Study on the influence of calculation domain on the accuracy of CFD simulation of power transmission tower aerodynamic coefficient

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Abstract: Wind load is the control load in the design of power transmission tower. The shape coefficient of that can be obtained by CFD. Small calculation domain can affect the calculation accuracy, and large one can reduce the calculation efficiency. In this paper, the calculation domains with different sizes are designed to optimize the calculation domain size.

Key words: Power transmission tower, Wind load, Aerodynamic coefficient, CFD

1. Introduction

Power transmission tower is a kind of flexible structure, and wind load is very important in the design of power transmission tower[1-7]. When the wind flows through the tower structure, the complicated vortex separation makes the problem of wind effect of the transmission tower very complicated. At present, wind tunnel experiment is still the main research method for power transmission tower, but it is difficult to obtain the whole flow field information. In this case, CFD has its advantages, and it can be used to optimize and evaluate the initial proposal more economically. The size of CFD calculation domain is related to the influence of the calculation boundary on the model region. If the calculation domain is too small, the calculation boundary will cause excessive calculation error. However, the large one requires more grids, which directly affects the computational efficiency. In order to study the suitable domain, two different sizes of computing domain are used in this paper.

2. Calculation model

Build the model of the angle steel tower with a ventilation rate of 0.3, as shown in Figure 1. The component member in the model is the angle steel. The geometric structure of the connection between angle steels is very complicated. The length thickness ratio of the longest steel member is more than 1000. Flow field meshing is very difficult, because the size of the mesh must be smaller than the thickness of the angle steel in order to accurately describe the geometric characteristics. If the size of the mesh is larger than the thickness of the angle steel, it is easy to distort and form negative volume during the generation of the mesh, which makes the model impossible to calculate. On the other hand, because the length to thickness ratio of the bar is too large, a large number of meshes will be formed in the longitudinal direction of the bar. The number of bars is large, resulting in a large number of overall grids.

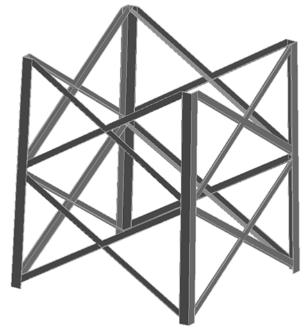

Figure 1. Body segment of angle steel tower

3. Computational domain

The calculation domain is set as a rectangular domain whose length, width and height is 12.5L, 5L (10L) and 4H respectively, as shown in Figure 2, where L and H are the length and height of the tower model. In order to minimize the influence of the exit boundary on the calculation results, the exit boundary is set 10L away from the tower model. The transverse width of the calculation domain is set at 5L and 10L respectively to study the influence of the transverse width of the calculation domain on the calculation results.

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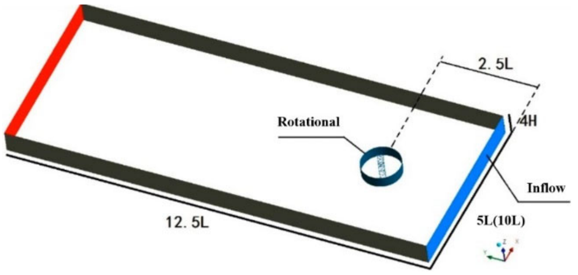
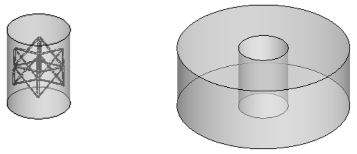
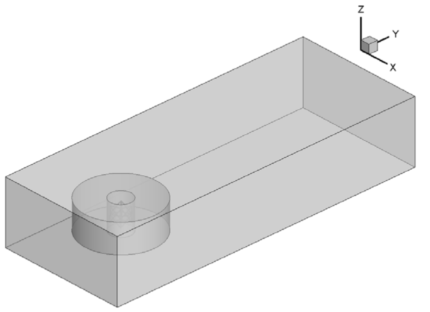


Figure 2. Calculation domain

In order to change the wind direction without re-modeling, the Generalized Grid Interface (GGI) is used in the calculation. The GGI is a coupling interface used to connect non-conformal meshes. When two domains are connected by the GGI, there is no need for one-to-one correspondence between nodes on adjacent interfaces. In the calculation, the tower model is placed in a cylinder surrounded by a cuboid. The unstructured grids are used in the cylinder to fit the complex geometric shape, and the hexahedral structured grids are used in the cuboid. The meshes at the intersection of the two areas are discontinuous. The cylindrical computing domain can rotate, which can change the wind direction. In the calculation, the calculation domain is divided into 3 subregions, namely R1, R2 and S, as shown in Figure 3. If the wind direction is changed, it only needs to rotate the subregion R1.



