

## Optimization design on dome shape of high-speed elevator

Cai weiyong<sup>1, a \*</sup>, Ling zhangwei<sup>1, b</sup>, Tang ping<sup>1, c</sup>, Ding zhen yu<sup>2, d</sup>

<sup>1</sup> Zhejiang Provincial Special Equipment Inspection and Research Institute

Kai xuan Road 211, Hangzhou, 310020, P. R. China

<sup>2</sup> Zhejiang University of Technology, College of Mechanical Engineering, Hangzhou,

Zhejiang 310032, China

<sup>a</sup> cwy831@126.com, <sup>b</sup> lingzhangwei@163.com, <sup>c</sup> tangpingjob@163.com, <sup>d</sup> zyding@zjut.edu.cn

**Keywords:** high-speed elevator, dome shape, aerodynamic

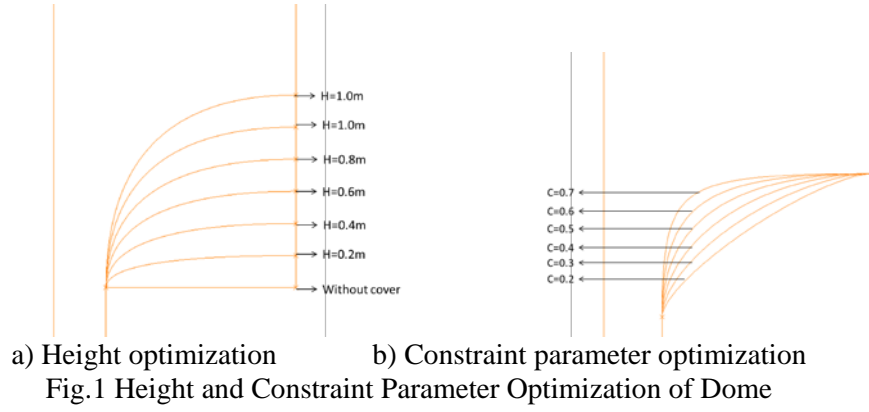
**Abstract.** This paper studies the aerodynamic optimization of dome of high-speed elevator. A 2-D flow field of typical sections is created with Fluent software. Conic curves with different height and constraint parameters are used to fit the dome. Comparing these drag coefficients of each shape of dome, the optimized shape of dome is created with the minimum drag coefficient value.

### 1. Introduction

As the development of the society and technology, the high-speed elevator come to a high-speed develop period due to the more and more high buildings. The high-speed elevator faces complex unsteady aerodynamic problems [1] and vortex-shedding phenomenon [2] that will cause vibration and noise [3]. Therefore, an air-deflector dome is installed so as to obtain better aerodynamic configuration. The domes with different height and shape have different aerodynamic characteristics [4]. This paper focuses on that the study on the optimization of the dome of high-speed elevator. The quadric curves are used to fit the dome's shape and Fluent to perform numerical simulation. All of drag coefficient for each dome shape are calculated and analyzed. The optimized height and constraint parameter values are found based on the analysis results, which can be used as a reference for dome designation.

### 2. Optimization Scheme of 2-D Flow Field and Numerical Simulation Method

The size of high-speed elevator which is used in the current research is length 2.3m, width 1.7m and height 2.4m. The operating speed is 12m/s. The width of wellhole is 2.6m. Due to the symmetric of the structure of elevator and wellhole, a two dimensional flow field of the elevator's symmetric plane is created. To find the optimized height value and compare the aerodynamic, quadric curves with different height values of 0m, 0.2m, 0.4m, 0.6m, 0.8m, 1m and 1.2m are used to describe the contour of the dome. The quadric curves with different values are shown in Fig. 1(a). After that, the optimized height value is gotten. Then, the flow field characteristic of domes with various constraint values of 0.2, 0.3, 0.4, 0.5, 0.6 and 0.7 are calculated while the height are fixed at the optimized value. The optimization scheme are shown in Fig.1 ( b). Finally, the best shape of dome of a high-speed elevator is gotten.



During this numerical simulation, Reynolds Average N-S Equation is used as governing equation [5]. In inertial system, Arbitrary Lagrangian-Eulerian expression is:

$$\frac{\partial}{\partial t} \int_{\Omega} \bar{W} d\Omega + \oint_{\partial\Omega} (\bar{F}_c - \bar{F}_v) dS = 0 \quad (1)$$

Where  $t$  is time,  $\Omega$  is control volume,  $\partial\Omega$  is the enclosed surface of control volume,  $S$  is arbitrary boundary area element,  $\bar{W}$  is conservative variable,  $\bar{F}_c$  is convective flux,  $\bar{F}_v$  is viscous flux (which can be ignored). Finite volume method is applied to solve the equation, and the turbulent model used here is  $k-\omega$ .

