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Flow visualization pattern on sharp edge T-junction through dividing flow channel

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Abstract

In the previous study, sharp edge T-junction had been investigated to determine head losses and flow pattern. In this study, sharp edge T-junction was used as inlet flow model scale to determine flow visualization pattern. The apparatus test provide a dividing flow channel on static conditions which is the inlet pressure larger than 1 atm. Pressure difference is measured by using a U-pipe manometer. The manometer was inserted between inlet and outlet. Flow rate is measured by collecting fluid into a measuring cup. The coefficient of losses is determined as a result for predicting the losses energy. Flow Visualization Pattern is one of solution to perform the mechanism of sharp edge T-junction as inlet flow model scale. The result shows that flow pattern from simulation has the same trend with experimental results. © (2014) Trans Tech Publications, Switzerland.

Author keywords

Dividing flow channel; Inlet flow model scale; Sharp edge; Static apparatus test; T-junction

Indexed keywords

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Engineering controlled terms: Channel flow; Flow patterns; Flow rate; Inlet flow; Manometers

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Flow Visualization Pattern on Sharp Edge T-Junction through dividing flow channel.

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Keywords: T-junction, inlet flow model scale, dividing flow channel, static apparatus test, sharp edge.

Abstract. In the previous study, sharp edge T-junction had been investigated to determine head losses and flow pattern. In this study, sharp edge T-junction was used as inlet flow model scale to determine flow visualization pattern. The apparatus test provide a dividing flow channel on static conditions which is the inlet pressure larger than 1 atm. Pressure difference is measured by using a U-pipe manometer. The manometer was inserted between inlet and outlet. Flow rate is measured by collecting fluid into a measuring cup. The coefficient of losses is determined as a result for predicting the losses energy. Flow Visualization Pattern is one of solution to perform the mechanism of sharp edge T-junction as inlet flow model scale. The result shows that flow pattern from simulation has the same trend with experimental results.

Introduction

T-junction channel is a common device in pipeline system, chemical engineering and engineering construction. In the previous study, T-junction channel had been investigated to determine head losses and flow pattern. [1] developed computational method for the prediction of incompressible flow in two-dimensional T-junction. [2] compared the numerical and experimental of a 90^o bifurcation that it can be concluded in the vertical branch region especially concerning the streamwise velocities. [3] was performed a large eddy simulation to verify its prediction capability to the comples turbulent flow in the T-junction and to investigate the characteristics of the vortical structures affecting the thermal fatigue in a T-junction. [4, 5, 6, 7] and [8] have been used pipes T-junction and [1, 3, 9, 2] have been used rectangular duct T-junction. [2] used rectangular duct with aspect ratio (AR) of 1:1 (40 mm x 40 mm) and [10] used (AR) of 2.5:1 (70 mmx30mm) for straight duct. In this study, inlet flow model scaled with rectangular duct with aspect ratio (AR) of 1:10 is investigated to determine flow visualization pattern and coefficient of losses as parameter to develop pump inlet design.

Methods

Fig.1 shows the schematic diagram of the experimental setup. The height of fluid surface at upper fluid tank was 150 cm from the fluid surface at bottom fluid tank. The valve and measuring cup is used to control the flowrate and to measure the volume of fluid flow at T-junction.

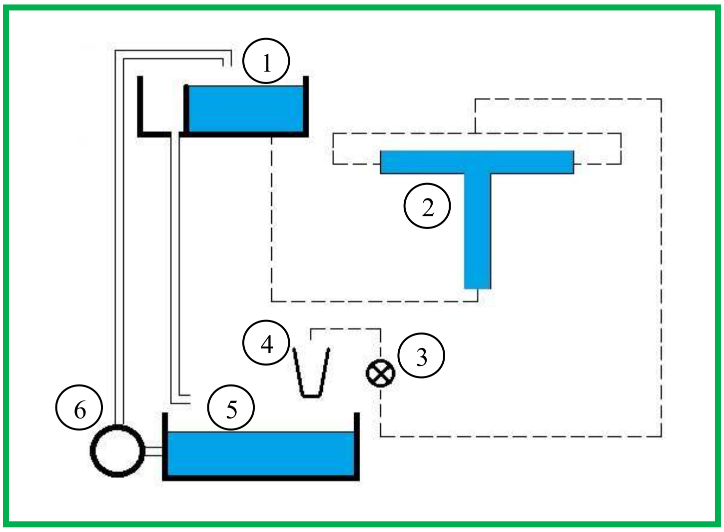

Fig. 1 Schematic diagram of the experiment apparatus : (1) upper fluid tank, (2) test T-junction, (3) valve, (4) measuring cup, (5) bottom fluid tank and (7) pump

