Kerosen Water Separation

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Kerosene-Water Separation in T-Junction with Orientation Upward Branch with a 60° Angle: Variation Of Diameter Ratio

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Abstract. Research on the T-junction is still underway for the flow of liquid-liquid (kerosene-water). Some research on the characteristics of kerosene-water separation was performed using T-junction oriented upward branch with a 60° angle. To observe the effect of diameters ratio on the phase separation that produced T-junction then made a test section with a horizontal pipe diameter 36 mm, while the side arm 36 mm diameter, 26 mm and 19 mm (diameters ratio of 1, 0.7 and 0.5) by using plexiglass pipe type. Based on experimental results and visualization of data flow in the test section, to the value obtained 60% water cut, the maximum separation efficiency of 94%, $F_K = 0.94$ and $F_W = 0.001$ with a diameter ratio of 1. For other diameter ratio of 0.7 and 0.5 respectively separation efficiency of 66%, $F_K = 1$ and $F_w = 0.34$ for 0.7 and separation efficiency of 84%, $F_K = 1$ and $F_w = 0.16$ for 0.5, the best value is obtained at a water cut 60% too. All the best conditions to achieve the above-stratified flow pattern.

INTRODUCTION

In applications such as piping systems in chemical processes and transport of oil and gas, often found branching-T (T-junction). At the location of offshore oil drilling, derived from crude oil exploration and offshore oil wells are still mixed with gas, water, and sand at the time of flow in the pipe. Hence, the components must be separated prior to flow to the place of destination. In general, a vessel used for the separation process, but these tools require a large space and the high price. In practical conditions that, some researchers propose an alternative, more economical and simpler to replace the task of the vessel by using T-junction. This method was chosen because of the cost of manufacturing and materials are relatively inexpensive, and it's simpler construction and installation [1].

The phenomenon of phase separation through a T-junction, both experimentally and by theoretical analysis have been carried out by the researcher for study the phenomenon of phase separation occurring in the T-junction. The method of separation of using a T-junction by Orenje which is the first introduced in 1973 to examine the separation of gas-liquid two-phase flow [4]. Based on his research revealed that the ratio of separation is influenced by various factors including the difference in pressure, the mass inertia of the fluid, the flow pattern in the upstream, and the T-junction geometry.

On the distribution of fluid flow in the T-junction is not easy to predict how much fluid is flowing into the side arm and run arm. T-junction geometry, flow pattern in the upstream, the slope of the side arm is an important variable in determining the phase separation of the gas-liquid between the arm. To make it easier to predict phenomena in the T-junction then defined eight variables related to the separation of the fluid flow rate of gas and liquid mass flow $\dot{m}_1, \dot{m}_2, \dot{m}_3$ the quality in each branch of x_1, x_2, x_3 and the pressure drop associated with the junction [5]-[6].

Study liquid-liquid phase separation is performed by [7]-[8] using the T-junction pipe horizontal position with the upward vertical orientation of the side arm. The working fluid used is kerosene and water. The results showed a high separation efficiency is achieved when the inlet flow pattern in the T-junction is stratified flow pattern. Researcher created a model to predict the occurrence of phase maldistribution in the T-junction, followed by the same research in the following year and focused on the study of stratified flow pattern with the interface and dispersed mixture. They

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stated that phase separation can be measured in terms of mass fractions, water cut, and the mixture superficial velocity on the flow pattern is different.

The effect of diameter ratio on pressure drop and phase distribution of the air-water at T-junction side arm vertical upward [6]. The study uses a horizontal inlet pipe diameter of 38.1 mm and 19 mm branch and 7.85 mm. The results show that the phase distribution of $D_3/D_1 = 0.5$ at most gas-phase flow to the side arm, and for $D_3/D_1 = 0.206$ indicates a gas phase flowing into the side arm at a low rate of extraction. Effect of diameter ratio for stratified flow towards the extraction rate in the branch can be seen in Figure 1. F_{BG} and F_{BL} were the rates of extraction of gas and liquid, and the diagonal line was the divided area of extraction. For F_{BG} and F_{BL} axis shows dominant extraction results, the nearest to the axis the most gas or liquid phase flow to the side arm.

