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Numerical Calculation of Coefficient of Force for Cylindrical Shape Smokestack Covered with Corrugated Iron

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Abstract: This paper deals with the influence of the shape of covering at smokestack to the resultant of load from wind effects. Calculation according to current standard takes into account only size of the wave-height of shaped sheets regardless of the shape of the waves, which leads in some cases to a substantial increase of the coefficient of force. The aim of this paper is to determine the equivalent coefficient of force for a cylindrical shape smokestack, which is covered with corrugated iron. The flow around smokestack is designed in software Ansys Fluent using the DES model. The calculated coefficient of force for the real roughness of a smokestack is compared with the values specified in the standard.

Introduction

Determination of load from wind effects at smokestacks depends on Reynolds number *Re* describing the flow, geometry of structure and surface roughness. Valid standard distinguishes the type and shape of roughness up to 3 mm. In the case of higher values, the equivalent roughness is determined from empirical relationship, which only takes into account the height of inequality, not its shape. This sometimes leads to a high increase of the coefficient of force. There can be assumed a fully developed turbulence in the boundary layer around the smokestack walls covered with corrugated sheets. This process is very complicated physical experiment because of the high *Re* [1,2,3]. There are given high demands on the number of cells in numerical modeling of the real covering, currently it is not realistic for a desktop PC [4,5,6]. The article deals with the possibilities of compensatory equivalent aerodynamic roughness of corrugated iron and defining the aerodynamic drag coefficient of flow around covered cylinders. The problem is solved by finite volume CFD code in software Ansys Fluent.

There is simulated a wind flow around a real smokestack of circular section of diameter 3.36 m. Cladding is made from corrugated sheet SP 18/76 with the wave height 18 mm. The basic wind speed is estimated to 22 m/s. Airflow with $Re = 5.5 \cdot 10^6$ is far in the supercritical region.

The solution is divided into two phases. In the first phase, the task is modeled as a turbulent flow in rough pipe, which has got one meter in diameter and 20 meters in length. The geometry of the walls is identical to the geometry of the sheet (Fig. 1). This is a 2D axially symmetric problem, which is solved in a steady state way using the SST k-ω model. This simulation is chosen because it allows a feedback control with published measured values of pressure losses. Seeking equivalent aerodynamic roughness, which software Ansys Fluent offers, is determined on the bases of the assessed loss of pressure and velocity.

In the second phase, the air flow around the smokestack is modeled in 3D (Fig. 2) in order to define the demanded aerodynamic drag coefficient required to calculate the effects of wind loads on structures. The model of smokestack is covered by non-profiled sheet. Corrugated sheet geometry is replaced by equivalent aerodynamic roughness which is set by us. The first cells at the smokestack walls are formed by the boundary layer so that the height of the aerodynamic roughness reaches the maximum to mid-height of the first cell wall. The solution of tasks uses unsteady fluid flow analysis using the DES model.

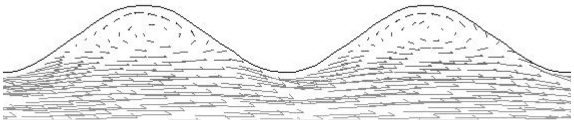

Fig. 1: Velocity vectors in the surroundings of corrugated iron

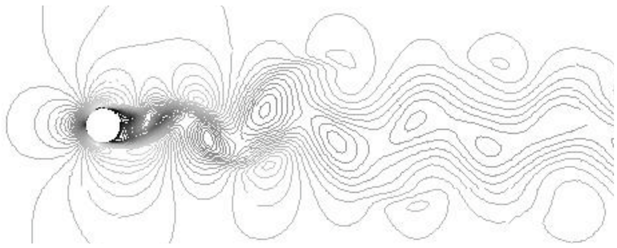

Fig. 2: The formation of vortices behind flow around smokestack

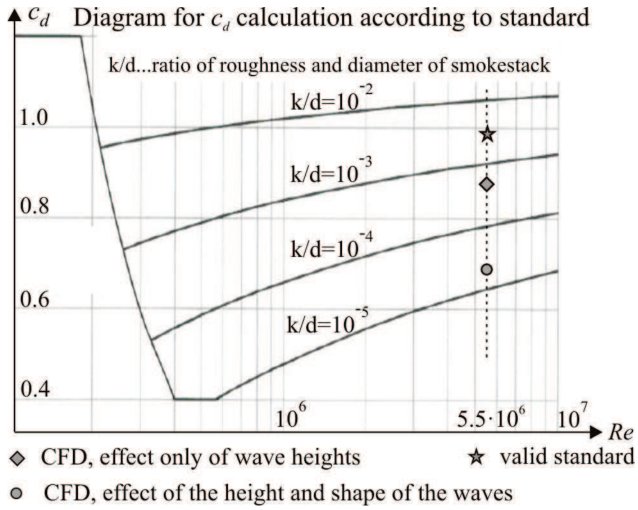

Fig. 3: The value of drag coefficient

Summary

The results show that the standard calculation of the effects of wind on the corrugated iron smokestack is overestimated (Fig. 3). The value of the resistance coefficient computed using CFD code should be considered as approximate only until it is verified by using either a physical experiment or a detailed numerical calculation, which allows the direct simulation of the actual geometry of a covered smokestack. Such task, however, would require a powerful supercomputer, for example that available in the National supercomputing center in Ostrava (http://www.it4i.cz/).

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