The test section of rectangular T-junction with aspect ratio AR of 1:10 (2 mm x 20 mm) was made of clear acrilic to get visualization. Fig. 2 shows the detailed cross section area of the T-junction.

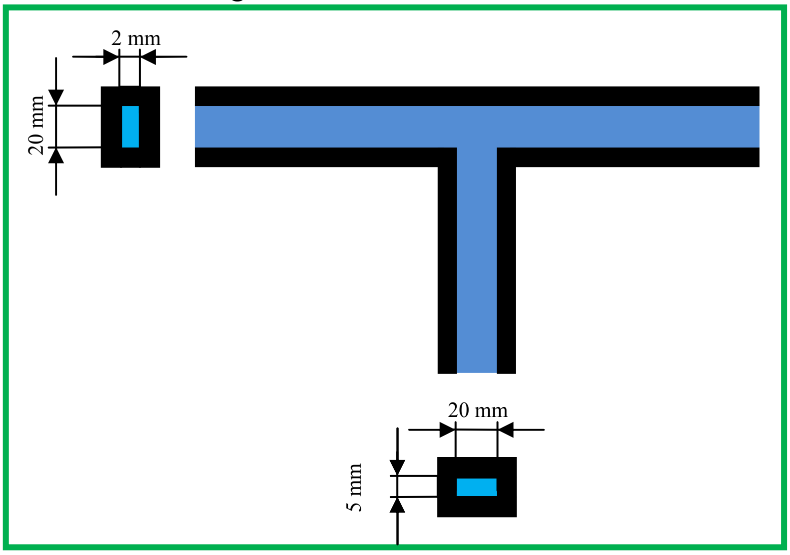

Fig. 2. Detailed dimension of the rectangular T-junction

Test Procedure is developed by several steps as described below:

1. Pre-setting
   a. The line and ducting was full-filled with water. Air in the duct is rejected through air rejection system at each outlet. The air rejection system consist of pipes with a valve as shown in Fig. 3. The valve is opened first and then closed when all of air was flowed out from the channel.
   b. Leak is measured by using the level of water after T-junction full-filled by fluid.
2. Experiment was carried out at various flow rate (Q) by operating the pump and opening the valve. Measurement of volume of water from outlet and its time is started after the manometer level is in steady condition. by a cup and stop-watch respectively.
3. Flow pattern is visualized by using camera.

