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Study On The Vortex Structure Of Coupling Combustion Stabilizer With Square Cylinder-Strong Swirl Flow

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Abstract

Strong swirl and a blunt body are two commonly used structure to form low velocity recirculation zone to stabilize combusting of high-speed gas. Compared with the vortex shedding mechanism of the square cylinder blunt, the computational results show that the vortex shedding mechanism of the coupling combustion stabilizer is controlled by the vortex of the swirling flow instead of the cylindrical vortex. Also, the flow around bluff body with swirling flow through the central opening can reduce drag, increase the length of the recirculation zone and reflux mass, and increase the number of vortexes so as to enhance the heat and mass transfer. Thus, coupling combustion stabilizer can enhance the stability of flame.

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Keywords: Swirl flow; Bluff body; Vortex shedding; Vortex structure

1. Introduction

Both the strong swirl and the flow around blunt bodies can form low velocity recirculation zone to stabilize combusting of high-speed gas, but the two kinds of vortex structure are different. After introducing the strong swirling, the vortex structure become the superposition of vortex motions in two directions. And the bluff body vortex is a single spanwise vortex. A square cylinder is the classic body structure to study the shedding of a spanwise vortex. The separating position of the flow around square cylinder is on the windward front corner which

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is fixed. The paper uses the square cylinder in the water tunnel experiment by Rodi et al[1,2] as the object of the numerical simulation, researching the vortex shedding when the Reynolds number is 21400. And open a hole in the center of the square cylinder to study the comprehensive effect of the strong swirl fluid vortex and the bluff body vortex.

2. Numerical simulation of flow around a square cylinder

2.1. Geometric structure

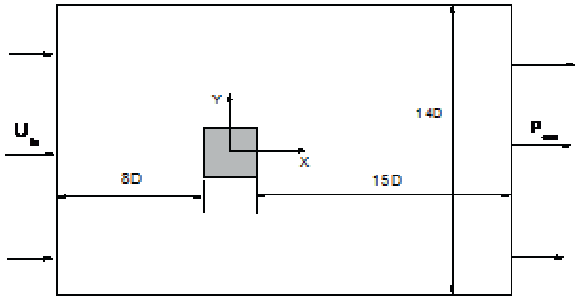

Fig. 1. Computation domain of square cylinder

Bosch and Rodi[3] indicate that the effects of entrance position on the simulation results can be eliminated when the distance from the entrance position to the square cylinder is more than 4.5D. This is 8D, and the spanwise width is 4D. The computational domain is shown in figure 1.

Table 1. The parameter value of square cylinder experiment

Parameter	Value
Diameter	D=0.04m
Inlet velocity	U=0.535m/s
Reynolds number	Re=UD/v=21400
Blockage ratio	7%
Aspect ratio	9.75
Turbulence intensity	2%

2.2. Boundary conditions

The inlet conditions are decided by the velocity, Reynolds number. The walls are the solid walls. The outlet is decided by the pressure ; Two surfaces along the spanwise are symmetric boundary.

This paper selects several commonly used RANS turbulence models to do numerical verification, and only SST model's results are in good agreement with the experimental data in the scale of the average recirculation zone. This is consistent with the conclusion by Jaeho Hwang [4]. Therefore, this paper uses the model to simulate the flow around a square cylinder.

2.3. Vortex structure

Vorticity is widely used to study the coherent structure and represent the vortex core[5]. Chong et al. use the characteristic value of velocity gradient to represent the vortex structure.

The low pressure area above the square cylinder can be approximately regard as the vortex core of the shear layer.