### 3. Result and Discussion

#### 3.1 Model and Mesh

The computation model includes a wellhole with length 300m and width 2.6m. The elevator and wellhole is shown in Fig. 2. To reduce computational time, only half model is simulated. Fig.2 shows the grid division of a dome with 0.2m height. The total number of grids is about 8,000. Those domes with other height values share similar grid division.



**3.2 Boundary Conditions.** A 12m/s operating condition is simulated. At the entrance of the wellhole set 12m/s inlet velocity condition; the sliding wall of the 12m/s movement is arranged along the direction of the hoist; at the outlet set a pressure boundary condition; no-slip boundary condition is set to the lift surface; and symmetric boundary conditions are set to the symmetric planes.

**3.3 Result Analysis.** From Fig.3 it can be seen that the drag coefficient decreases as the height of the dome increases. Fig.4 shows velocity distribution with different height values of 0, 0.4m, 0.8m and 1.2m. It is obvious that the velocity gets better distributed and the obstruction at the edge of the dome ameliorated as the value of  $H$  increases.

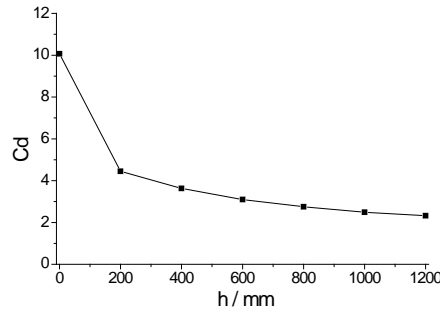


Fig.3 Drag Coefficient Corresponding to Different Height Values

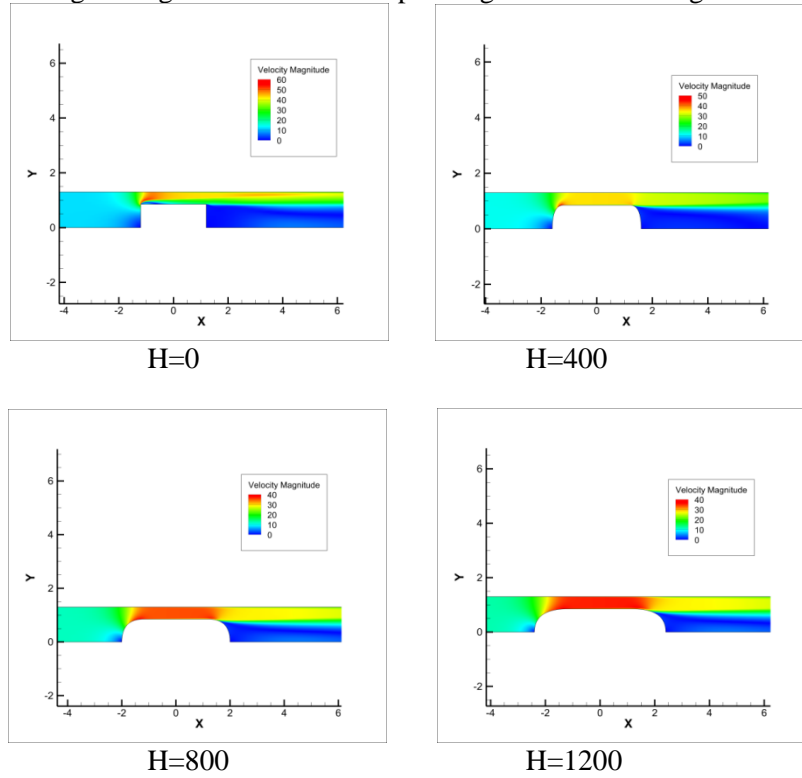


Fig.4 Velocity distribution Corresponding to Different Height Values

Fig.5 indicates that the drag coefficient decrease firstly and then increases with the increase of constraint parameter, and the minimum value appears at  $c=0.5$ . Fig.6 shows velocity distribution corresponding to different constraint parameters of 0.2, 0.4, 0.6 and 0.7. From 0.2 to 0.6, the velocity is even distributed, and the obstruction at the edge of the dome is improved. If the constraint parameter continually increases, the obstruction will get worse again.

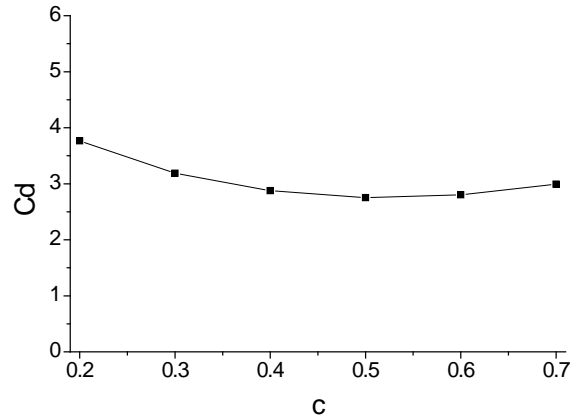


Fig.5 Drag Coefficient Corresponding to Different Constraint parameters

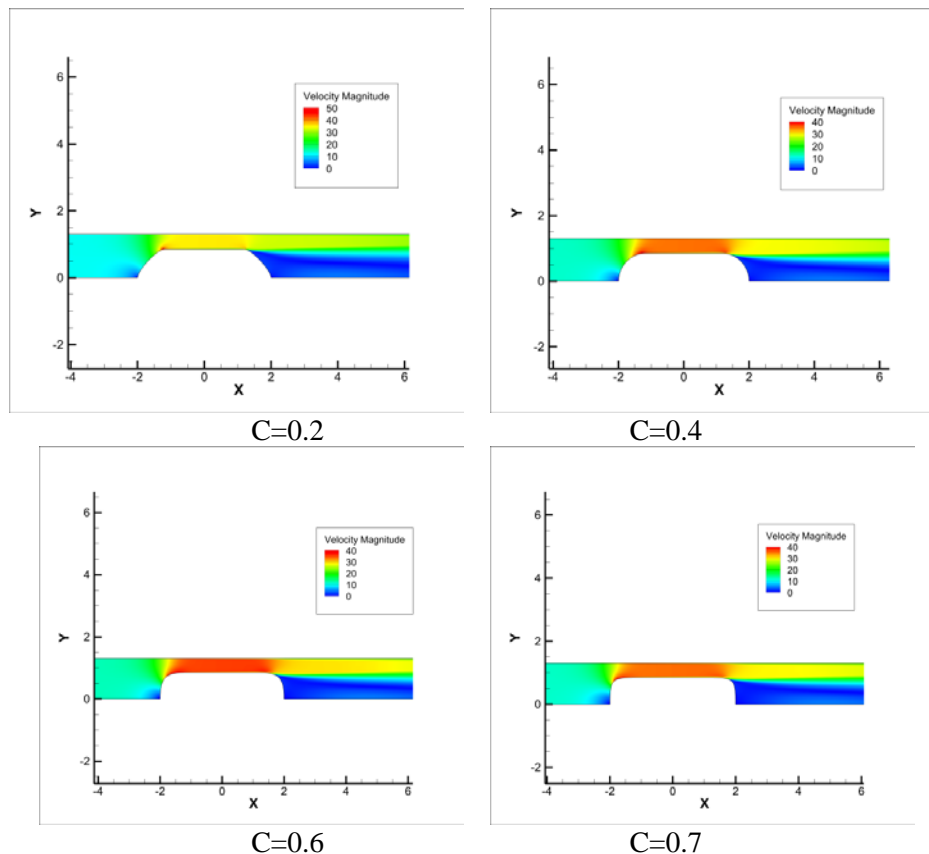


Fig.6 Velocity Distribution Corresponding to Different Constraint parameters

#### 4. Conclusion

This paper study on the aerodynamic characteristics of high-speed elevator domes with different height and constraint parameters in order to optimize the dome's shape. The result shows that,

1. As the height of the dome increases, the drag coefficient will decrease and the flow between dome and wall becomes easier and smoother.
2. The flow between the dome and wall tend to be smoother as the constraint parameter increases. However, if the constraint parameter goes too large, the flow will be unsmooth again, which represents the drag coefficient increased again.

#### Acknowledgment

This project is supported by the Major Project of Zhejiang Bureau of Quality and Technical Supervision (NO. 20130128 ).

#### References

- [1]. Terumichi Yoshiaki, Yoshizawa Masatsugu, Fukawa Youji. Lateral Oscillation of a Moving Elevator Rope and Cab in High-rise Building. Nippon Kikai Gakkai Ronbunshu. 1993, 55(9): 686~693
- [2]. Harrison J.C.. An Experimental Method for Appraisal and Comparison of Vibration in High-rise Elevator Cars. Elevator Word. 1998, (6): 81~85
- [3]. Shigate M. Inaba H. Development of Super High Speed Elevators. Elevator Word. 1995, (4): 69~73
- [4]. Naik, forsythew. Improving ride quality in high-speed elevators [J]. Elevator Word, 1997, 45(6): 88- 93.
- [5]. Yang H.W, So A.T.P. A 2-Dimensional Aerodynamic Model for Super-high-speed Elevators. International Journal of Elevator Engineering. 1998, (2): 19~32