ANSYS CFX 5.7.1 Calculation of Aerodynamic Wind Loads Acting on Parabolic Television Satellite Antenna under the Influence of Windstorm and Windflaw

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Problem description

The problem of numerical simulation of viscous flow and calculation of pressure and velocity fields and wind loads acting on parabolic axisymmetric satellite antenna.

The dish focus is equal 0.75 m, the diameter is 2 m, the dish is set on cylindrical holder at the 0.5 m height above ground or building surface.

The thickness of the dish is 0.02 m, the angle of the deflection from the vertical is 20°. CAD-model of antenna is depicted in Figure 1a.

Numerical calculations were carried out in *ANSYS CFX-5.7.1* program on Intel Pentium 4 CPU 2.00 GHz personal computer with 1 GB of operative memory.

Tetrahedral mesh (250 000 nodes) with prismatic boundary layers was generated by the *ANSYS CFX-Mesh* module in the *ANSYS Workbench* environment.

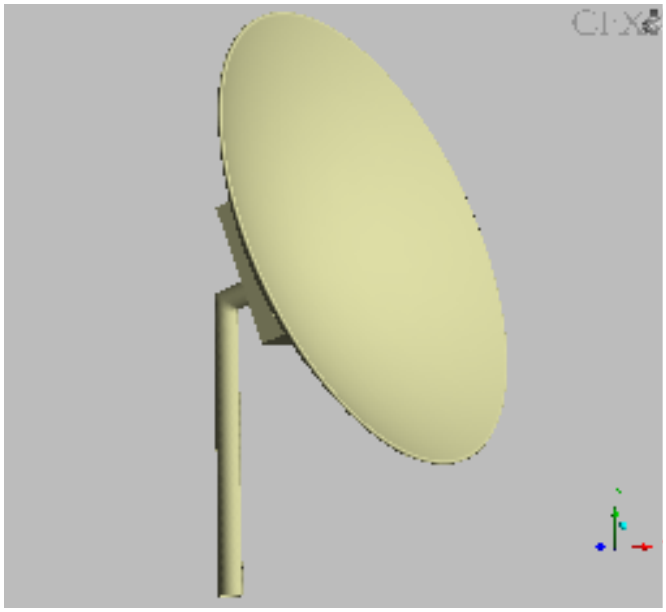
For solving three-dimensional Navier-Stokes equations describing compressible viscous turbulent flows the finite volume method, node centered high-resolution scheme for convective and viscous parts and *SST (Shear-Stress-Transport) k-ω* turbulence model for separated flows modeling were used.

To obtain steady-state convergent solution for one flow regime (horizontal wind velocity was equal 5 m/s, 25 m/s and 50 m/s) 100 –150 time iterations were required, this corresponds 2 – 3 hours of personal computer working.

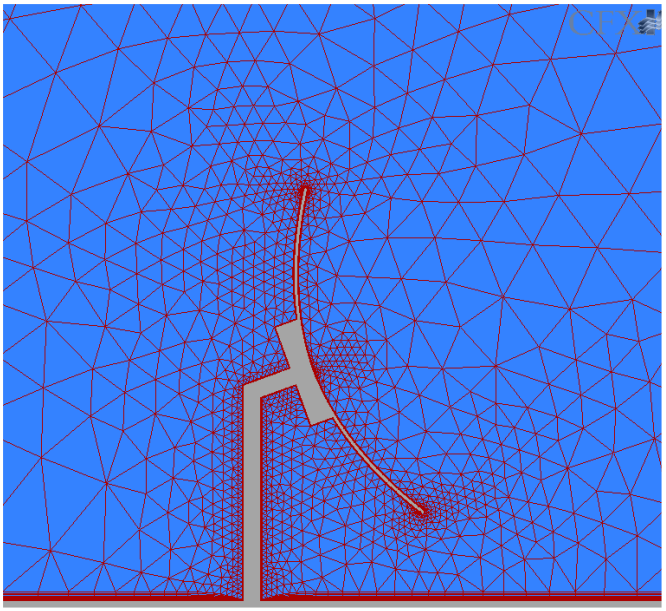
Computational domain is represented by the parallelepiped, its planes are disposed at the distance 20 m from the antenna in the direction of wind (OX axis), at the distances 10 m and 7.5 m in the vertical (OY axis) and side (OZ axis) directions accordingly.

