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Analysis of Fluid Flow Characteristic with Different Temperature and Different Methods in T-junction Pipe

Muhammad Ilhamni Uluumal Hikam [1], Nasrul Ilminnafik[2]*, Muh. Nurkoyim Kustanto [3], Gaguk Jatisukamto[4], Yuni Hermawan[5].
[1]Universitas Jember, Indonesia, 211920101002@mail.unej.ac.id
[2]Universitas Jember, Indonesia, nasrul.teknik@unej.ac.id
[3]Universitas Jember, Indonesia, nurkoyin@unej.ac.id
[4]Universitas Jember, Indonesia, gaguk.ft@unej.ac.id
[5]Universitas Jember, Indonesia, yunikaka@unej.ac.id

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ABSTRACT

Thermal fatigue is a material deterioration caused by temperature. Thermal fatigue or commonly referred to as Thermal Fatigue is a potential risk in the piping system, it can occur in the mixing flow at the T-junction. Thermal fatigue depends on the magnitude of the frequency, location, temperature attenuation, and the ratio of the angular flow velocity of the branch pipe to the main pipe. T-joint pipe is the most common piping system structure and is widely used in industrial fields such as petrochemical, marine, nuclear and so on. The research method used is experimentation and simulation using the Ansys student 2021 software with the Realizable method. The results showed that the experimental and simulation results were different but had a graphical tendency. The experimental results showed that the highest temperature was found at a speed of 0.8 m/s at the inlet hot was 35°C, while the simulation results showed a flow velocity of 0.8 m/s at the inlet hot reaches a temperature of 41°C at the right side of the thermocouple 250mm from the lip of the outlet. Flow characteristics with maximum variable temperature distribution, resulting from the ratio of the difference in velocity of cold inlet flow of 0.2 m/s with a diameter of 56mm and hot inlet flow of 0.8 m/s with a pipe diameter of 19mm.

Key words : Thermal Mixing, T-Junction, Fluid, Fatigue, Thermal

1. INTRODUCTION

Thermal fatigue is a material deterioration caused by temperature. Thermal fatigue or commonly referred to as Thermal Fatigue is a potential risk in the piping system, it can occur in the mixing flow at the T-junction [1]. Thermal fatigue depends on the magnitude of the frequency, location, temperature attenuation, and the ratio of the angular flow velocity of the branch pipe to the main pipe [2]. T-joint pipe is the most common piping system structure and is widely used in industrial fields such as petrochemical, marine, nuclear and so on [2]. T-junction is a structure that can divide one flow into two outlet streams. [5]. T-Connection Pipes are applied to materials that match the conditions of the flowing fluid, such as PVC pipes which are commonly used to drain household waste. T-junctions are typically designed in industrial piping systems to divide or combine fluid flows of different temperatures, different densities, or different concentrations [2]. According to the type, the structure of T-joints is divided into two, branched T-joints and impact T-joints [5]. The T-junction is widely used as a phase separation component to separate two-phase flows because of its simple structure and low cost. Tests with constant flow ratio and temperature difference were carried out to investigate temperature fluctuation near the wall, velocity profile and mixing process at the T-junction made of acrylic glass. Vattenfall method T-junction experiments were carried out in an acrylic glass setup with a temperature at main inlet flow of 36°C and branch inlet flow of 19°C [7]. Experimental data has been used for CFD simulation. T-joint pipe systems are widely used due to their simple function and construction. Research on T-connection pipes has been carried out experimentally and in simulations with various variables. However, simulation research with differences in speed and angle has not been studied much. The temperature difference of 30°C is the focus and differentiator from previous studies. Therefore, the purpose of this research is to observe and explore the effect of flow velocity in branch pipes at different angles on the character of fluid flow by simulating the K-epsilon Standard Realizable model.

2. METHODOLOGY

The research analysis on the character of fluid flow with angle variations is designed in the CFD Fluent software and performs the specified fluid material settings. In addition to using the simulation method, this study uses the experimental method as validation. Figure 1 shows the geometry of the ansys, the main pipe diameter is 56mm and the branch pipe diameter is 19mm. The main pipe flow rate is 0.2 m/s and the branch pipe flow rate is 0.8 m/s.

Figure 1: Geometry T-Junction 90°

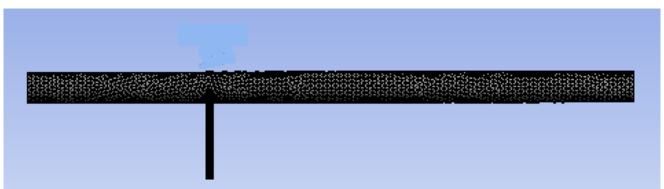

Figure 2: Meshing T-Junction 90°

3. RESULT AND DISCUSSION

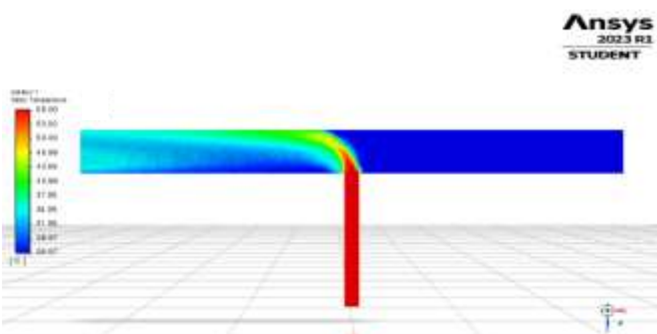

Figure 3: Temperature Distribution on 90°

Figure 3 is the visual result of the temperature distribution simulation from the variation of the 90° T-joint pipe angle. The cold inlet speed in this simulation is 0.2 m/s with a main pipe diameter of 56mm and a hot inlet speed of 0.8 m/s with a pipe diameter of 19mm. The simulation results show that the highest temperature reaches 43°C in the main pipe after the mixing of different temperatures occurs.

