Calculation of Aerodynamic Driving Moment and Wind Loads on Parabolic Reflector under Varied Wind (ANSYS CFX 10.0 Software Package)

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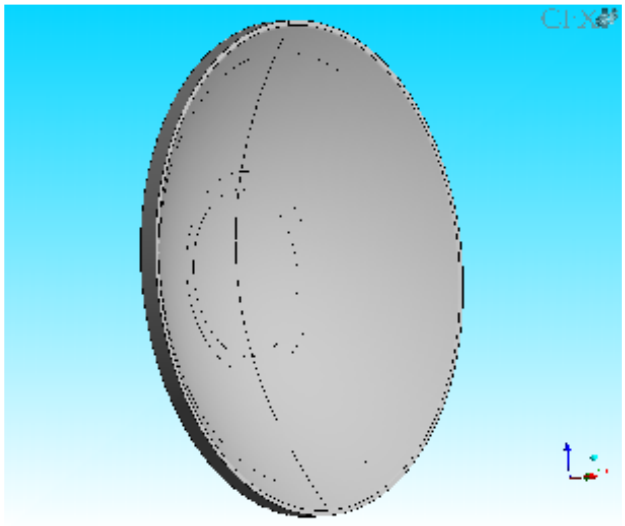
Problem description

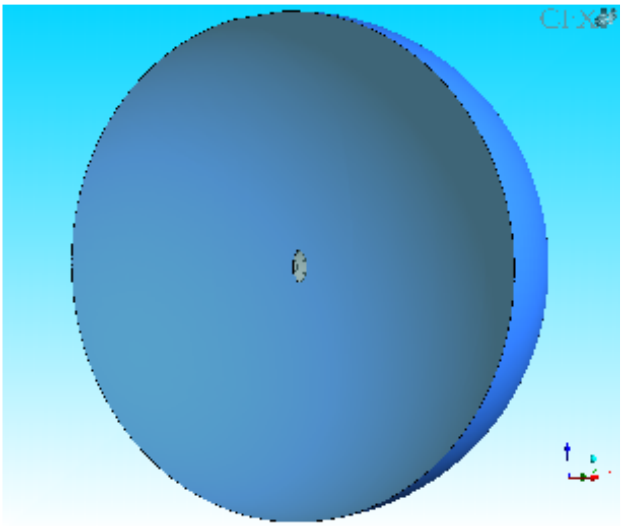
We handle a problem of numerical simulation of viscous flow and wind loads calculation for parabolic antenna reflector under varied wind.

The reflector diameter is equal 3.775 m, the wind velocity is 35 m/s, the wind direction is varied from 0° to 180° with the increment equal 20°. The reflector CAD-model and computational domain are depicted in the Figures 1a and 1b.

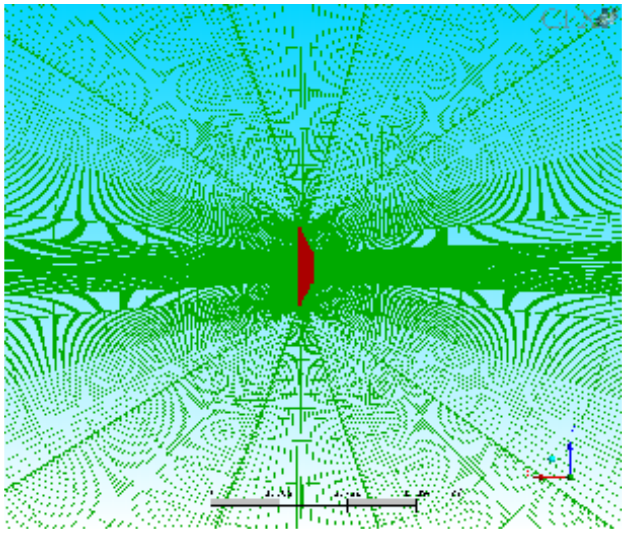
Numerical calculations were carried out in ANSYS CFX 10.0 program on Intel Pentium 4 CPU 2.00 GHz personal computer with 2 GB of operative memory. Hexahedral volume mesh with prismatic boundary layers (553 000 nodes) was generated in the ANSYS ICEM CFD 10.0 program pocket (Hexa module). Fragments of computational mesh at the symmetry plane and at the reflector surface are represented in Figures 1c – 1f.

