Numerical Simulation of Temperature Field of Tee Pipe in Marine Fresh Water Cooling System

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Abstract

The engine in the ship is an important guarantee for the operation of the ship. To ensure the stable operation of the ship’s engine, a normal temperature is required, and the engine emits heat during operation. Therefore, the fresh water cooling system of the ship is a necessary equipment for the operation of the ship. The piping is very important for the numerical simulation of temperature field.

Keywords

Tee Pipe; Numerical Simulation; Temperature.

1. Introduction

1.1 Background of topic selection

The engine in the ship is an important guarantee for the operation of the ship. To ensure the stable operation of the ship’s engine, a normal temperature is required, and the engine emits heat during operation. Therefore, the fresh water cooling system of the ship is a necessary equipment for the operation of the ship. The piping is very important for the numerical simulation of temperature field. Therefore, the discussion and research on the numerical simulation of the temperature field of the marine fresh water cooling system tee tube in this subject is of great significance for both actual production and theoretical discussion.

1.2 Introduction to marine fresh water cooling system

The ship's fresh water cooling system is a system used on ships to cool engines and other equipment, including three-way valves, expansion tanks, high and low fresh water coolers, high temperature fresh water valves, and oil coolers. The main cooling part is the piston and cylinder of the engine, as shown in Figure 1.1.

1.3 Research content and objectives

This subject mainly simulates the flow field inside the temperature field of the marine fresh water cooling system tee. Numerical simulation is performed through ANSYS modeling and simulation to calculate the temperature and pressure distribution inside the tee. Then use Fluent software to simulate the temperature field. After calculation, the temperature vector cloud diagram and pressure distribution cloud diagram of the three-way tube are obtained, and finally presented in the form of a paper. By simulating the three-way pipe in the fresh water system of a ship, the temperature inside the three-way pipe can be clearly shown, such as pressure distribution and temperature distribution, and the temperature loss inside the pipe and the pressure change at the branch and connection can be seen. In the actual production process, it has a guiding role in the design of the three-way pipe of the ship's fresh water cooling system system, and also has reference value for related temperature field experiments.

2. Calculation of important characteristic parameters of tee pipe

2.1 Pipeline classification and material selection

According to the design temperature and design pressure, three-way pipes can be divided into three types. Different types of pipes need to be selected according to different engines. The specific classification rules can be seen in Table 2.1. This article is a temperature simulation of a low-speed diesel engine, so the first-class piping system is selected.