Generated in *ANSYS CFX-Mesh* module unstructured tetrahedral mesh with prismatic layers near the solid boundaries has 880 331 cells (616 111 tetrahedra, 264 220 edges) and 248 444 nodes.

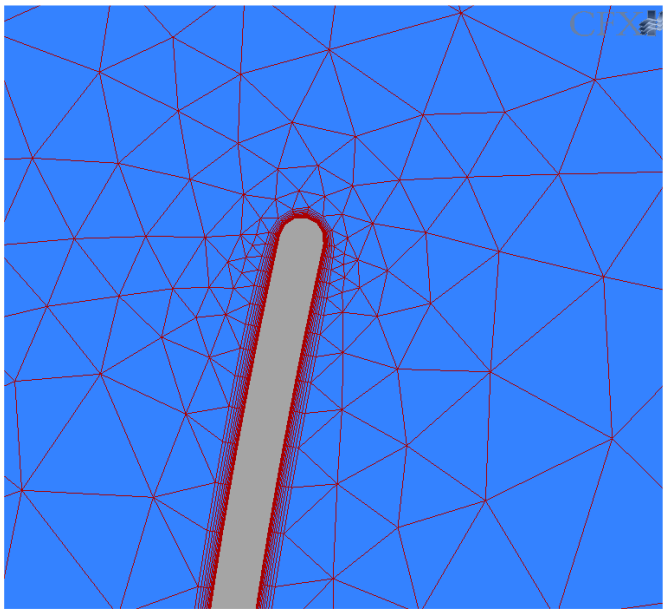
On the domain boundaries “Opening” type (at the 4 parallelepiped planes), “Wall” (on the antenna surface and on the ground) and “Symmetry” (in the vertical symmetry plane) boundary conditions were used. In the boundary layers near the ground and near the body surface, in the domains with the abrupt curvature variation and at the vicinity of surface fractures provocative viscous separation the mesh cells were refined and pressed down. On the antenna surface together with holder 14 222 nodes are collocated. Fragments of computational mesh in the symmetry plane, near the dish edge and on the dish surface are depicted in Figure 1b) – 1d).



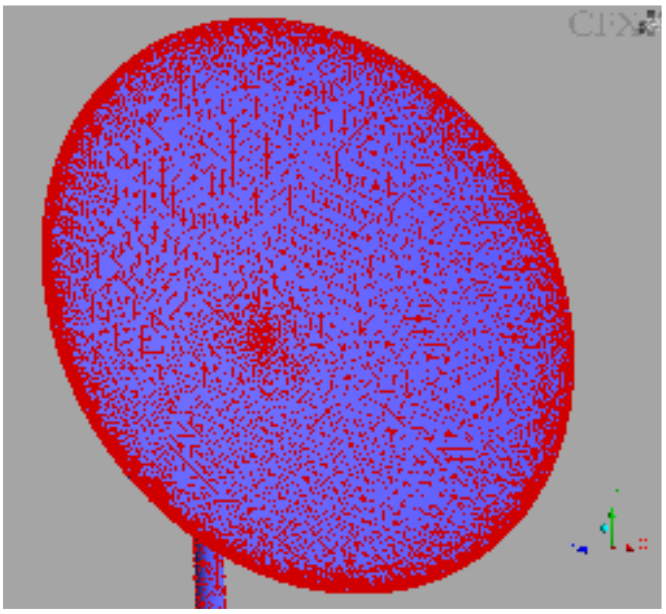
a) CAD-model of the antenna



b) Computational mesh in the symmetry plane



c) Computational mesh near the dish edge



d) Surface mesh on the dish

Figure 1. CAD-model and computational mesh fragments

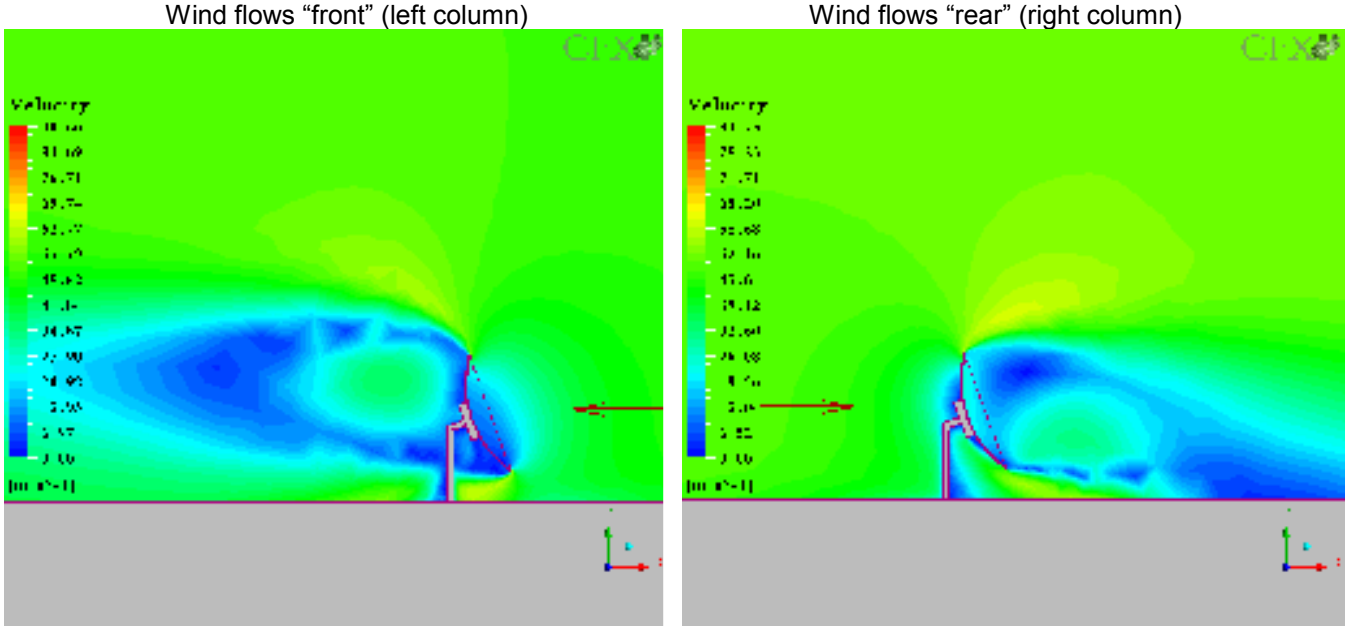
Numerical results for velocity and pressure fields and integral wind loads (vertical lift, horizontal wind resistance - aerodynamic drag and pitching moment) are presented for “halcyon” horizontal wind (5 m/s), windstorm (25 m/c) and windflaw (50 m/s); Reynolds number lies in the $Re=(0.7\text{-}6.6)\cdot 10^6$ diapason.

Two cases were considered – the wind flows front and rear about the antenna.

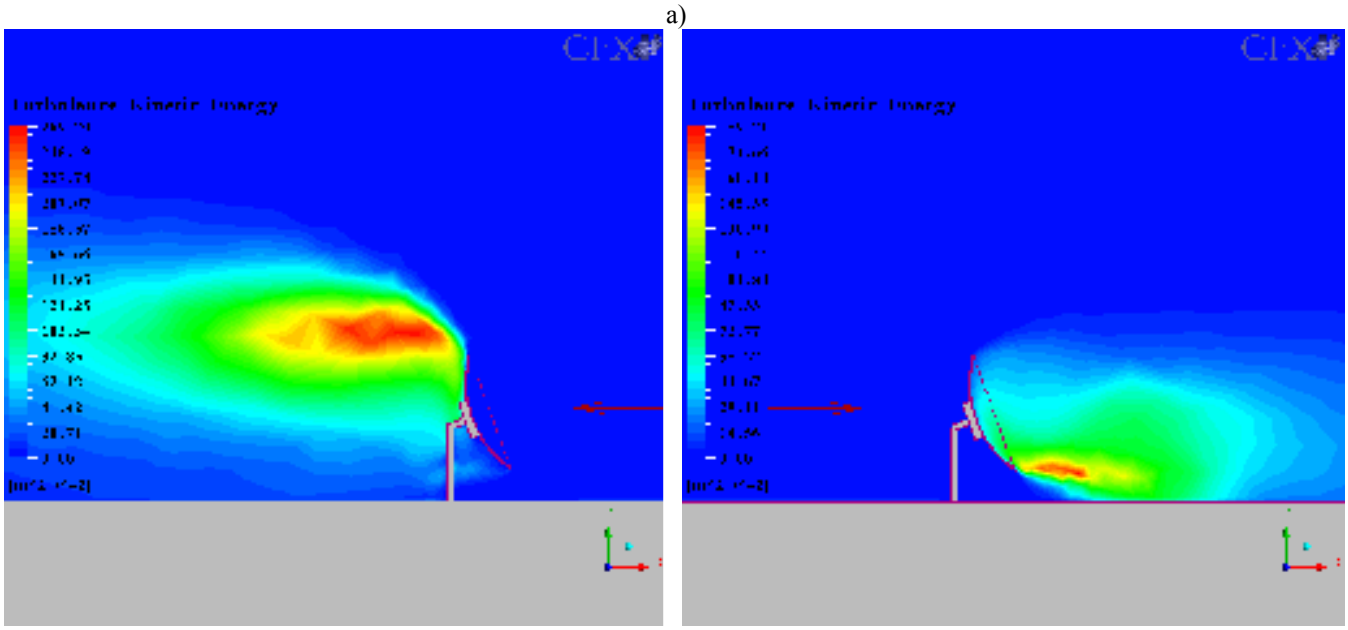
Geometry of satellite antenna is the typical example of the bluff body. In the down stream from the antenna configuration sizable zone of separation is formed.

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 zone.

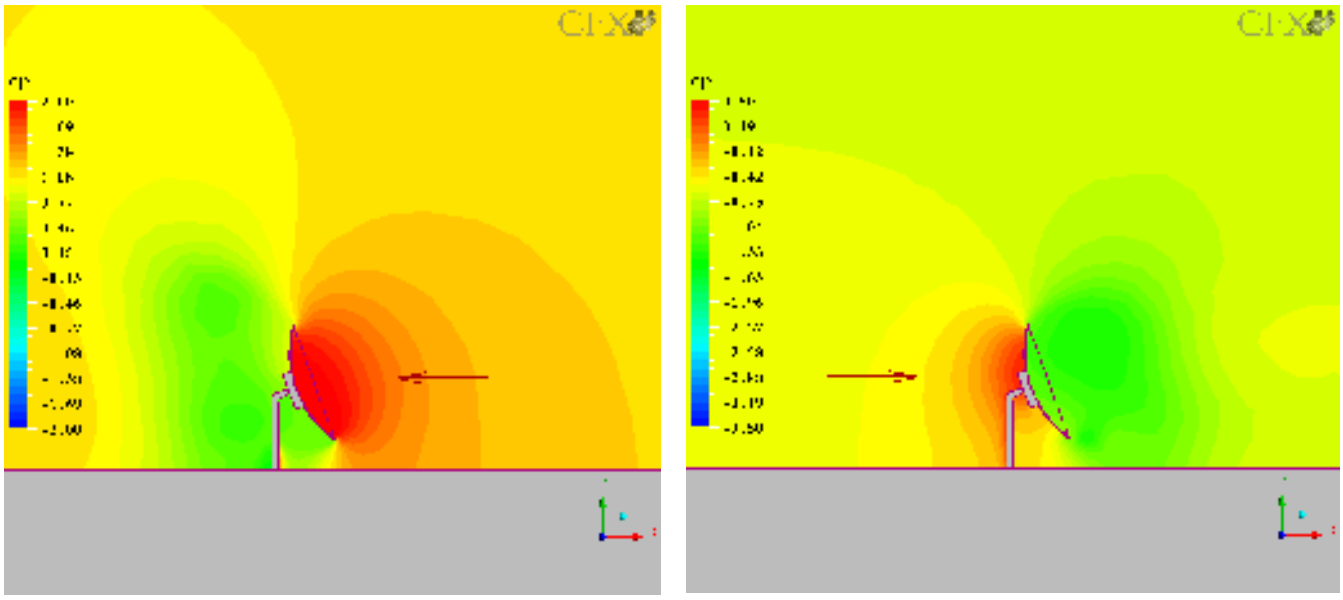
Wind flows “front” (left column) Wind flows “rear” (right column)



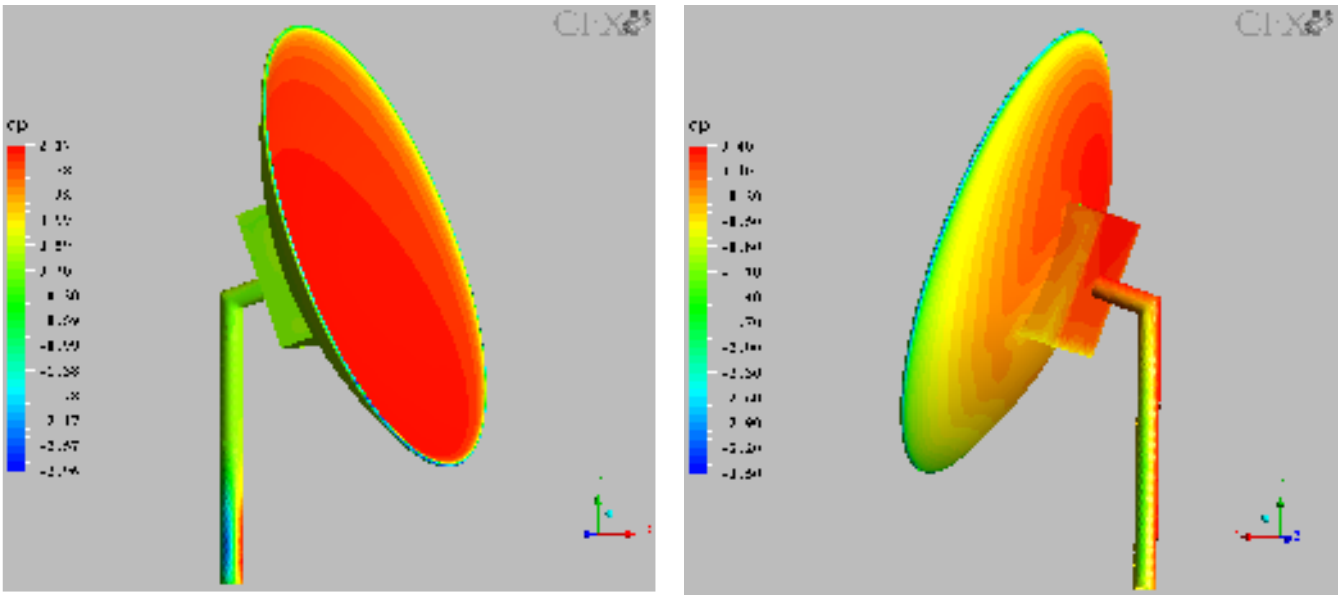
a)



b)



c)



d)

Figure 2. Velocity (a), turbulence kinetic energy (b) and pressure coefficient (c) distribution in the vertical symmetry plane and on the antenna surface (d); wind direction is denoted by red needle, wind velocity is equal 50 m/s

Figure 3. Wind loads against wind velocity (forces – in newtons, moment – in newton·meter, wind velocity with "-" – wind flows front, with "+" – wind flows rear)

Analysis of results and conclusions

ANSYS CFX 5.7.1 calculations of aerodynamic wind loads acting on parabolic television satellite antenna under the wind flow with the velocity 5 m/s, 25 m/s, 50 m/s have shown high accuracy *CFX* program as gas dynamic CFD package and have allowed to reflect main features of separated turbulent flow around bluff body.

Numerical simulation of wind flow around the antenna in two cases – “front” wind and “rear” wind – has shown that in the first case the dish was mounted under negative angle of attack, the paraboloid concavity resulted in sail effect and the wind produced loads in 1.5 – 2 times grater in comparison with the second case when the wind blows into the antenna flat end. The C_l, C_d, C_m coefficients accordingly for vertical (lift) and horizontal (shear, or drag) forces and pitching moment have been calculated. In the case of “front” wind the absolute values of these coefficients amount C_l =0.57-0.58, C_d =1.32-1.35, C_m=0.71-0.73; for “rear” wind C_l =0.21-0.24, C_d =0.89-0.94, C_m=0.62-0.64 (the square of dish plane projection and dish diameter have been taken as relative base values for coefficients calculation).

ANSYS CFX results may be used direct in antenna design strength calculations to determine load limit, adequate strength and coefficients of safety for windstorm and windflaw.