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SIMULATIONS OF AIR FLOW OVER A PARABOLIC ANTENNA

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Abstract
In this paper it is present the influence of the wind on a parabolic antenna, in order to study this influence it was made simulations of air flow over a parabolic antenna. The simulations are made with antenna positioned at 90°, 135°. A three – dimensional finite element is simulated for determination of the antenna displacement.

1. Introduction

Study of the fluid structure interaction is complex, software for numerical simulations don't include all the aspects of the problem, because of that are developed software which are dedicated for fluid structure interaction which are: ANSYS CFX, FIDAP, LINFLOW.

From the point of view of fluid structure interaction the structure of parabolic antenna presents many particularities.

Antenna is an open structure and it has a thin wall, a pillar and a cantilever arm which fix the LNC receiver.

The relative motions between the parabolic surface and the LNC receiver may affect the reception signal gain, especially in the microwave range.

In order to analyses the fluid structure interaction it must consider the flow in which appear the dynamics effect with steady and unsteady vortex.

With the help of the ANSYS software is simulating fluid structure interaction in the case of the parabolic antenna. The structure of the parabolic antenna is rotated at the different angles around the vertical axis, the angles at which the simulations were made are 90° and 135°. The simulations are done with the module ANSYS Multi-field (MFX). The use of this module implies that the domain of the fluid is solved with the CFX software and the structure domain is solved with the ANSYS software.

The antenna model was simplified, replacing the fixed support by 12 equivalent springs (fig. 1). The spring constant was set in order to obtain the value for the frequency of the first mode approximately equal to the frequency of first mode which was determinate experimental and its value is 14.28 Hz, pressure and velocity fields don't change because of that simplification. This simplified model was chose in order to reduce the computation time, though running was performed on a dual processor SUN station the computation time for simplified model was about 24 hours on a SUN station with dual processor.

The antenna is suspended on 12 springs (fig. 1).

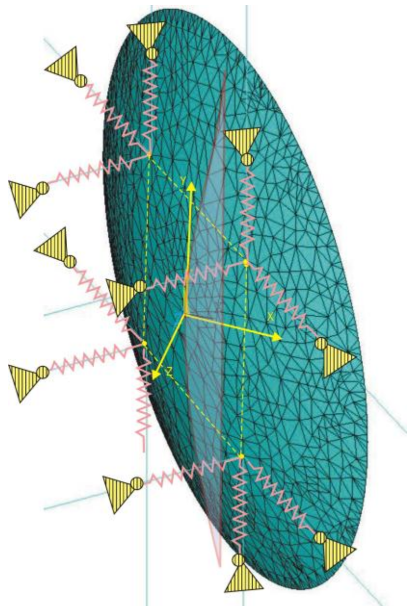

Fig.1.

The mesh was done in Meshing module from ANSYS Workbench. The mesh have 2393 nodes and 9804 elements.

The settings for the fluid domain was done in ANSYS CFX-Pre module.

The fluid is air with density of $1.185\,\mathrm{kg/m^3}$ and the dynamic viscosity of $1.831\mathrm{e}\text{-}05\ \mathrm{kg\,m^{-1}s^{-1}}$

The turbulence mode was set to $k-\varepsilon$

The boundary conditions were set:

- freewalls
BOUNDARY:freewalls
Boundary Type = WALL
Location=F23.21,F24.21,F25.21,F26.21
Option = Stationary
MESH MOTION:

```
BOUNDARY CONDITIONS:
END
WALL INFLUENCE ON FLOW:
Option = Free Slip
- inlet
BOUNDARY:inlet
Boundary Type = INLET
Location = F22.21
BOUNDARY CONDITIONS:
FLOW REGIME:
Option = Subsonic
END
MASS AND MOMENTUM:
Option = Cartesian Velocity Components
U = MyVelX(t)
V = 0 [m s^-1]
W = 0 [m s^-1]
END
MESH MOTION:
Option = Stationary
END
TURBULENCE:
Option = Medium Intensity and Eddy Viscosity Ratio
- interface
BOUNDARY:interface
Boundary Type = WALL
Location=F18.21,F19.21,F20.21
BOUNDARY CONDITIONS:
MESH MOTION:
ANSYS Interface = FSIN_1
Option = ANSYS MultiField
Receive from ANSYS = Total Mesh Displacement
Send to ANSYS = Total Force
END
WALL INFLUENCE ON FLOW:
Option = No Slip
END
WALL ROUGHNESS:
Option = Smooth Wall
- outlet
BOUNDARY:outlet
Boundary Type = OPENING
Location = F27.21
BOUNDARY CONDITIONS:
FLOW DIRECTION:
Option = Normal to Boundary Condition
END
Option = Subsonic
END
MASS AND MOMENTUM:
```