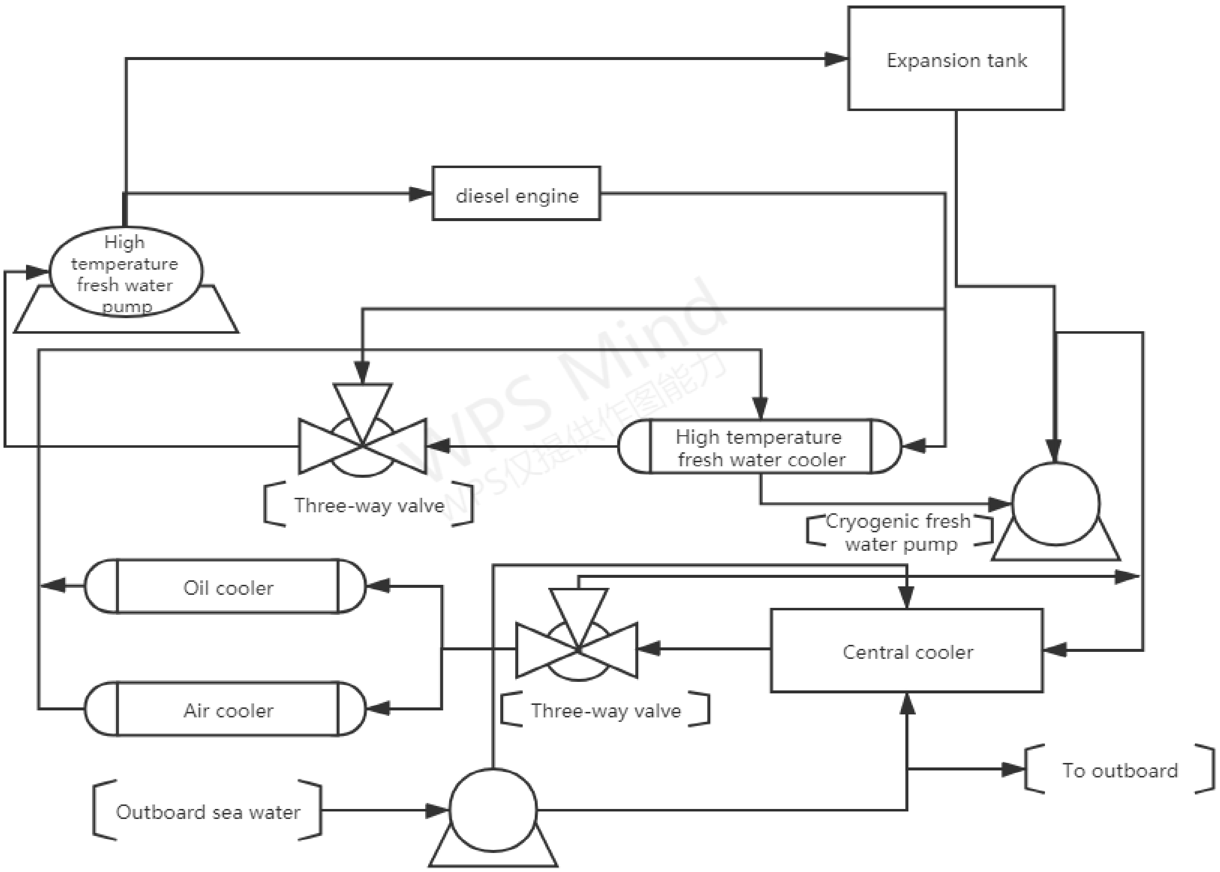

Figure 1.1

Table 2.1

grade	I		II		III	
Pipeline	Design pressure /MPa	set tempreture /℃	Design pressure /MPa	set tempreture /℃	Design pressure /MPa	set tempreture /℃
Steam and hot kerosene	>1.6	>300	≦1.6	≦300	≦0.7	≦170
Fuel oil	>1.6	>150	≦1.6	≦150	≦0.7	≦60
Other medium	>4.0	>300	≦4.0	≦300	≦1.6	≦200

2.2 Temperature design

Determining the temperature is an important part of the numerical simulation of the temperature field. The temperature needs to be continuously mixed and tested to achieve a temperature that can reduce temperature loss and save costs, and reach a temperature that meets the cooling requirements, so that the ship's engine can work stably.

The temperature can be determined according to the "Ship Design Practical Manual", the specific temperature design can refer to Table 2.2

Table 2.2

Diesel engine type	temperature range	Temperature difference between inlet and outlet
Medium and high speed diesel engine	70℃~80℃	12℃
Low speed diesel engine	60℃~70℃	

2.3 Pipe diameter design

The pipe diameter can be calculated according to the velocity of the fluid in the tee pipe. The specific formula is as follows: $d_i = 0.0188\sqrt{\frac{q_v}{v}}$ or $d_i = 0.0188\sqrt{\frac{q_m}{v}}$

di—the inner diameter of the pipe (m);

qv—volume flow rate (m3/h);

v—The fluid velocity in the pipe (m/s).

qm—mass flow rate (kg/h);

ρ—fluid density (kg/m3);

It can be seen from the above table that the flow velocity range of the suction pipe and the discharge pipe of the fresh water cooling pipe are both 1.2~2.7m/s, and 2m/s is selected here. According to the ship task design book, the volume flow rate of the first inlet is 80m3/h, and the volume flow rate of the second inlet is 40m3/h. According to the above formula, the inner diameter of the pipe is 120mm and 85mm respectively.The size of the three-way pipe is shown in Figure 2.3