(a) R1 region (b) R2 region

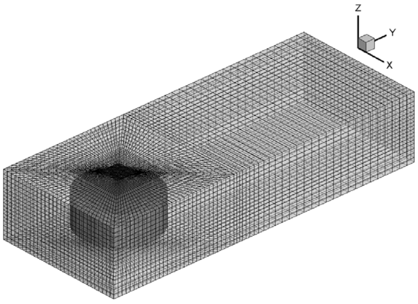


(c) All region

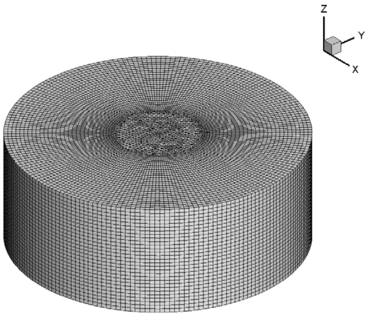
Figure 3. Computational domain

4. Meshes

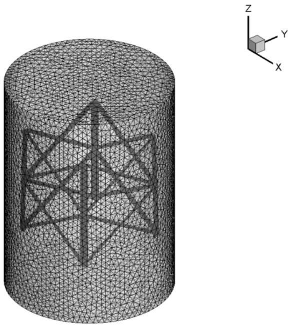
The maximum mesh size of the domain S is 0.2L, and the minimum size is 0.05L. The domain R2 has a maximum mesh size of 0.05L and a minimum mesh size of 0.01L. The maximum mesh size of the domain R1 is 0.01L, and the minimum mesh size is the thickness of the angle steel. The grid growth rate is set uniformly as 1.2. Figure 4 shows the meshes of the computing domain.



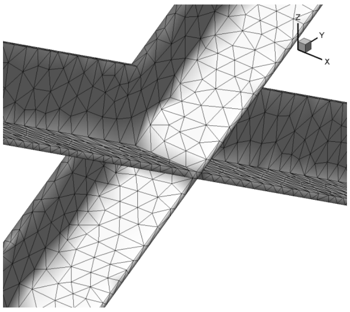
(a) All



(b) R2



(c) R1



(d) Tower surface

Figure 4. Meshes

5. Simulation results and conclusions

In order to analyze the influence of computing domain size on the calculation results, the transverse width of the small computing domain is set as 5L, and the transverse width of the large one is set as 10L. From Table 1 to Table 3, it can be seen that the results of shape coefficient have little deviation with different sizes. It is to say, if the transverse width of calculation domain is 5L, the calculation requirements can be satisfied, and the increase of transverse width does not greatly improve the simulation accuracy. Table 4 shows the shape coefficients of power transmission towers under different wind directions.

Table 1. The aerodynamic results

Computing domain	Wind direction	F_x	F_y	F_z	M_x	M_y	M_z
Small	0°	0.0546	2.0682	-0.4461	-0.3037	0.0061	-0.0045
Large	0°	-0.0084	1.8744	-0.4513	-0.2735	-0.0008	-0.0008

Table 2. The aerodynamic coefficient results

Computing domain	Wind direction	C_x	C_y	C_z	C_{mx}	C_{my}	C_{mz}
Small	0°	0.0638	2.4178	-0.5215	-0.3551	0.0072	-0.0053
Large	0°	-0.0098	2.1913	-0.5276	-0.3197	-0.0010	-0.0009

Table 3. The shape coefficient results

Computing domain	Wind direction	μ_x
Small	0°	2.4178
Large	0°	2.1913

Table 4. The shape coefficient results with different wind directions

Wind direction	0°	15°	30°	45°	60°	75°	90°
μ_x	2.1913	2.4964	2.2757	1.8687	2.5761	2.7049	2.1394

Acknowledgments

This work in this paper has been funded by the science and technology project of State Grid “Research on vortex-induced vibration fatigue and control technology of transmission line steel tube tower considering environmental factors”. (Project code: 5200-202156071A-0-0-00)

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