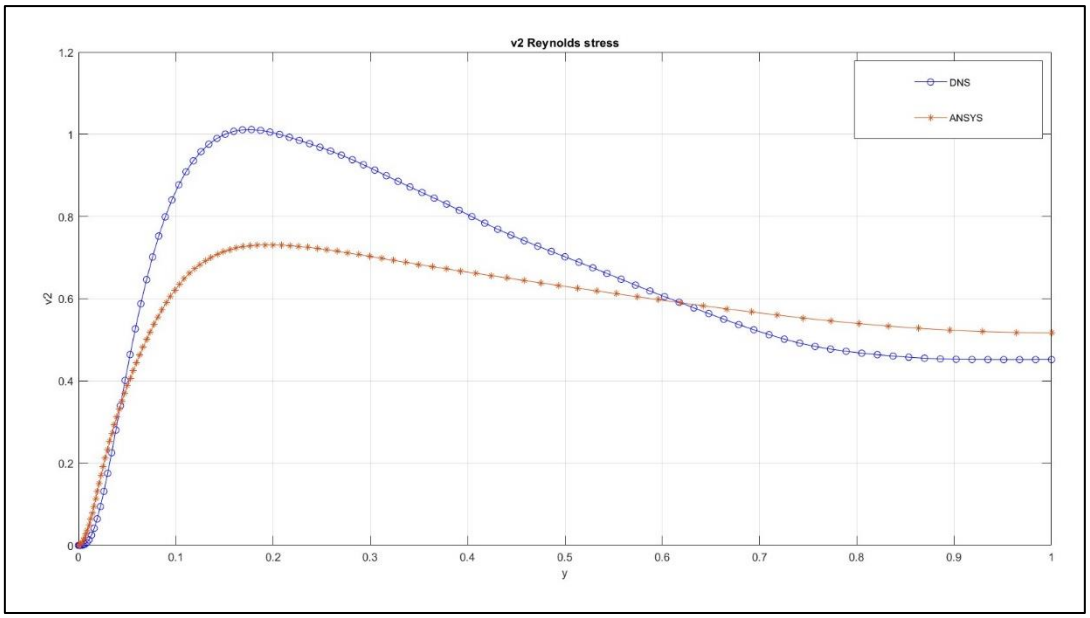

Fig 11: Comparison of v2 stress profiles

w2 Reynolds Stress:

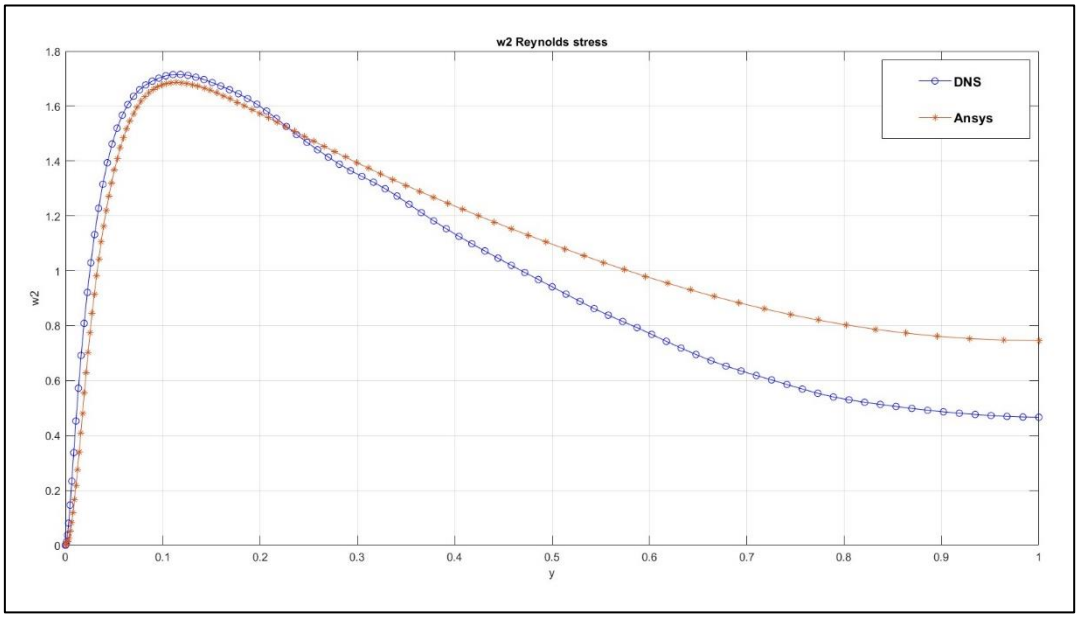

Fig 12: Comparison of w2 stress profiles

-uv Reynolds Shear Stress:

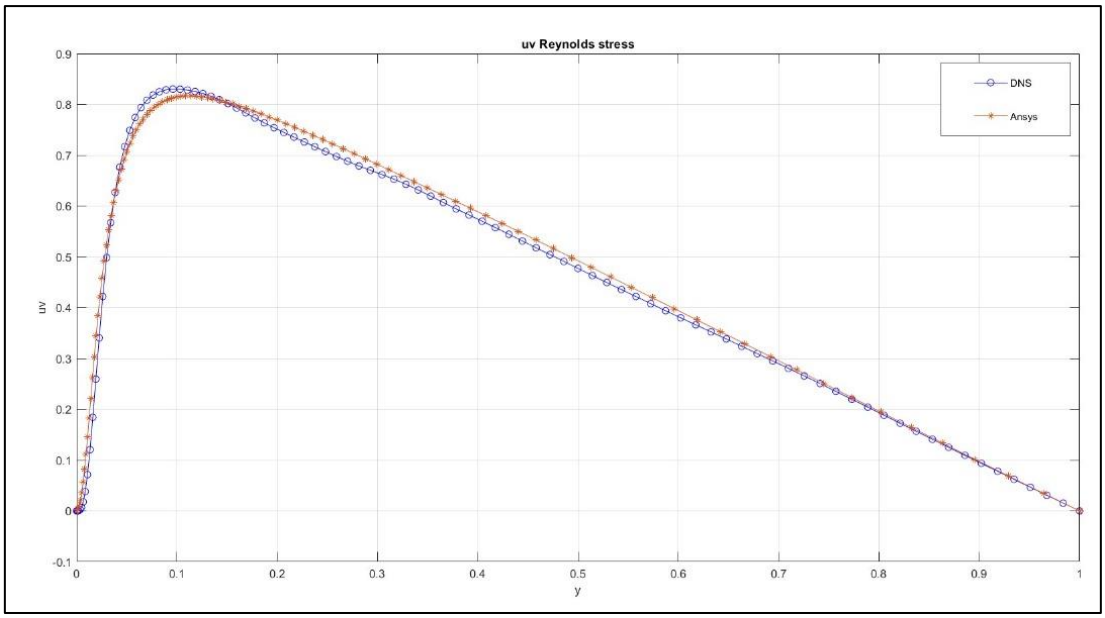

Fig 13: Comparison of -uv stress profiles

Turbulence Kinetic Energy:

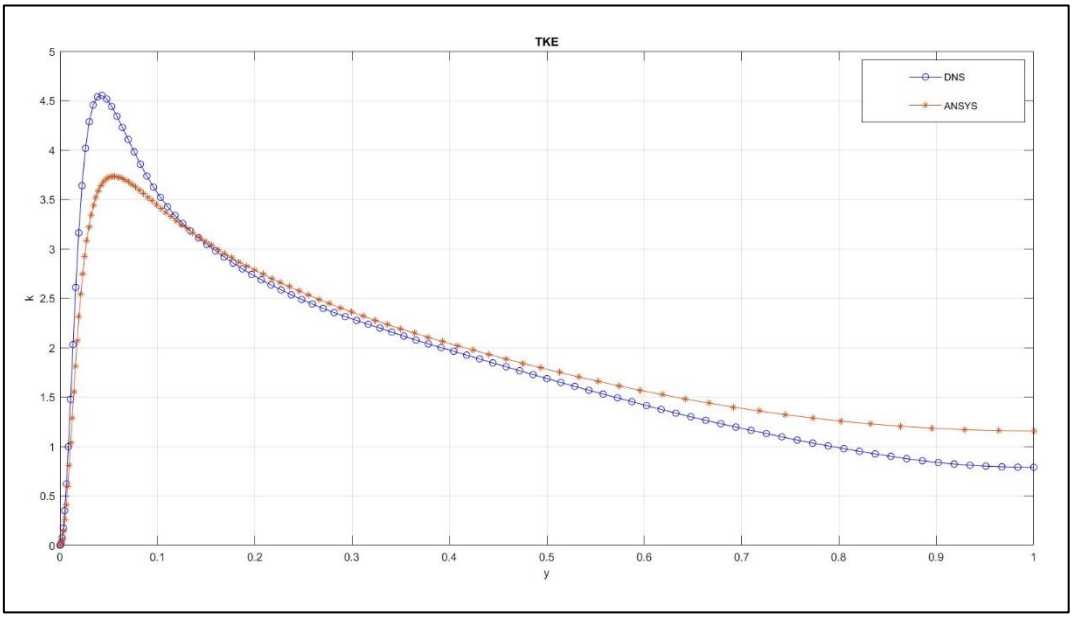

Fig 14: Comparison of Turbulence Kinetic energy profiles

Dissipation Rate of TKE (Epsilon):

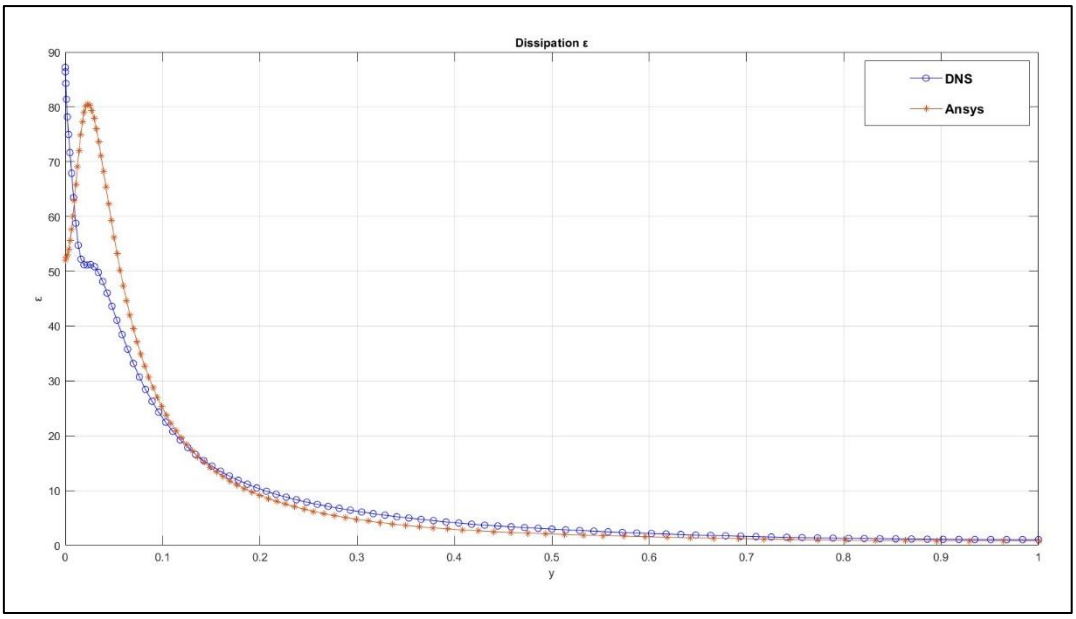

Fig 15: Comparison of Epsilon profiles