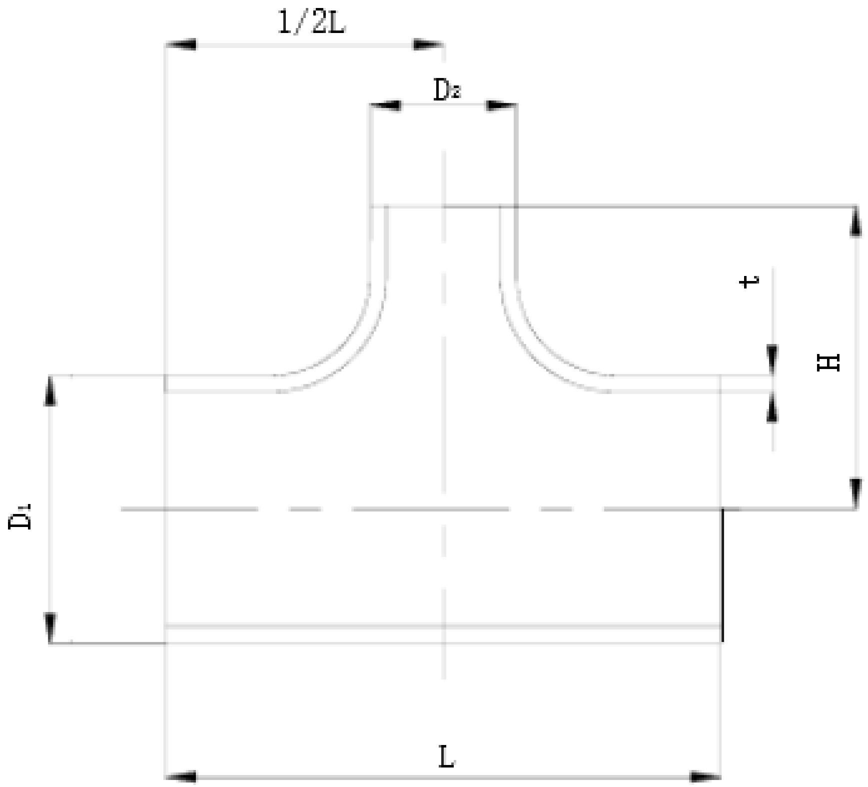

Figure 2.3

3. The model is based on assumptions

3.1 Build a computational domain model

The numerical simulation of the temperature field of the three-way pipe in the marine fresh water cooling system is a simulation of the internal flow field of the three-way pipe, and the calculation domain model of the flow field can be established without ignoring the wall thickness. This paper chooses the piping modeling of the tee in the marine fresh water cooling system, and the model is shown in Figure 3.1

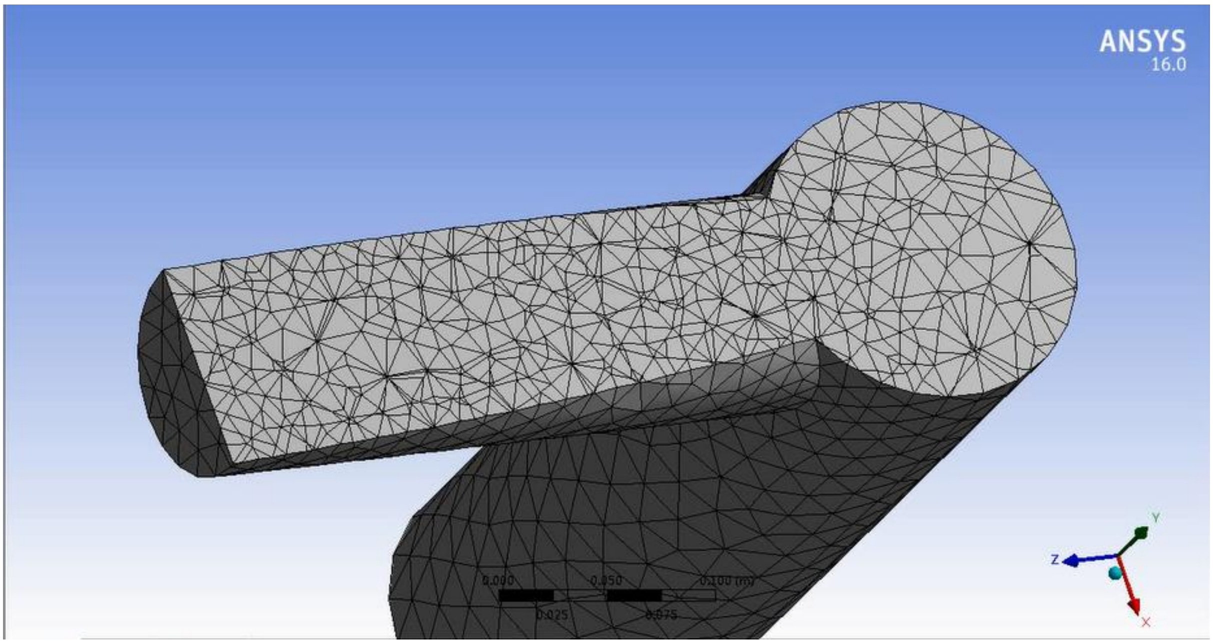

Figure 3.1

In the pipeline, the flow velocity of the fluid close to the pipe wall is approximately equal to zero. Therefore, when the pipe is gridded, the grid of the pipe wall is rectangular, and the flow area in the middle is triangular.

