

Numerical Research on Flow and Heat Characteristics of H₂O in the Ejector Type Mixer

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ABSTRACT: Ejector type mixer has a hot water pipeline based on the Venturi tube. Cold water flowed from the left side of the pipe. After the gradual reduction of the pipeline, its speed went up and its pressure decreased, making vacuum degree in pipe throat and drawing hot water into the main pipe. After cold and hot water was mixed, it flowed out from the right pipe outlet. Fluent was used to get three-dimensional numerical simulation of the fluid in the ejector type mixer. The flow field and temperature field were observed and analyzed, and the influence of cold water's inlet speed and hot water pressure on outlet flow temperature was analyzed and summarized. The corresponding curve was drew.

KEYWORD: ejector type mixer; turbulence model; outlet temperature; speed; pressure

1 INTRODUCTION

Mixer is the device that makes two or more substances together. It is widely used in industrial fields (X. Ma et al, 2004) (H. Yang, 1985) (X. Cheng, 2013). Wu Changju (C. Wu et al, 2008) had reached the flow characteristic of microfluidics in the hydrostatic drive. Liang Zuoxing (Z. Liang et al, 2015) had reached the dynamic gas distribution system design for a new type mixer. Hot and cold water mixer is widely used in schools, hotels, swimming pools and some large bath centers. But the flow field and temperature field are complex. How to control the outlet temperature meanwhile saving water and sources is the key problem to be solved. At present there are only a few literatures about this subject. Someone (C. Zhou et al, 2013) had studied the influences that inlet diameter, inlet velocity, inlet temperature of hot water within the mixer made on the flow field distribution and the mixed effect. But they ignored the influence that inlet pressure of hot water made on the outlet temperature. This article studied the influences that cold water inlet velocity, hot water inlet pressure made on the outlet temperature by the Fluent software. It provides the theoretical foundation for the mixer's structural design, improvement and engineering application.

2 ESTABLISHMENT OF MODEL

2.1 The establishment of physical model and mesh generation

Generate grid mesh for the structure of ejector type mixer using Gambit software as shown in figure 1. Cold water flowed into the pipes from the left side. Through the gradually reducing pipeline, it speeded up and its pressure declined. This produces vacuum degree in the throat pipe to indraft hot water into the main pipe from the hot water pipe. Hot and cold water mixed and then flowed by the right side of the pipe out at the exit. Mixer throat pipe diameter $d = 1$ cm, the main pipe diameter $D = 2$ cm, the hot water pipe diameter $d_0 = 0.8$ cm.

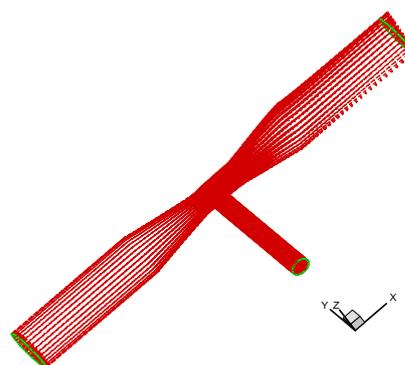


Fig.1 Mixer reseau diagram

2.2 The establishment of the mathematical model

Standard k-e turbulent model is used in this paper. Control equation are as follows:

Continuity equation

$$\frac{\partial \rho_i}{\partial t} + \nabla \cdot (\rho_i \mathbf{v}_i) = 0. \quad (1)$$

Momentum equation

$$\frac{\partial \rho_i \mathbf{v}_i}{\partial t} + \nabla \cdot (\rho_i \mathbf{v}_i \mathbf{v}_i) = -\nabla p + \nabla \cdot \mathbf{T}_i + \rho_i \mathbf{g}. \quad (2)$$

Stress tensor

$$\mathbf{T}_i = \mu_i [\nabla \mathbf{v}_i + \nabla \mathbf{v}_i^T] - \frac{2}{3} \mu_i \nabla \cdot \mathbf{v}_i \mathbf{I}. \quad (3)$$

Energy equation

$$\rho_i c \left[\frac{\partial T}{\partial t} + \mathbf{v}_i \cdot \nabla T \right] = \nabla \cdot [k \nabla T]. \quad (4)$$

3 RESULTS AND DISCUSSIONS

Cold water inflow velocity $V_{in} = 1 \text{ m/s}$, temperature $T_{in} = 300 \text{ K}$; Hot water temperature $T_0 = 360 \text{ K}$, Hot water pipe inlet pressure $p = 0 \text{ Pa}$. Figure 2 is fluid pressure nephogram. We can see along the X axis color was changing from red to yellow, cyan transition from the picture. The pressure along the X axis direction reduced gradually. Figure 3 is fluid Temperature nephogram. In the throat pipe cold and hot water mixed. The temperature reduced gradually along the X axis direction from the throat pipe. Figure 4 (a) is x-y Velocity nephogram and figure 4 (b) is x-z Velocity nephogram. Figure illustrated the transition is from green to yellow, red color. We can Judge that cold water accelerated in the throat pipe according to it.