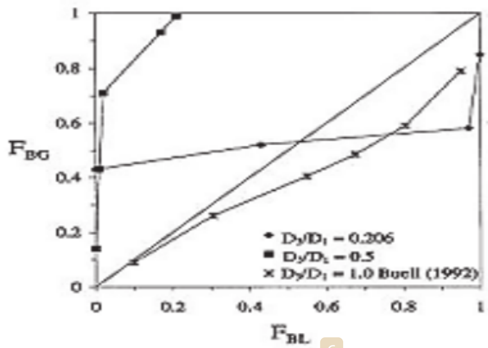

Figure 1. Influence of diameter ratio to phase separation at $J_L = 0.0021$ m/s and $J_G = 2.7$ m/s [6]

An experimental study on the influence of variation in the angle of the T-junction of the kerosene-water separation characteristics was observed [2]. Variation of angle used is 30°, 45°, 60°, and 90°. The test section using a glass pipe with a diameter of 1-inch inlet and 0.5-inch side arm. From the research reported that the flow pattern that occurs are Stratified (ST), Stratified Wavy (SW), Three Layer (3L) and Dispersed (Do/w or Dw/o). Flow pattern will change with increasing superficial velocity, and a good separation occurs in the stratified flow pattern (ST). The highest separation efficiency occurs at an angle of 90° to 64% water cut and $J_{mix} = 0.23$ m/s. The higher the value of water cut the separation efficiency will be higher.

An experimental study on the influence of variation in bend radius of T-junction of kerosene-water separation characteristic [3]. Variation of bend radius is 5 mm, 15 mm and 25 mm. Test section using a plexiglass pipe with a diameter of 36 mm horizontal pipe and 19 mm sidearm.

Reported that a good separation occurs in the stratified flow pattern (ST), and the highest separation efficiency = 99% occurs at 15 mm bend radius to 45% water cut and J_{mix} 0.42 m/s. The higher phase separation occurs at J_{mix} 0.22 m/s to 45% water cut with the value of $F_k = 1$ and $Fw = 0.07$. All of the condition research occurs at an angle 90°.

BASIC OF THEORY

Separation Efficiency

To find out the results of phase separation and optimization of operating conditions on the T-junction, then proposed a new criterion, namely the separation efficiency [8]. Before discussing the two-phase flow necessary to know some of the parameters used in this research. Subscript **1** (inlet side), **2** (run arm), and **3** (the branching/sidearm). The simplicity of this method can be seen in Figure 2.

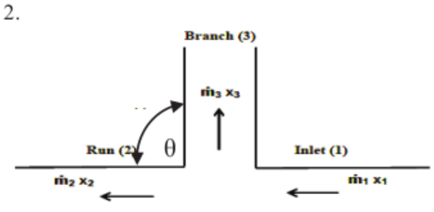

Figure 2. Two-phase flow parameters in the T-junction

In general, the results of phase separation in the T-junction is shown by using the ratio of the phase fraction of the inlet toward the left side arm, as shown in figure 3 where **k** and **w** subscript for kerosene and water phase. In figure 2, **x** is the mass of the quality of kerosene (kerosene mass flow rate ratio of the total mass flow rate) and **m** the mass flow rate.

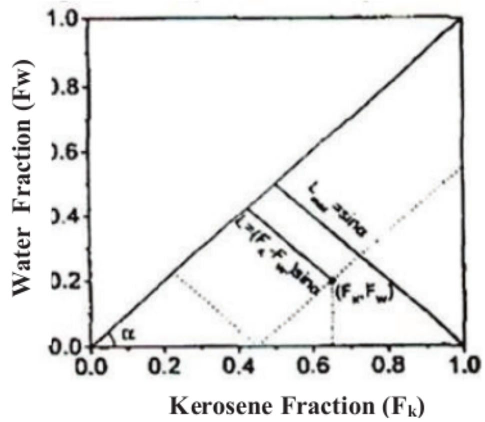

Figure 3. Criteria to demonstrate the separation phase at T-junction [7]

The fraction of kerosene and water leaving the inlet to the side arm can be written:

$$F_k = \frac{\dot{m}_{k3}}{\dot{m}_{k1}} \tag{1}$$

$$F_w = \frac{\dot{m}_{w3}}{\dot{m}_{w1}} \tag{2}$$

$$L = (F_k - F_w)\,.\sin\alpha \tag{3}$$

$$\eta = \frac{L}{L_{maks}} = |F_k - F_w| \tag{4}$$

Ideal Separation

Efficiency occurs when the ideal (100%), then the fraction of mass that goes into the sidearm can be written as:

$$\frac{\dot{m}_3}{\dot{m}_1} = x_1 \tag{5}$$

Ideal for first-line separation, pure kerosene in the side arm and the resulting mixture to flow into the run. This means that the fraction of water in the branch w = 0 and the quality of the mass of kerosene $x_3 = 1$. Then an equation for this line can be written:

$$\eta = F_k = \frac{1}{x_1}\frac{\dot{m}_3}{\dot{m}_1}\left(\frac{\dot{m}_3}{\dot{m}_1} \leq x_1\right) \tag{6}$$

For the ideal separation line, pure water run out onto the arm while a mixture of the side arm. This means the quality of the mass of kerosene in the run $x_2 = 0$. The equation for this line can be written:

$$\eta = 1 - F_w = -\frac{1}{(1-x_1)}\frac{\dot{m}_3}{\dot{m}_1} + \frac{1}{(1-x_1)}\left(\frac{\dot{m}_3}{\dot{m}_1} \geq x_1\right) \tag{7}$$

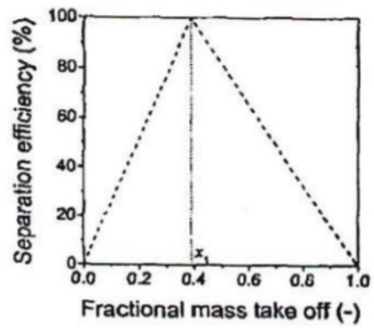

Figure 4. Presentation method of separation efficiency and the ideal separation [6]

To identify the optimal flow conditions up to the side arm is then disaggregated data is described as the separation efficiency (η) versus the mass fraction to the side arm (m_3/m_1) as shown in figure 4. Data residing on the left diagonal line represents in eq 6 and the data residing on the right represents in eq 7. The line cutting both diagonal shows ideal separation.

RESEARCH METHOD

Schematic diagram of experimental is shown in figure 5. Pipes made of materials plexiglass, pipe diameter 36 mm horizontal and vertical pipe diameter 36 mm, 26 mm and 19 mm with orientation 60° upward. Comparison of pipe diameters (D_3/D_1) of 1, 0.7 and 0.5. The working fluid used is water with ρ = 998 kg/m^3 and kerosene with ρ = 819 kg/m^3. In the beginning, water pumped from the holding tank into the pipeline until full; then kerosene is pumped from the holding tank into the drain so that water and kerosene will be mixed in the mixing area. After water and kerosene are mixed in the mixing area, and flow rate are both set by using a valve and measured by a flow meter water and kerosene with a scale value according to the test matrix. The flow of the mixture then flows into the test section. Once the flow of constant retrieval data then performed for several parameters, namely testing the water and kerosene level (volumetric tube) which inside the side arm and run arm (in volumetric per unit time). Flow pattern is obtained too from flow visualization using the recorded camera on the inlet and branching T-junction.

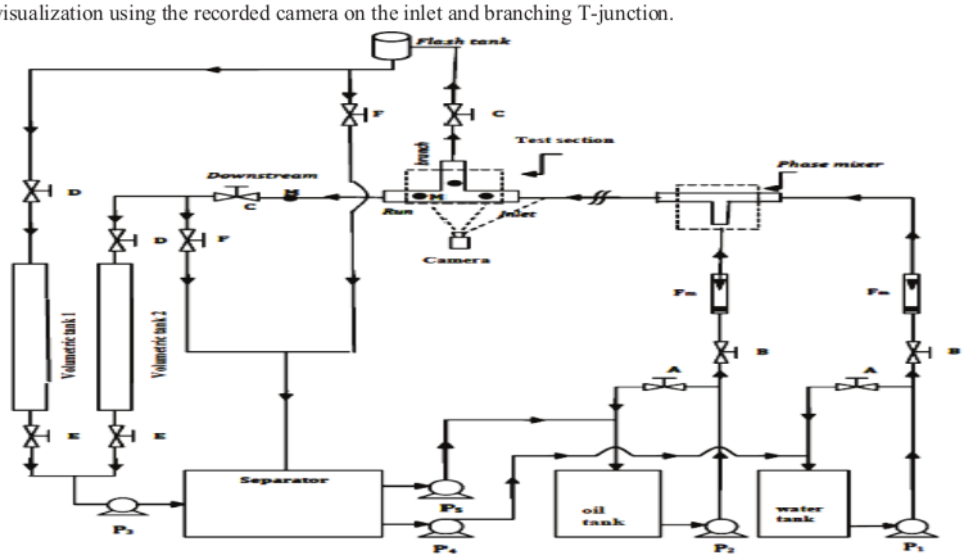

Figure 5. Schematic diagram of experimental

RESULTS AND DISCUSSIONS

Data results are presented in a graphical form the separation efficiency of phase separation and phase fraction flowing into the side arm (see figure 6 and 7). Visualization under best condition separation is seen in figure 8.

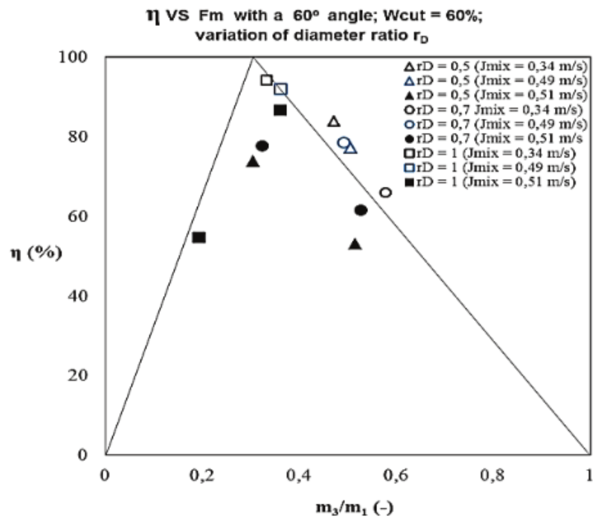

Figure 6. Separation efficiency in a T-junction 60° angle under variation of diameter ratio

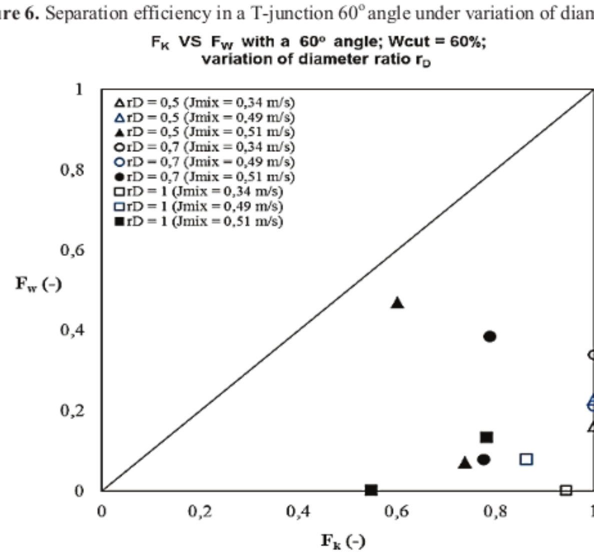

Figure 7. Phase separation result in a T-junction 60° angle under variation of diameter ratio

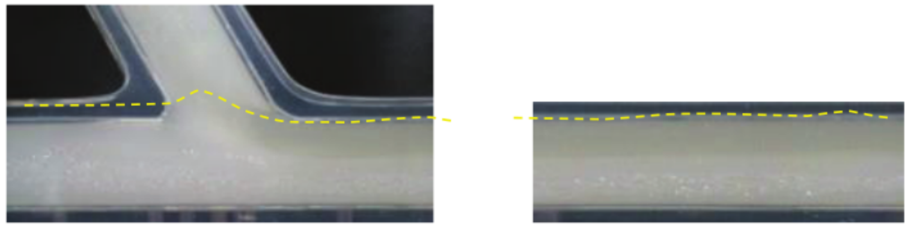

Figure 8. Stratified flow pattern in the best condition separation

Figures 6 and 7 show the highest separation efficiency is achieved at rD = 1 at 60% water cut was 94%. This condition is obtained at Fk = 0,94 and Fw = 0.001 under the value of Jw = 0,20 m/s and Jk = 0,4 m/s . Figure 8 shows almost all phases of kerosene are directed to the branch; only a little bit flowed into the run. This is due to a cross-section of branch rD 1 at inclination 60o cause the centrifugal force acting on the branch but because the cross section of a larger branch, that works on centrifugal force causes a slight bend radius kerosene forced to join the run and a little water come into the branch. The flow pattern under this condition was Stratified at inlet and Three Layer-2: almost all of kerosene (0,94) come into the branch together with a little bit water (0,001), but kerosene that passes into the run is about 0,06 and the rest is water. For small diameter ratio (≤ 1) all phases of kerosene are directed to the branch, but more water comes into the branch too. This condition causes a decrease in separation efficiency although Fk = 100% but Fw more than 16%.

In the literature review of an experimental investigation of influence of variation in the angle of T-junction and the variation in bend radius of T-junction was reported [2] and [3], there was a little part of my research scheme to get preliminary information about readiness the experimental setup, besides test section, was using is difference T-junction.

CONCLUSIONS

Liquid-liquid separation in T-junction with orientation 60^o vertical up branch: variation of diameter ratio in 15 mm bend radius has investigated and concluded as follows:

1. T-junction geometry plays an important role in the performance of phase separation. Changes in the ratio of branch diameter and the inlet resulted, in general, will affect the efficiency of phase separation and phase separation result into side arm.
2. Diameter ratio 1 causes a slight bend radius kerosene forced to join the run, and a little water comes into the branch so the value of F_k only 94% but F_w only 1%. However for diameter ratio less than 1 (0.7 and 0.5) cause all phases of kerosene is directed towards the branch, but more water comes into the branch too so the value of F_k 100% but F_w more than 16%.
3. The flow pattern under good condition separation was **Stratified** at inlet and **Three Layer-2** in T-junction**.**

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REFERENCES

1. B. J. Azzopardi, and P. B. Whalley, "The effect of Flow Patterns Two Phase Flow in a T-junction", Int. Journal of Multiphase Flow, vol. 8, 1982, pp. 491-507.
2. T. B. Ega, "Studi Eksperimental Pengaruh Variasi Sudut T-junction Terhadap Karakteristik Pemisahan Kerosen-Air", Tesis Magister Teknik Jurusan Teknik Mesin dan Industri, FT-UGM, 2009.
3. S. Tineke, "Studi eksperimental pengaruh variasi radius belokan pada T-junction terhadap karakteristik pemisahan kerosen-air", Tesis Magister Teknik Jurusan Teknik Mesin dan Industri, FT-UGM, 2010.
4. L. Y. Wang, Y. X. Wu, Z. C. Zheng, J. