Considerations regarding Aerodynamic Interaction between Two Wind Turbines. Case of Study: Two Wind Turbines with Rotor Diameter of 6 Meters

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Abstract: *In this paperwork are presented results of a study regarding the aerodynamic interactions between two turbines. Each turbine is a 3 blades turbine, with the rotor diameter of 6 meters. This study concludes that the optimum distance between wind turbines should be about 6 times the diameter of the rotor (36 meters in this case).*

Keywords: *Fluid flow engineering, Structural engineering, Wind energy*

1. Introduction

Nowadays, there are a lot of wind farm sites on development. The wind energy is one of the cleanest energy in the world, with a minimum effect on the environment. In order to obtain the maximum power on a available area, we need to know how the turbine interact with each other. In this paperwork, there are studied 2 turbines, having the rotor diameter 6 meters. Increasing the distances between them the authors found the distance where the aerodynamic influence is neglectable.

2. Wind turbine geometry

The studied type of the wind turbine is presented below in a 3D cad geometry:

Fig. 1. The studied wind turbine

During the study, there are considered two turbines, having different distances. The distances between turbines are measured starting from the hub's rear end of the first one, up to the hub's front end at the second one. These two turbines are situated in a 50m cylindrical air domain. The length of the cylindrical varies, and will be presented in the following sections of this paperwork.

3. Study cases

For this paperwork, there are considered 9 study cases (abbreviated as SC), with different distances between rotors according to Table no.1.

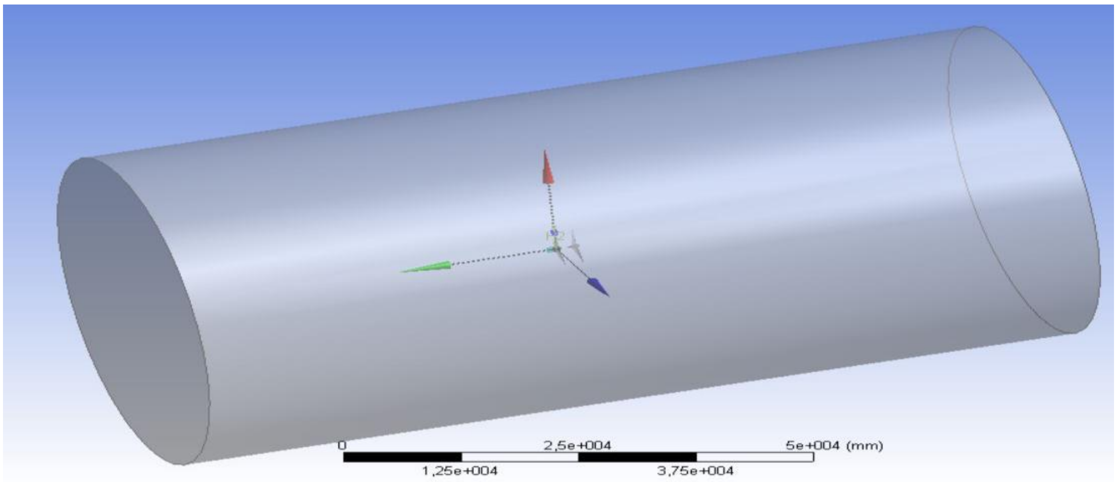

Fig. 2. SC1 Geometry

4. Mesh

The mesh was generated automatically, as a CFD mesh [1,2,3] with a relevance parameter of 100 (the biggest value for relevance).

Statistics for mesh are presented in the bellow table:

Table 1: Geometry details and mesh statistics for each study case

Study case	Distance between rotors	Number of Nodes	Number of Elements
SC1	0	260254	1535479
SC2	3	280742	1657594
SC3	6	290952	1718499
SC4	9	280294	1654775
SC5	12	266769	1575242
SC6	18	253733	1498090
SC7	24	255032	1505591
SC8	30	242813	1433612
SC9	36	220523	1301465

Mesh discretization networks are presented below, in figure 3 as example.