Keep the inlet pressure of the hot water 0 pa, other conditions unchanged. Set the inlet velocity of the cold water of 1 m/s, 2 m/s, 3 m/s, 4 m/s, 5 m/s in turn, monitoring the temperature of the export water. And then change the hot water inlet pressure to 1 m water column, and then in turn set the cold water inlet velocity of 1 m/s, 2 m/s, 3 m/s, 4 m/s, 5 m/s, monitoring the temperature of the export water. Then change the hot water inlet pressure to 2 m water column, and then in turn set the cold water inlet velocity of 1 m/s, 2 m/s, 3 m/s, 4 m/s, 5 m/s, monitoring the temperature of the export water. According to this method, in turn, change the hot water inlet pressure to 3 m, 4 m water column, 5 m water column. Use Fluent software to simulate mixed flow export water temperature and the temperature change law is shown in figure 5.

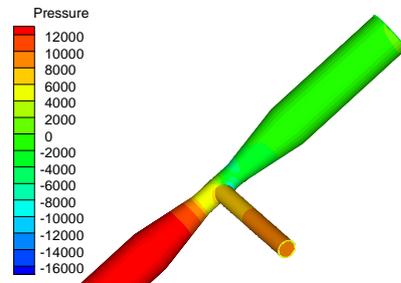


Fig.2 Pressure distribution

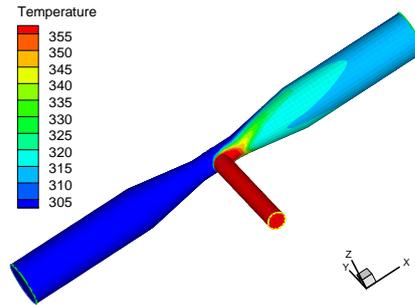
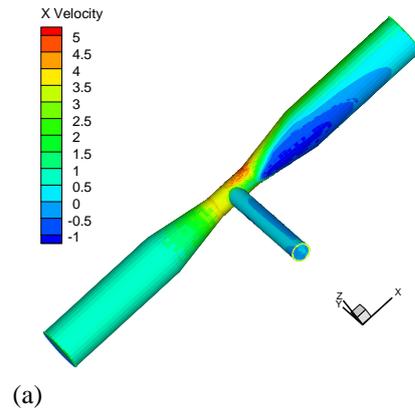
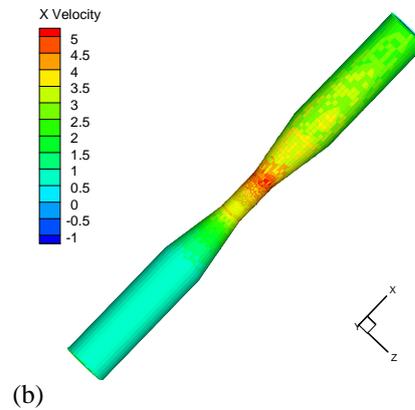


Fig. 3 Temperature nephogram



(a)



(b)

Fig.4 Velocity distribution in different planes (a) X-Y plane, (b) X-Z plane

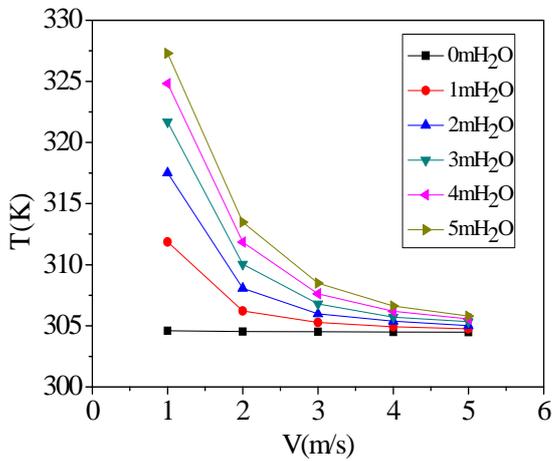


Fig.5 Outlet temperature with different inlet speeds on different pressures diagram

By different pressure outlet temperature along with the change of the cold water inlet velocity curve shows that in the case of the cold water inlet velocity is constant. With the increasing of hot water inlet pressure, outlet temperature also increases. And the greater the cold water inlet velocity is, under the same pressure difference, the amplitude of the increase of the outlet temperature is smaller.

Under the condition of the constant pressure, with the increase of the cold water inlet velocity, the outlet temperature declined. In addition, the figure shows that curve slope is reduced. That is, temperature decrease rate is decreasing, the curve gradually becomes level, and the temperature drop rate gradually tends to zero. Therefore, when the cold water and hot water are in the mixed flow apparatus under the condition of constant temperature, with the cold water inlet velocity increasing, ultimate outlet temperature tends to a certain value.

4 CONCLUSION

In this paper, by using the Fluent software to carry out the three dimensional numerical simulation of the fluid in the mixed flow ejector in observation and analysis of the internal flow field and temperature field. And analyzed the influence that cold water inlet velocity, hot water inlet pressure these two factors made on the fluid outlet temperature in the mixer. And then come to the conclusion as follows:

(1) In the case that the cold water inlet velocity is constant, with the increasing of hot water inlet pressure, outlet temperature also increases. And the greater the cold water inlet velocity is, under the same pressure difference, the amplitude of the increase of the outlet temperature is smaller.

(2) In the case of constant pressure, with the increase of the cold water inlet velocity, the outlet temperature is declining. And with the cold water inlet velocity increasing, the final outlet temperature tends to a certain value.

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