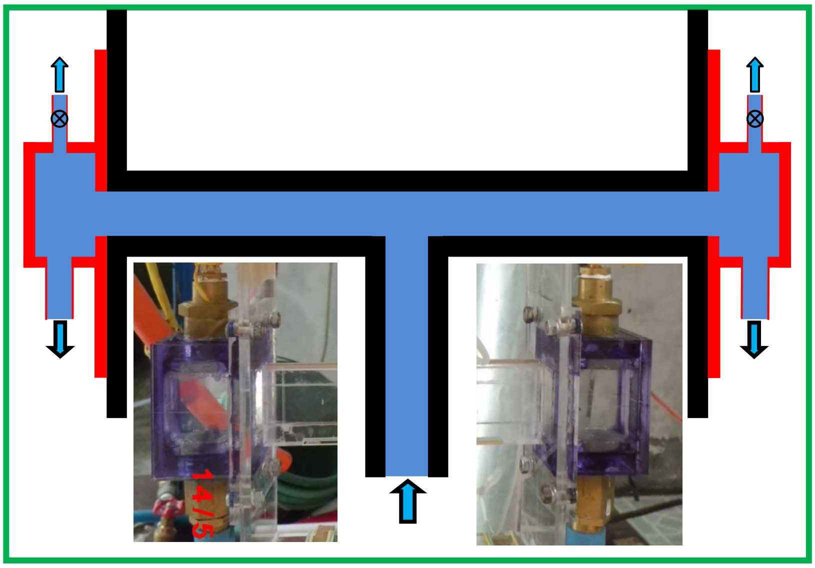

Fig. 3. The schematic diagram of the air rejection system

In this experiment it is assumed that Q in = Q out. Therefore, only Q out was measured and the leak was prevented by adjusting the level of water after T-junction fully with water. Water flow volume (VL) is measured by using measuring cup in milliliter and at the same time, time (t) is measured by using stopwatch in second. Then, the flow rate (Q) is estimated as: Q = VL/t (m^3/s), flow velocity (v)=Q/A (m/s), Losses (KL) = $\Delta P/(1/2.\rho.v^2)$ and Re = (ρ. v. d) /μ

For flow visualisation the gleeter was used as particle track to show the flow pattern and the salt was added to the water to make the fluid density was nearly the same with density of particles. Density of fluid (ρ_f) and particle (ρ_p) are 1080,27 kg/m^3 and 1270 kg/m^3 respectively. Fluid viscosity μ = 0,142007 kg/(m s).

In the simulation procedure, the first step the geometry of T-junction is modeled in CAD software. Then, it was imported to finite element method software which is ANSYS rel. 14.5. Boundary condition is set by three parts which is inlet, two outlet and wall (Fig. 4). The solver is prepared after the model and boundary condition its set.

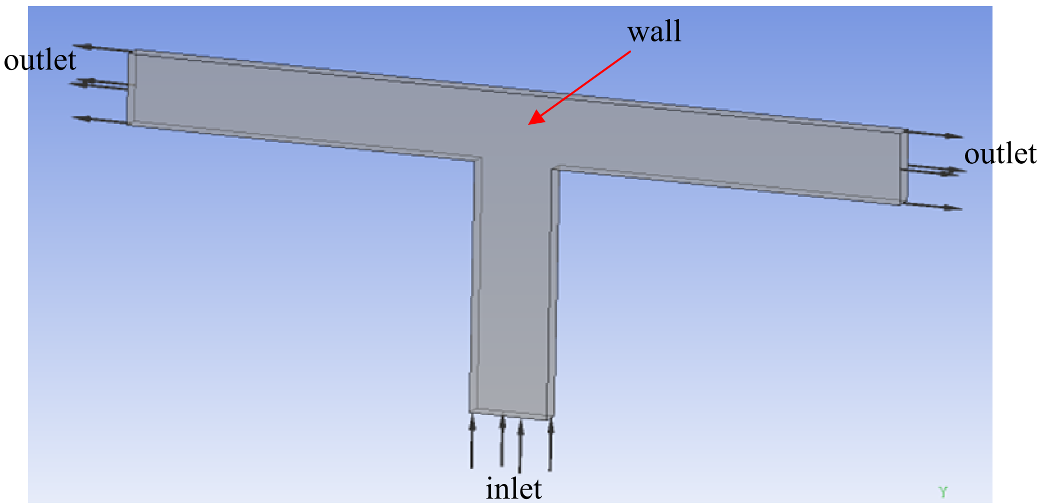

Fig. 4. Boundary condition for T-junction model

Result and Discussion

The relationship between pressure difference and flow rate on five sample repetitions is estimated from measurement data as shown in the Fig 5. The pressure difference increased liniarly as the flow is increased.