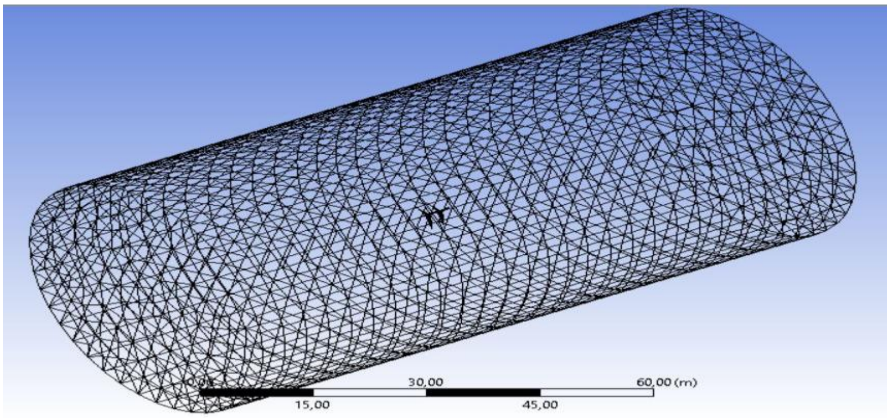

Fig. 3. SC1 Discretization network

5. Analysis setups and boundary conditions

The carried-out analysis is transient analysis, with a total time of 300 seconds, with 1 second time step.

The turbulence model is considered to be the Shear Stress Transport.

Boundary conditions are:

- The inlet of the cylindrical domain is a constant speed one, speed is 10 [m/s];
- The outlet of the cylindrical domain is a constant pressure one, with relative pressure 0 [atm];
- The cylindrical border is defined to be "free sleep wall";
- The turbines are defined to be "smooth wall"

Graphical representations of the boundary conditions and axes definitions are presented in the following picture:

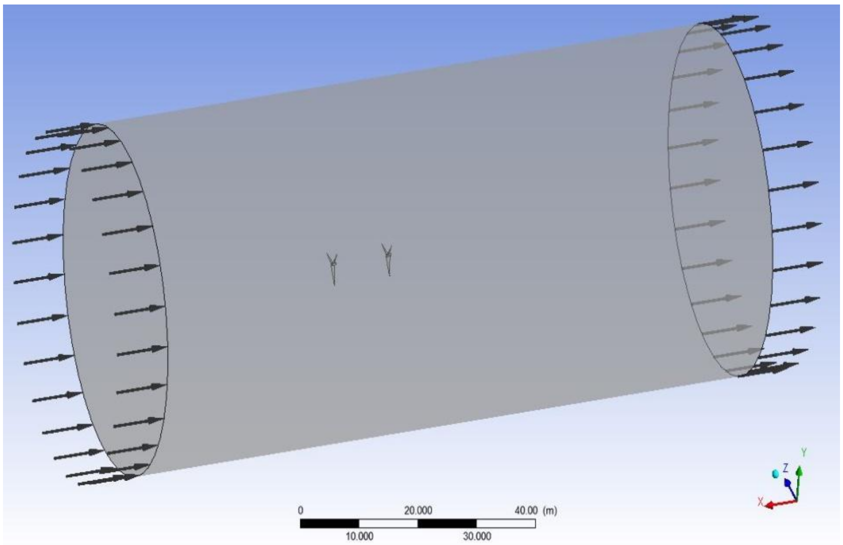

Fig. 4. SC4 Graphical representation for the boundary conditions, and axes definitions

6. Graphical results

In the bellow picture are presented graphical results regarding the flow around the two turbines and the pressure distribution diagram on the turbines:

6.1 Speed lines around turbines

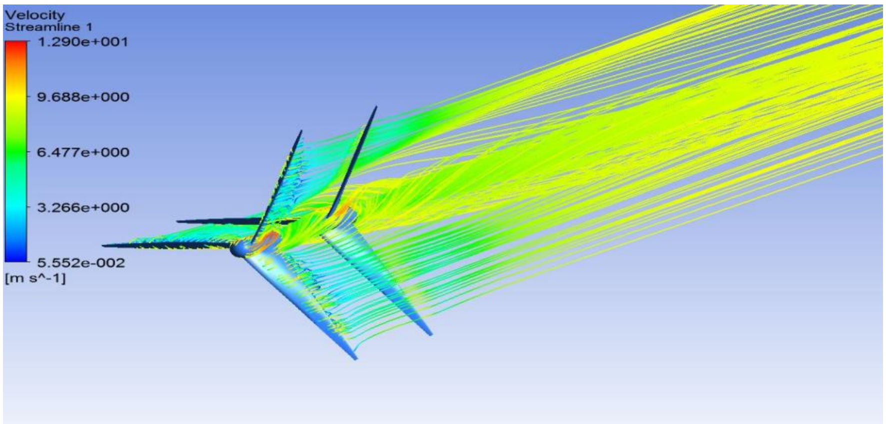

Fig. 5. SC1 Speed lines around turbines

6.2 Relative pressure distribution on turbines

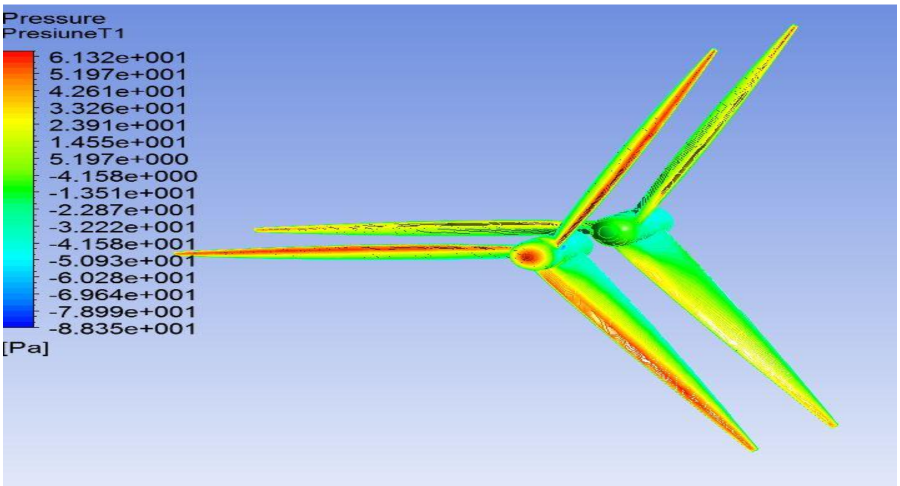

Fig. 6. SC1 Relative pressure on turbines

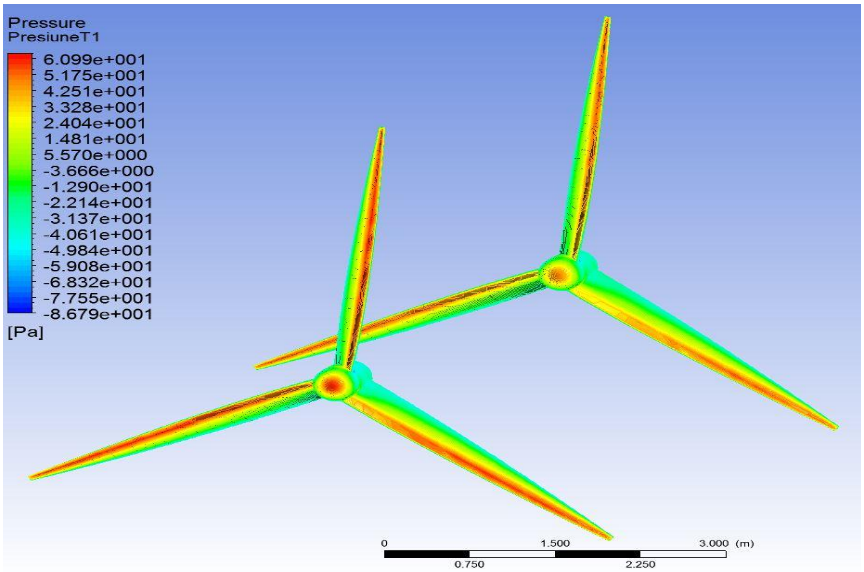

Fig. 7. SC5 Relative pressure on turbines

7. Numerical results

For numerical results, this study is considering the torque on the turbines. For this study, the Ox Torques are relevant [4,5,6].

The axes are defined in Fig. **4**.