For solving three-dimensional Navier-Stokes equations describing compressible viscous turbulent flows the finite volume method, node centered high-resolution scheme for convective and viscous parts and *SST (Shear-Stress-Transport) k-ω* turbulence model for separated flows modeling were used. To obtain steady-state convergent solution for one flow regime (wind velocity and wind direction are fixed) 100 – 150 iterations were required, this corresponds 5 – 7 hours of personal computer working.

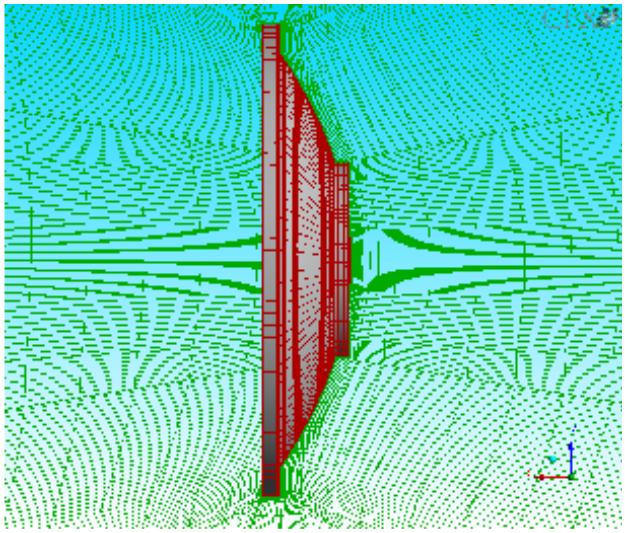




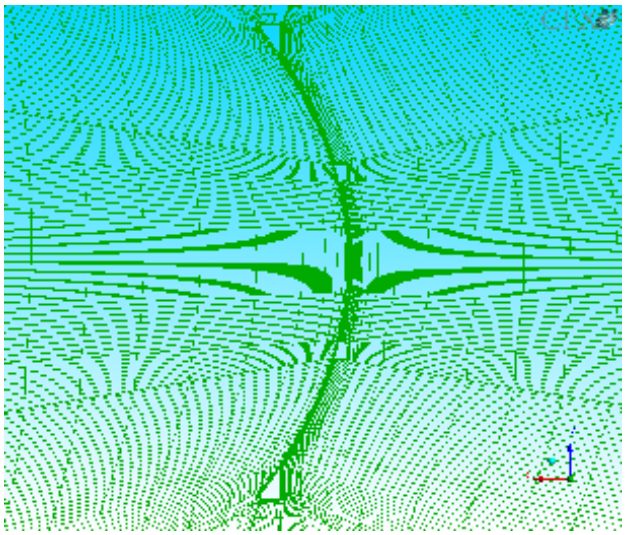
a) CAD-model of the reflector



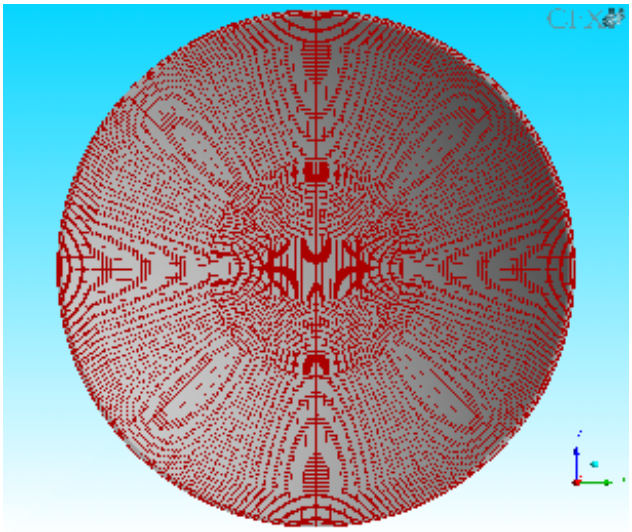
b) Computational domain



c) Computational mesh at the symmetry plane



d) Mesh fragment at symmetry plane and at the reflector surface (side view)



e) Mesh fragment at the symmetry plane