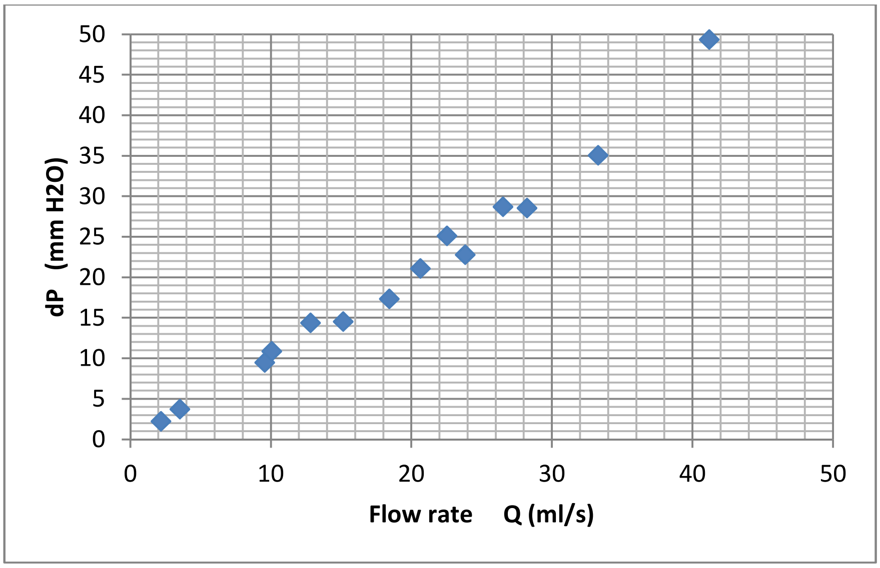

Fig. 5. Plot of ΔP – Q relationship

Flow patterns visualized by using camera and simulaton result are shown in the Fig. 6 and Fig. 7, respectively. Fig. 6a, 6b and 6c describes flow visualization pattern at V=1.08 m/s, 0.57 m/s and 0.17 m/s. Fig.7a, 7b and 7c describes flow visualization pattern on V=1.1 m/s, 0.6 m/s and 0.1 m/s. Turbulent flow (Fig. 6a, 6b, 7a and 7b) and laminar flow (Fig. 6c and 7c) are observed in the recirculation. The simulation flow pattern has the same trend with the experimental result.