FLOW REGIME:
Option = Opening Pressure and Direction
Relative Pressure = 0 [Pa]
END
MESH MOTION:
Option = Stationary
END
TURBULENCE:
Option = Medium Intensity and Eddy Viscosity Ratio
The settings for Solver Control
SOLVER CONTROL:
ADVECTION SCHEME:
Option = High Resolution
END
CONVERGENCE CONTROL:
Maximum Number of Coefficient Loops = 3
Minimum Number of Coefficient Loops = 2
Timescale Control = Coefficient Loops
END
Convergence Target = 1e-3
Under Relaxation Factor = 0.75
END
COUPLING STEP CONTROL:
Maximum Number of Coupling Iterations = 10
Minimum Number of Coupling Iterations = 1
SOLUTION SEQUENCE CONTROL:
Solve ANSYS Fields = After CFX Fields
END
CONVERGENCE CRITERIA:
Residual Target = 1.E-4
Residual Type = RMS
END
EXTERNAL SOLVER COUPLING CONTROL:
COUPLING DATA TRANSFER CONTROL:
END
END
TRANSIENT SCHEME:
Option = Second Order Backward Euler
TIMESTEP INITIALISATION:
Option = Automatic

2. Numerical set up

2.1 Angle between antenna axis and flow direction is 90°

Fluid domain is a parallelepiped with the dimensions 6 m x 6 m x 12 m. Direction and sense for the wind is normal on the right face of the fluid domain, it is represent by the blue arrow in the figure 2.

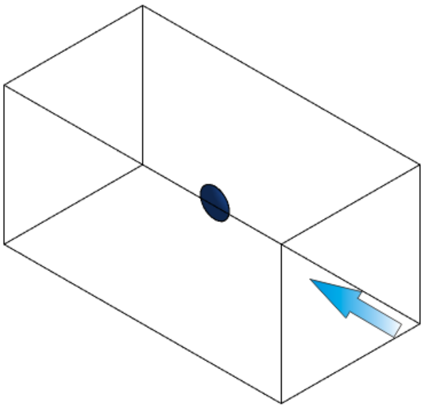

Fig.2. Fluid domain and the antenna position

In figure 3 is given the displacement time history of a point on parabolic shell, function of a linear sweeping input velocity, from 0 to 60 m/sec (figure 4).

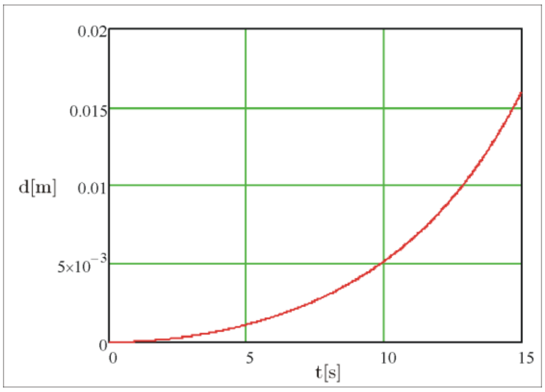

Fig.3.

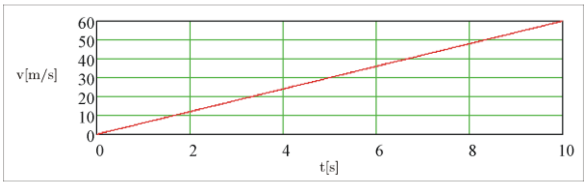

Fig.4.

The figure 5 represent the same point displacement at a real shape gust (recorded as in figure 6), the gust velocity being amplified, for a strong gust, at the mean velocity of 25 m/sec, (figure 8). The real shape gust (figure 6), was recorded in real conditions (figure 7)

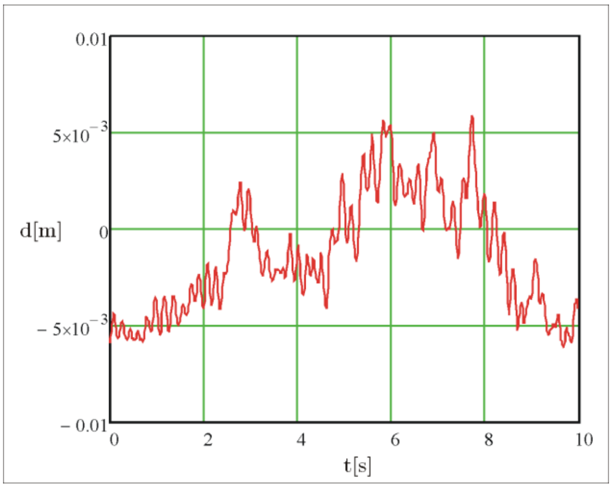

Fig.5.

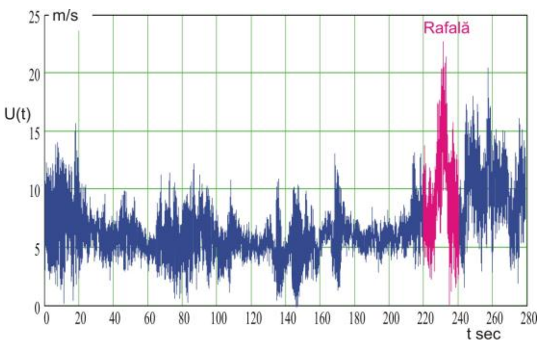

Fig 6.

Fig. 7.

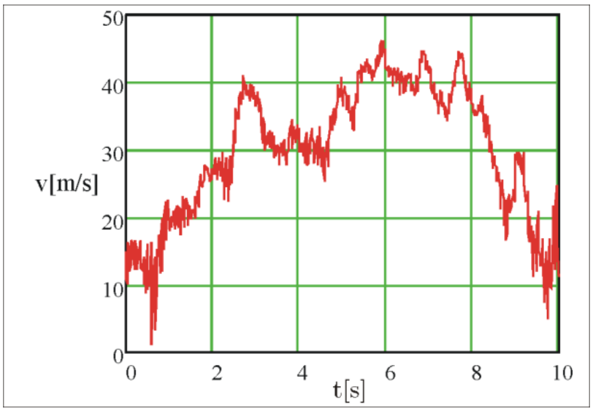

Fig.8.

2.2 Angle between antenna axis and flow direction is 135°

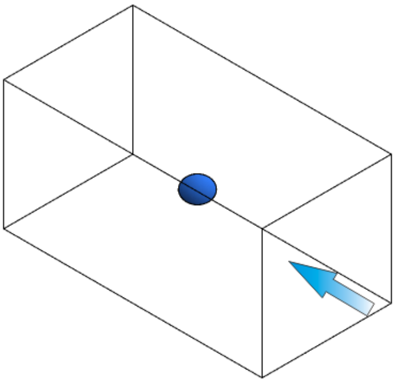

Fig.9. Fluid domain and the antenna position

In figure 10 is given the displacement time history of a point on parabolic shell, function of a linear sweeping input velocity, from 0 to 60 m/sec (figure 4).

The figure 11 represent the same point displacement at a real shape gust (recorded as in figure 6), the gust velocity being amplified, for a strong gust, at the mean velocity of 25 m/sec, (figure 8).

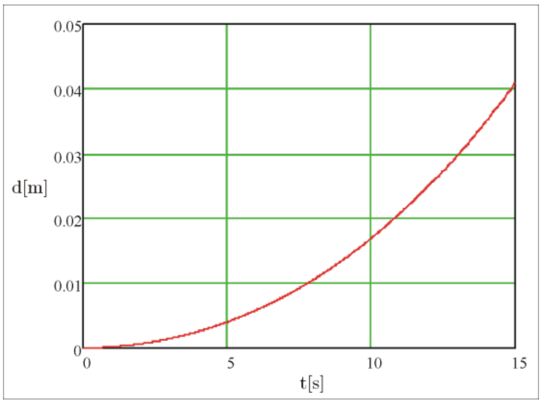

Fig.10.

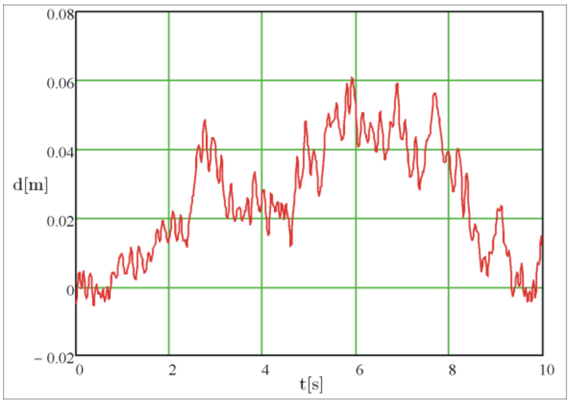

Fig.11.

Conclusions

In this paper it was study the influence of the wind on a parabolic antenna structure. The parabolic antenna components are elastic structures, which under external static and dynamic loads induce structural deformations, occurring deviations in the rays paths and finally the deviation of the reflected waves to the focal point where is situated the LNC receiver. Because of those deformations the flux of the waves on the LNC decreases and may affect the reception signal gain, especially in the microwave range.

References

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