f) Mesh fragment at the reflector surface (front view)

Figure 1. CAD-model and computational mesh fragments

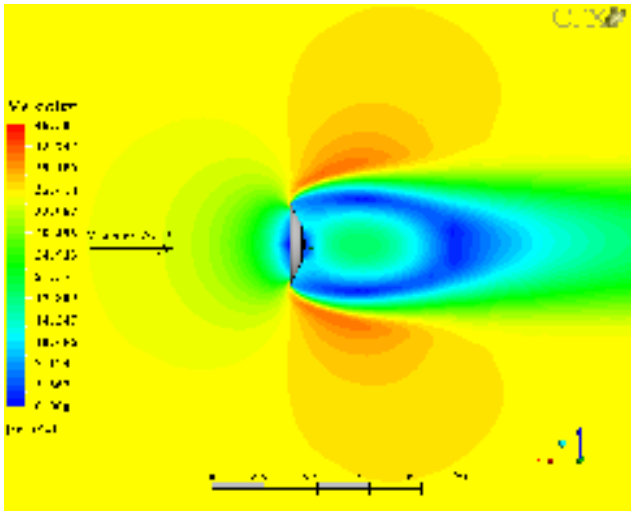
Computational results

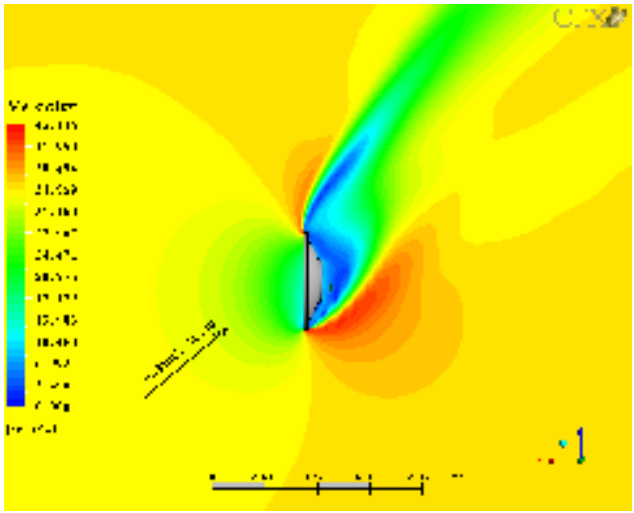
Numerical results for velocity and turbulent kinetic energy fields and streamlines at the vertical symmetry plane are presented in the Figure 2 for various wind directions; Reynolds number is equal $Re=8\cdot10^6$.

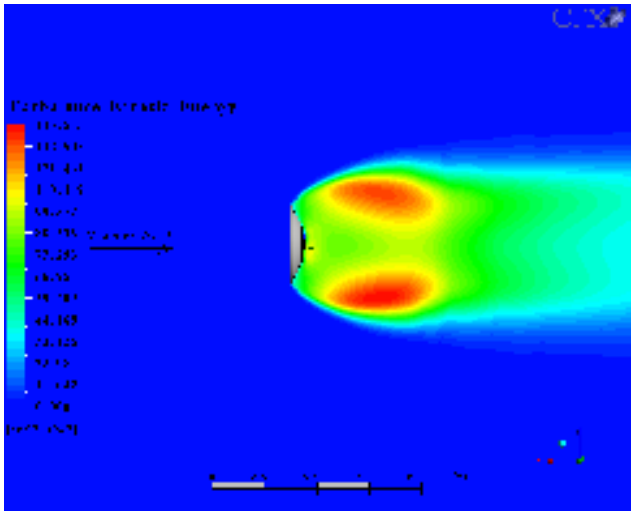
The reflector is a good example of the bluff body, when in the down stream from the configuration sizable zone of separation is formed. This phenomenon is provided of turbulent boundary layer separation from sharp or blunt edges and characterized by small velocity values (“dead” zone) and high density of turbulence kinetic energy in the separation zones.