The relevant results are presented below:

Table 2: Absolute values of the Ox torques on the wind turbines

Distance between hubs [m]	Ox torques (absolute values) [KNm]	
	Turbine 1	**Turbine 2**
0	1513.4	916.37
3	1549.4	1165
6	1558.6	1317.6
9	1564.4	1347.2
12	1578.5	1389
18	1604.6	1440
24	1602.1	1471.3
30	1619.7	1513.2
36	1647.8	1564.4

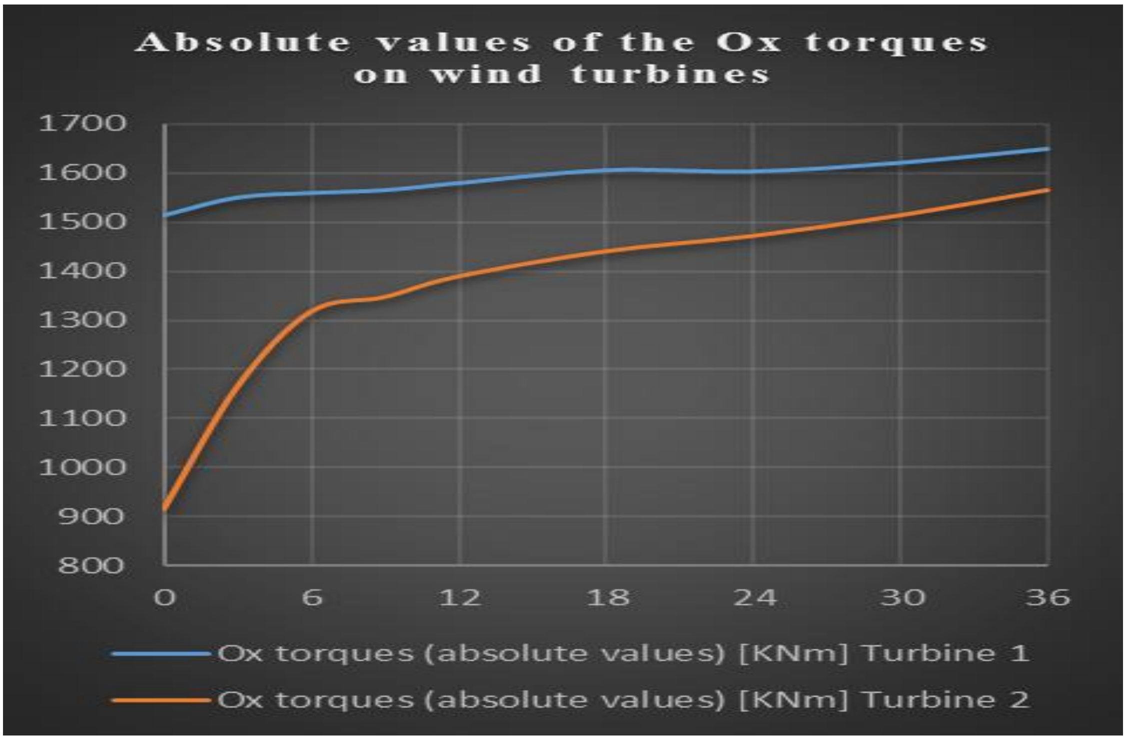

Fig. 8. Absolute values of the Ox torques on the wind turbines

8. Conclusions

Considering graphical variation presented in Fig. **8**, we can see that both turbines are influencing each other.
The most affected one is the Turbine 2, because Turbine 1 is in front of it and "takes" the air.
Also, the Turbine 1 is affected by the second turbine, which puts a backpressure and affects in a negative way the flows around it.

Table 3: Percental differences between toques on wind turbines

Distance between hubs [m]	Percental differences between toques on wind turbines
0	39.45
3	24.81
6	15.46
9	13.88
12	12.01
18	10.26
24	8.16
30	6.58
36	5.06

As it can be seen in Table **3**, at the distance of 36 meters (6 times the diameter of the turbine rotor) between hubs, the percental differences between turbines goes to about 5% and bellow. This value can be acceptable in most cases, considering the limited area available for the wind farm. As a final conclusion, the authors of the study recommend the wind farm developers to plant the wind turbine at intervals equal with 6 times diameter of the rotor.

References

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