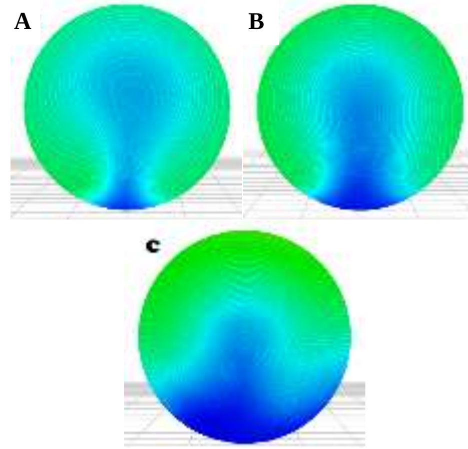

Figure 4: Temperature Distribution (A) 100mm from T-Junction (B) 175mm from T-Junction (C) 250mm from T-Junction

The visual simulation results in Figure 4 show that a hot inlet flow velocity of 0.8 m/s almost complete mixing is visible at 100mm from the T-junction. The temperature distribution of the mixture almost spreads to almost all parts of the main pipe, this is due to the hot inlet flow velocity hitting and hitting the diagonal axis of the cold inlet flow, resulting in mixing and the flow character becomes turbulent.

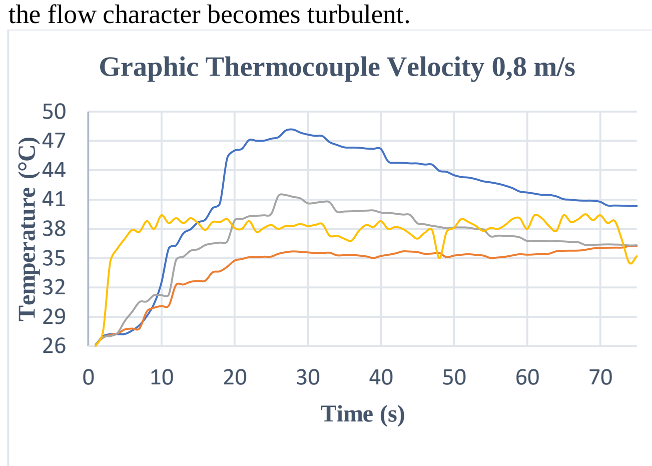

Figure 5: Graphic Temperarture Distribution Experiment and Simulation

Figure 5 is a graph of the simulation data and experimental research results. The blue line is the data for the location of the 100mm thermocouple from the T-junction, then the gray line is the data result line for the location of the 175mm thermocouple from the T-junction, the red line shows the data for the location of the 250mm thermocouple from the T-junction and the yellow line is the result of the data experimental hot inlet flow velocity of 0.8 m/s. The highest temperature reaches 48°C at the thermocouple position 100mm after the T-junction. Differences in experimental and simulation results could be due to data collection conditions that could not reach perfect words.

The Reynolds number is a number that can indicate the pattern of fluid flow. The results of Reynold's calculation on speed variations are as follows:

$$\text{Re} = \frac{\rho u D}{\mu}$$
$$= \frac{997{,}2\, {kg}/{m^3}\ X\ 0{,}8\, {m}/{s}\ X\ 0{,}056\ m}{0{,}9\ X\ 10^{-3}\, {Ns}/{m^2}}$$
$$= 49.643 \text{ (Turbulent)}$$

The moment ratio is the ratio of the main pipe moment and the branch pipe moment (3). The moment ratio is the result of calculating the formula that shows the characteristics of fluid flow with collisions.

$$M_m = D_m \text{ x } D_b \text{ x } \rho_m \text{ x } V_m^2$$
$$= 0{,}056 \text{ m x } 0{,}019 \text{ m x } 997{,}2 \text{ kg/m}^3 \text{ x } 0{,}8^2 \text{ m/s}$$
$$= 0{,}679053$$
$$M_b = \frac{\pi}{4} \text{ x } D_b^2 \text{ x } \rho_b \text{ x } V_b^2$$
$$= \frac{\pi}{4} \text{ x } 0{,}019^2 \text{ m x } 997{,}2 \text{ kg/m}^3$$
$$= 0{,}2825$$
$$MR = \frac{Mm}{Mb} = \frac{0{,}679053}{0{,}2825} = 2{,}403727 \text{ (\textit{Wall Jet})}$$

4. EDITORIAL POLICY

The submitting author is responsible for obtaining agreement of all coauthors and any consent required from sponsors before submitting a paper. It is the obligation of the authors to cite relevant prior work.

5. CONCLUSION

Flow velocity affects the character of the mixed fluid flow in the pipe near the outlet. It is evident that according to the calculation of the moment ratio and Reynolds number, the calculation is influenced by flow velocity, the character of each variation is different. flow speed of 0.8 m/s produces MR 2.403727 so it is called Wall Jet. The Reynolds number shows that the character of the flow is turbulent, as evidenced by the calculation of variations in the branch pipe velocity of 0.8 m/s reaching more than 4000.

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