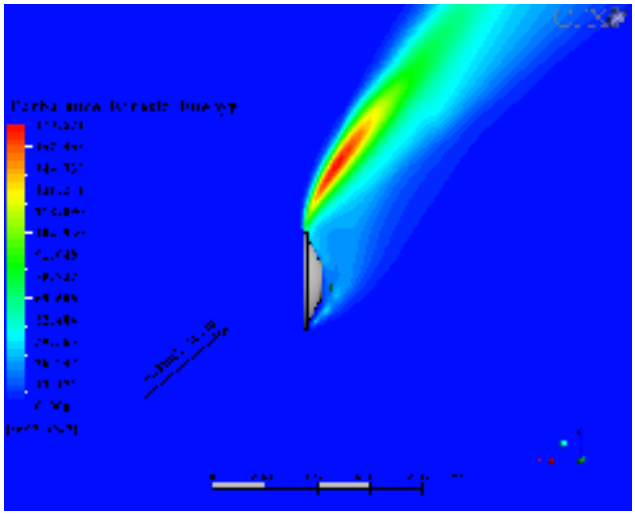
Wind direction

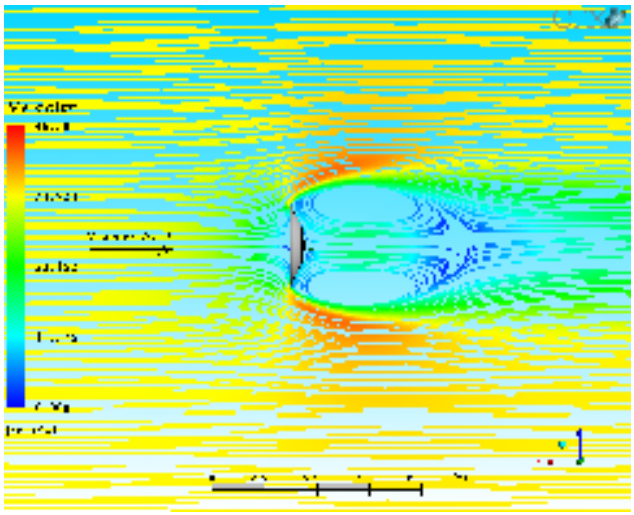
0 **40°**

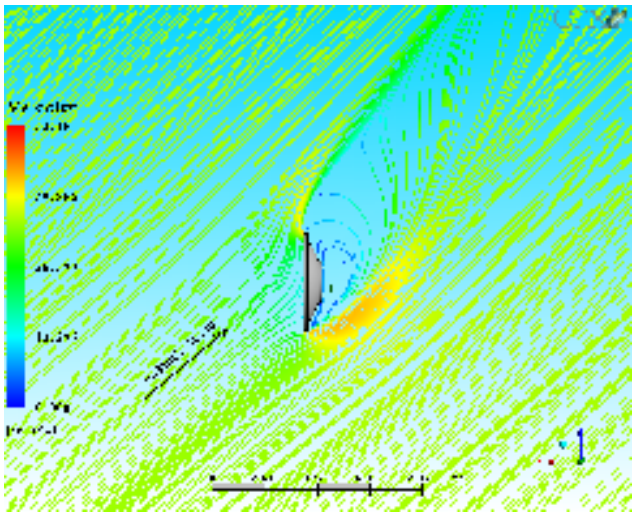




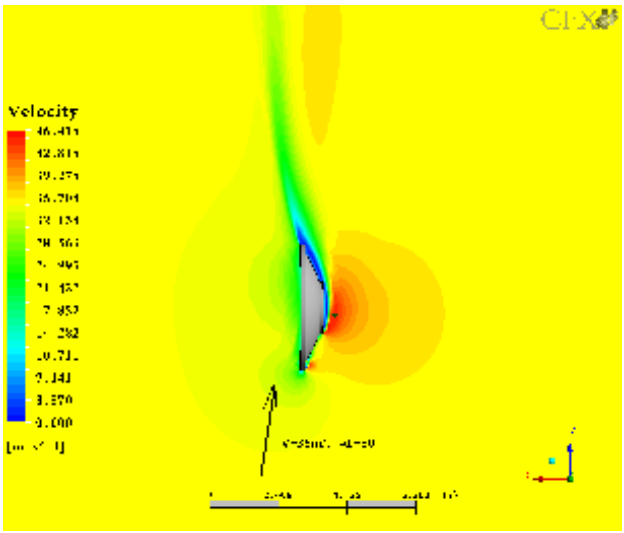


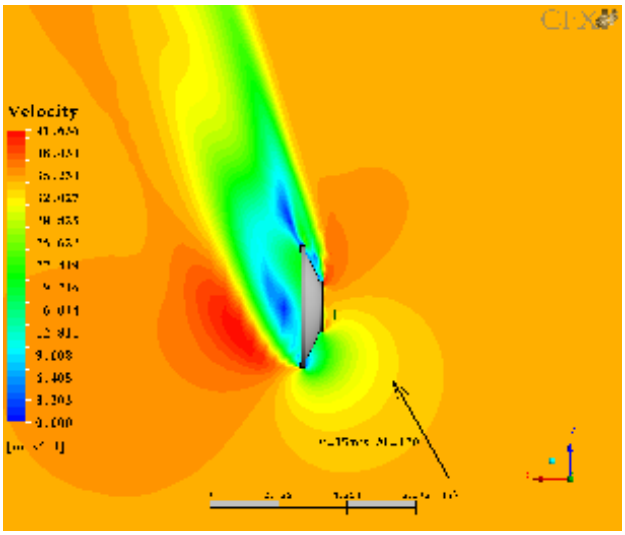


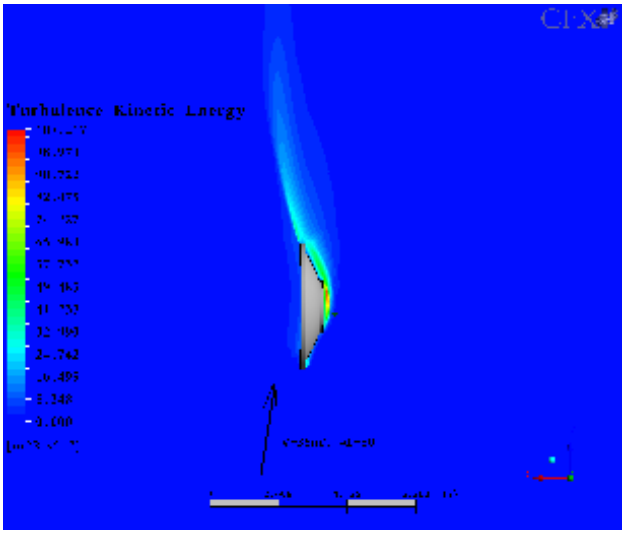


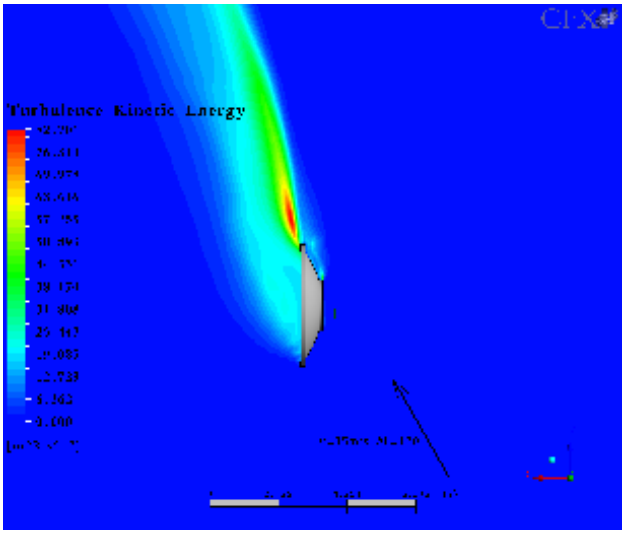


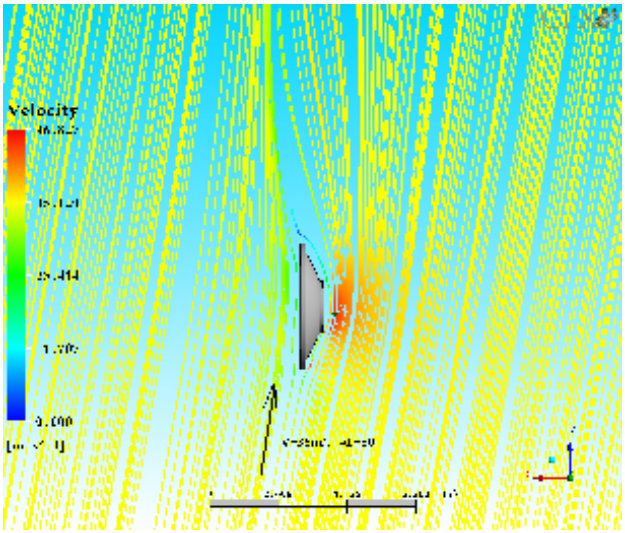
80° **120°**

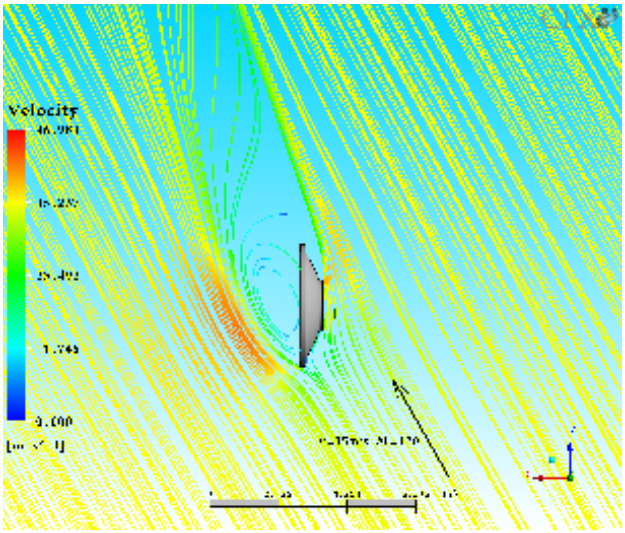

Velocity


Velocity


Turbulence Kinetic Energy


Turbulence Kinetic Energy


Velocity


Velocity

160° **180°**

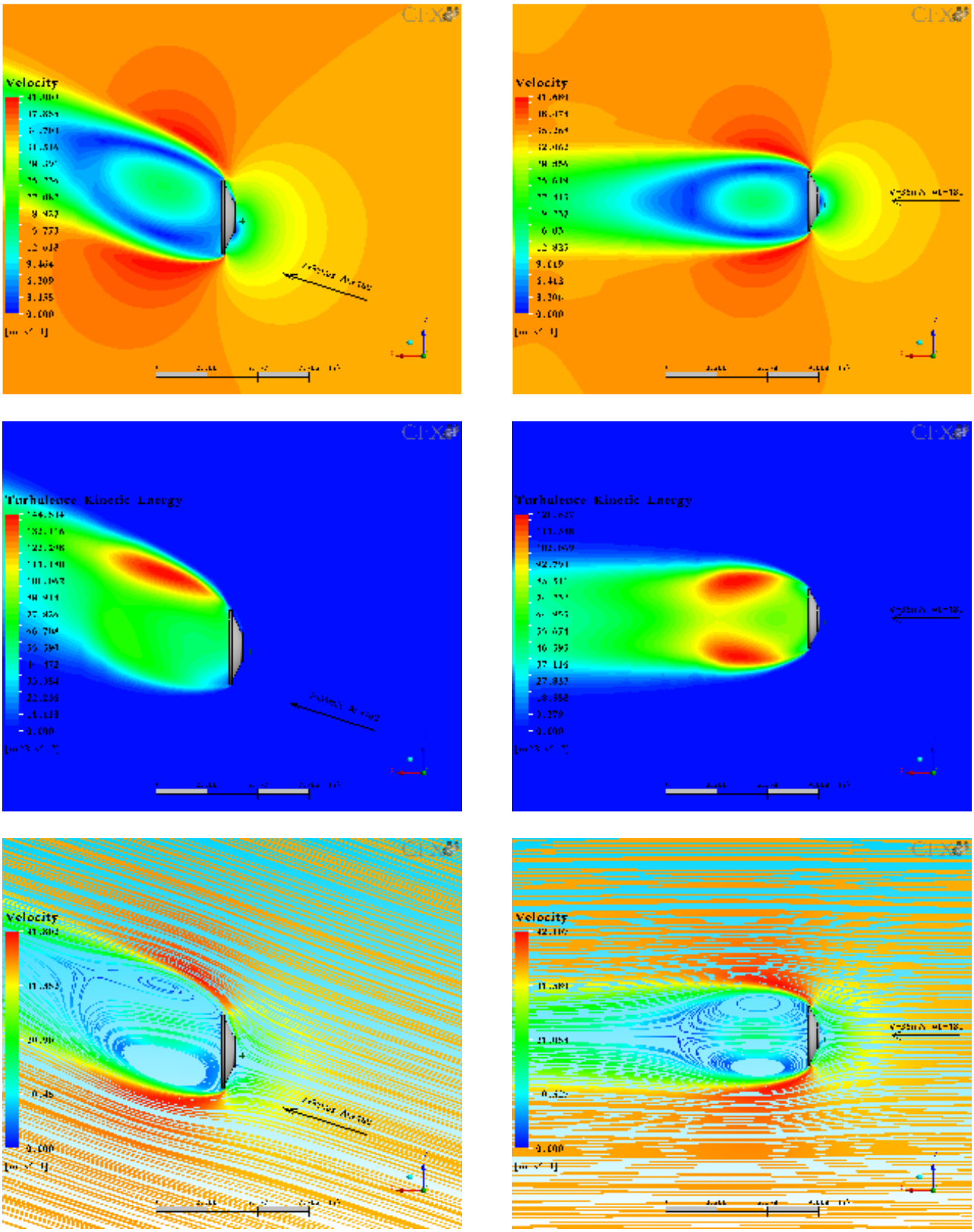


Figure 2. Velocity, turbulence kinetic energy distributions and streamlines at the vertical symmetry plane; wind direction is denoted by black needle

On the base of calculations of distributed gas dynamics characteristics (surface pressure, skin friction) integral wind loads (lift, drag) and driving moment coefficients were determined (see Figure 3).

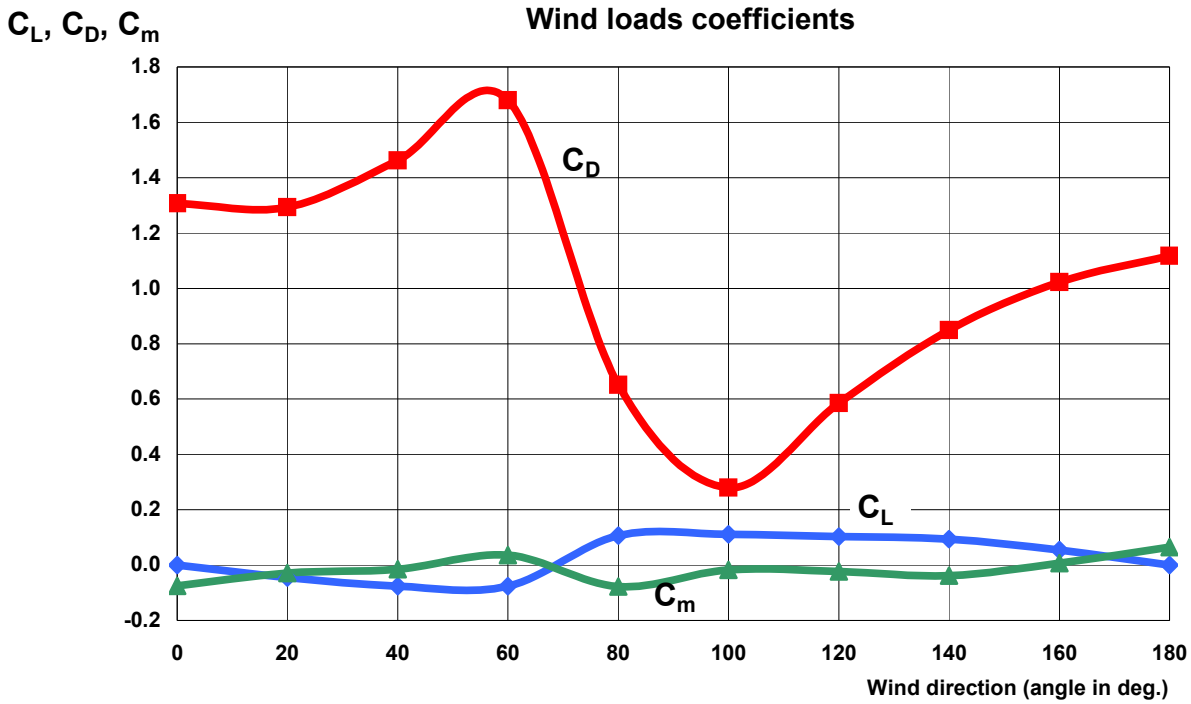


Figure 3. Wind loads coefficients C_L, C_D, C_m vary with the wind direction

Analysis of results and conclusions

ANSYS CFX 10.0 calculations of aerodynamic wind loads acting on parabolic antenna reflector under the wind flow with the velocity 35 m/s and the wind direction angle varied from 0° to 180° have shown good accuracy CFX program as gas dynamic CFD package and have allowed to reflect main features of separated turbulent flow around bluff body and to determine aerodynamics forces and moments coefficients.

Numerical simulation of wind flow around the reflector in two cases – “front” wind (0°) and “rear” wind (180°) – has shown that in the first case drag coefficient is equal to C_D=1.31 and in the second case C_D=1.12. The reflector concavity results in “sail effect” and the maximum drag is registered at the wind direction angle equal to 55°- 60° (C_D=1.68), the minimum drag coefficient (C_D=0.28) is registered at the wind angle equal to 100°. The lift coefficient C_L lies in the diapason from –0.08 to 0.11 (the square of reflector plane projection and reflector diameter have been taken as relative base values for coefficients calculation).

ANSYS CFX results may be used directly in the reflector design strength calculations to determine load limits, adequate strength and coefficients of safety for windstorm.