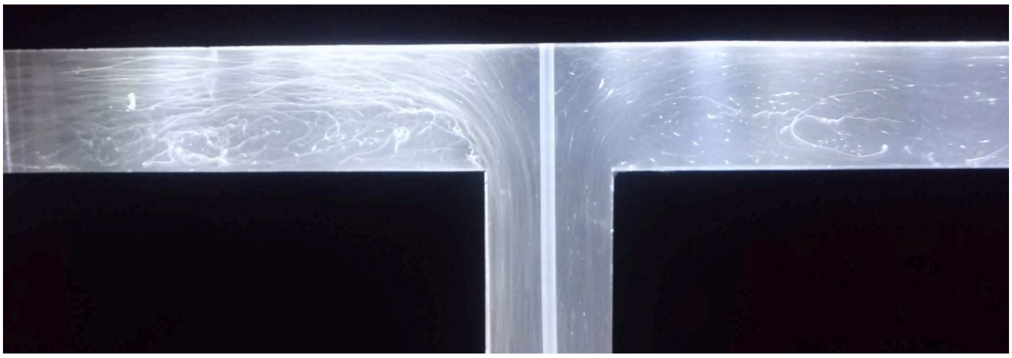

Fig.6a. Flow visualization pattern on V=1,08 m/s

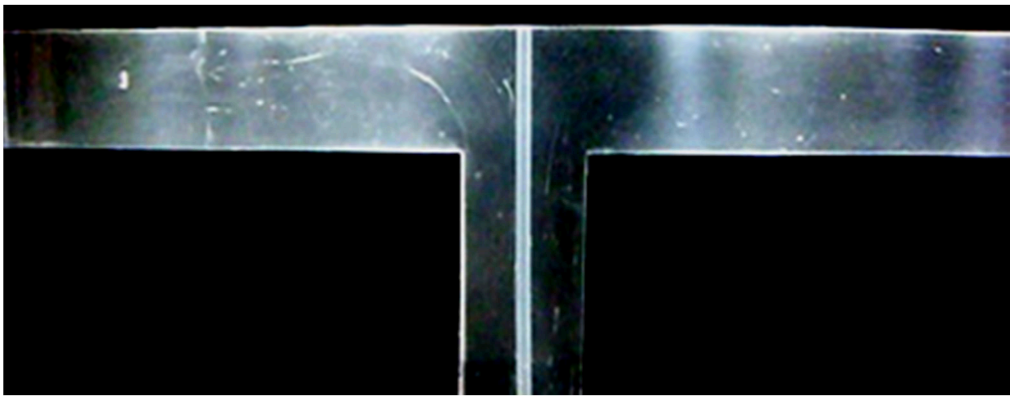

Fig.6b. Flow visualization pattern on V=0,57 m/s

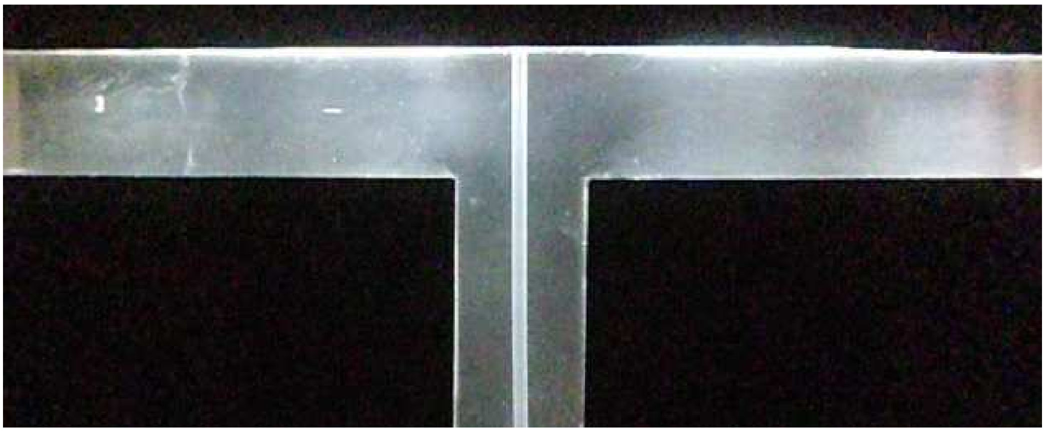

Fig.6c. Flow visualization pattern on V=0,13 m/s

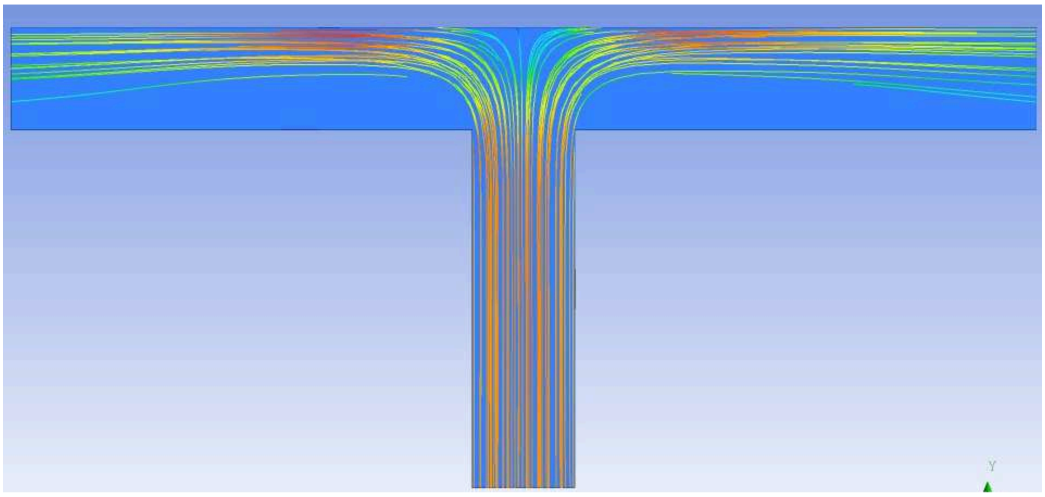

Fig. 7a. Flow visualization pattern on V=1.1 m/s

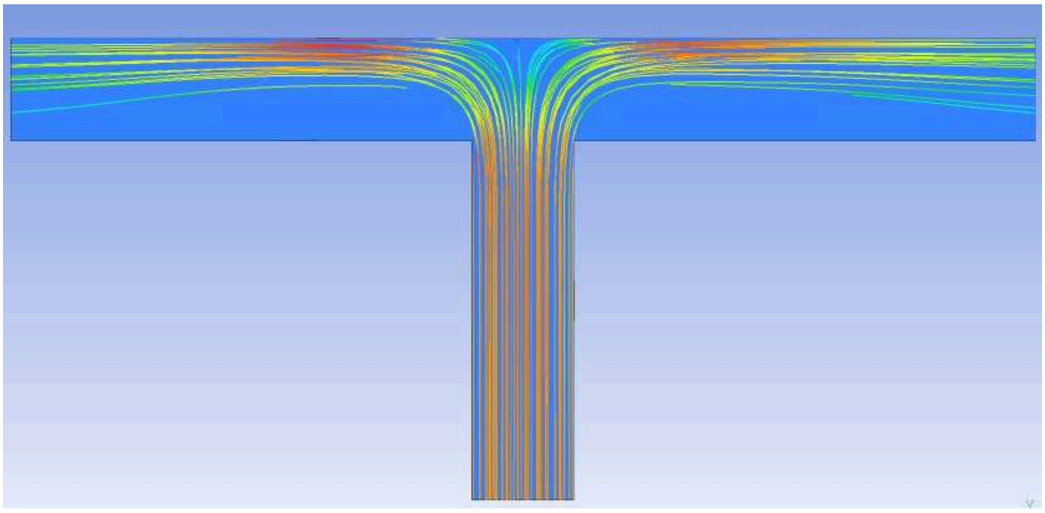

Fig. 7b. Flow visualization pattern on V=0.6 m/s

As can be seen in the Fig.6a and Fig.6b, flow visualization pattern from the inlet to limit region of elbow duct was parrallel until the horizontal channel. The