3.2 Numerical analysis of fluid in tee pipe

For the established model, the following assumptions are made:

(1) The cooling water is a continuous medium fluid, and the fluid flow is turbulent.

(2) In the two inlets, set Velocity Magnitude=0.3m/s, Turbulent Intensity=5%, Hydraulic Diameter =0.15m, Temperature=40℃ as the boundary conditions, and most of the boundary conditions can choose the default value After calculation, the flow monitoring diagram is obtained, as shown in Figure 3.2

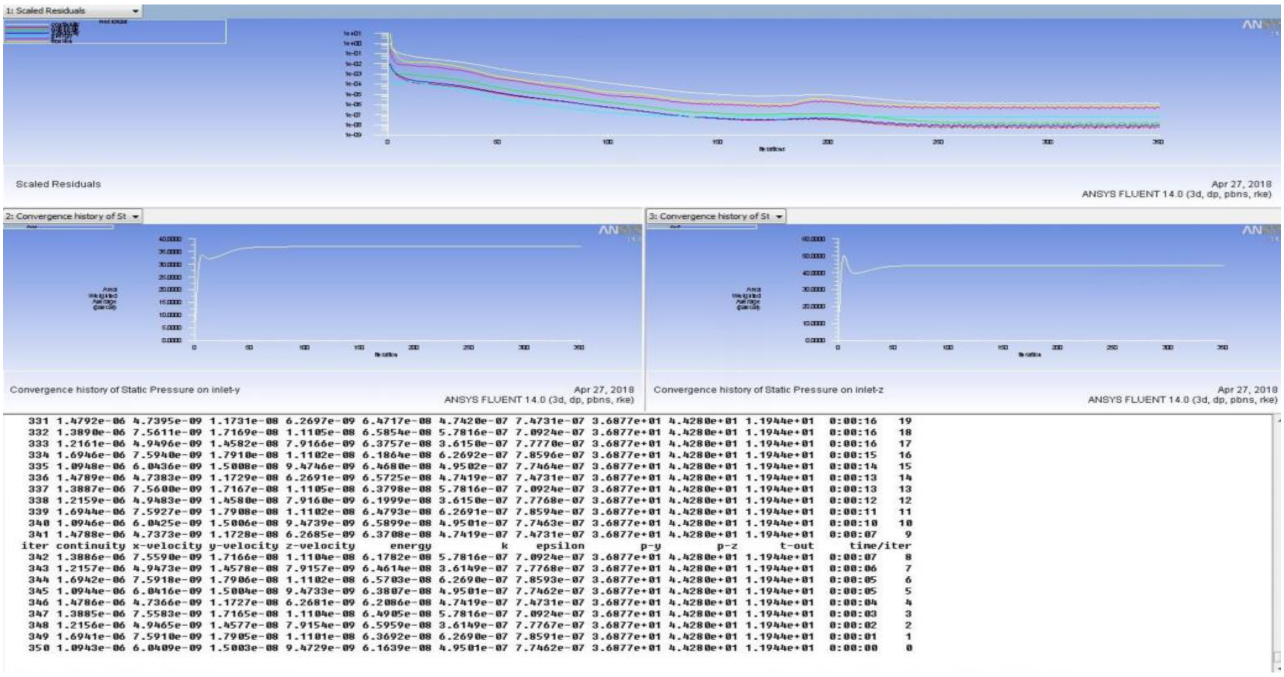

Figure 3.2

4. Results analysis and discussion

The Figure 4.1 shows the pressure distribution nephogram of the tee pipe installation. The red part represents high pressure, and the blue part represents negative pressure. It can be seen from the figure that the pressure on the upper part of the tee pipe is large, resulting in negative pressure at the joint. When two streams of fluid with different pressures flow through the same pipe, the pressure is the minimum at the junction of the pipeline and reaches the maximum at the end of the pipe.

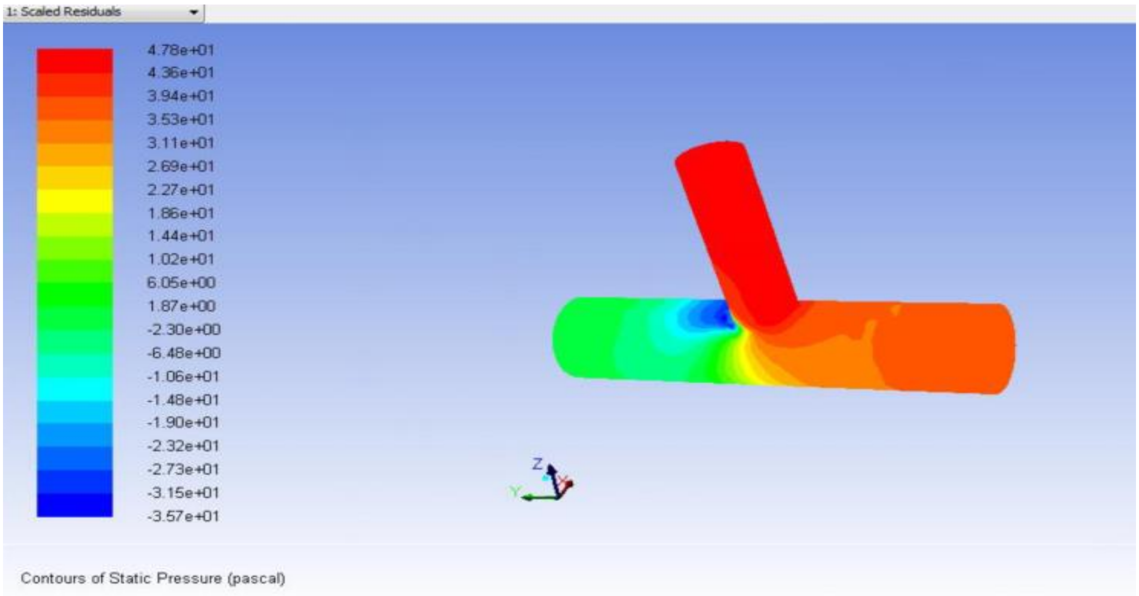

Figure 4.1

The Figure 4.2 shows the temperature distribution nephogram of tee pipe. Red represents the high temperature part, and blue represents the low temperature part. Two streams of fluid with different temperatures flow through the same pipe after mixing, and the longer the pipe is, the closer the outlet fluid temperature is to the average value

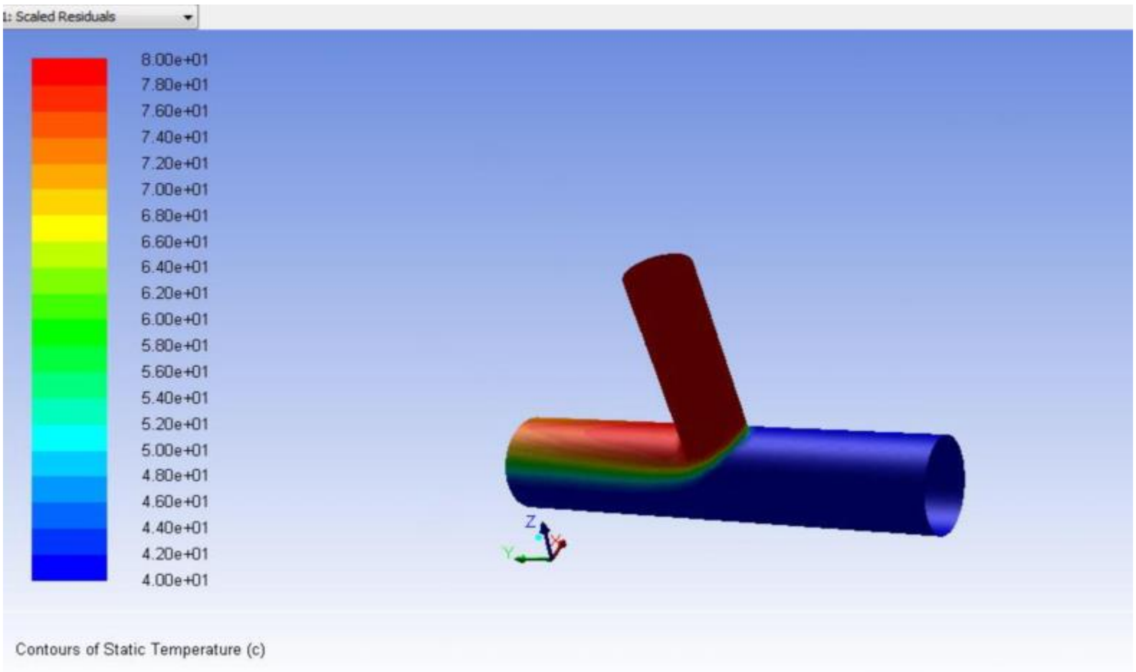

Figure 4.2

The Figure 4.3 shows the velocity vector nephogram of the three-way pipe. The upper part of the three-way pipe is the inlet of hot fluid. The internal temperature is higher, the molecules are more chaotic and the flow rate is larger. At the junction of the hot and cold fluid convection heat transfer, resulting in a stepped temperature field and velocity field, effective control of the flow rate can achieve the purpose of enhancing heat transfer.

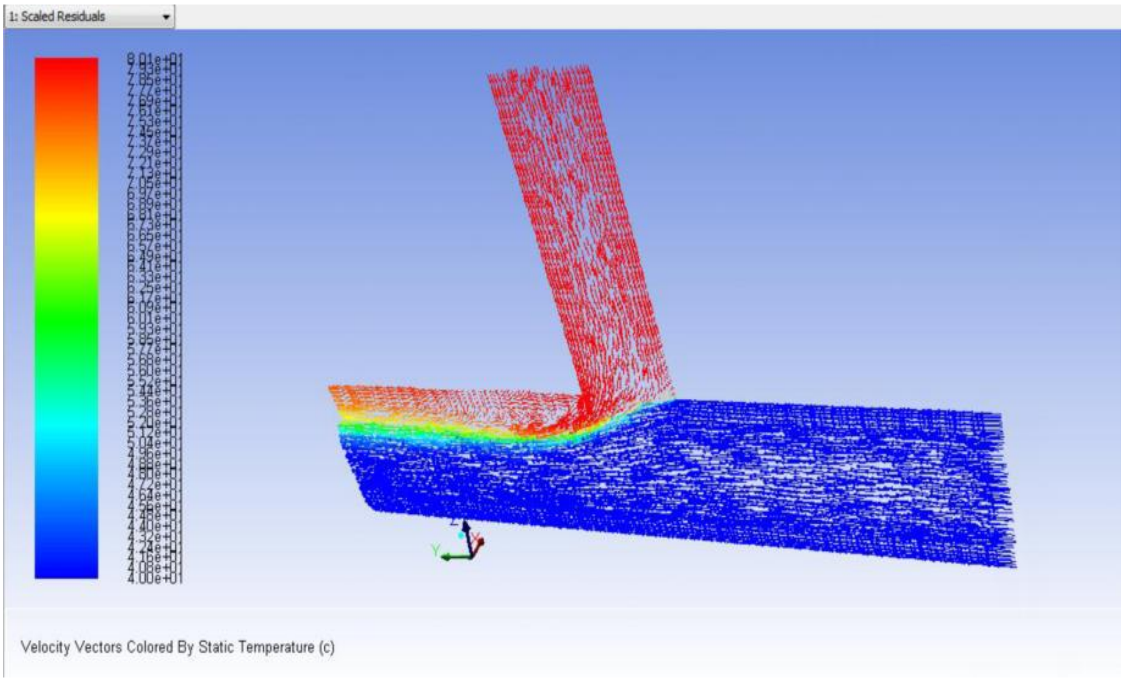

Figure 4.3

5. Summary

A set of three-way pipe device used in ship fresh water cooling system is designed. ANSYS software is used for modeling and meshing, and fluent software is used for simulation calculation

(1) When two streams of fluid with different pressures flow through the same pipe after mixing, the pressure is the minimum at the junction of the pipe and the maximum at the end of the mixing pipe.

(2) After mixing, two streams of fluids with different temperatures flow through the same pipe. After mixing, the temperature is between them. The longer the pipe is, the closer the outlet fluid temperature is to the average value.

(3) Two streams of fluid with different velocities flow through the same pipe after mixing. Through the numerical analysis of velocity length, temperature field and pressure field of tee pipe by fluent, the corresponding distribution diagram is obtained

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