centre of upper horizontal channel are stagnation region. Bottom area of otlet ducts was recirculating flow zones. In the outlet duct fluid flows at the upper region.

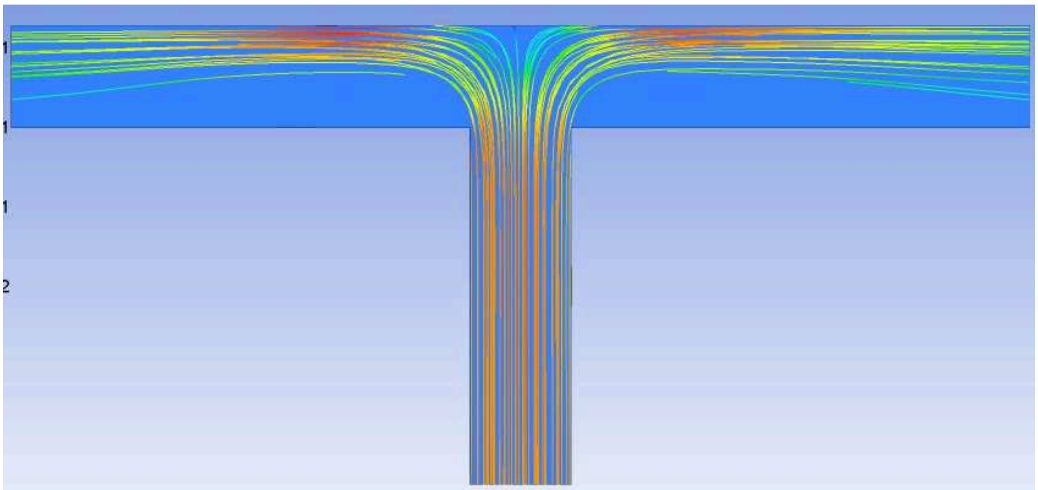

Fig. 7c. Flow visualization pattern on V=0.1 m/s

Conclusion

Computational and experiment study at dividing T-junction duct had been investigated to determine head losses and flow pattern. It is shown that the pressure difference increased liniarly as the flow rate increased. The simulation flow pattern has the same trend with the experimental result.

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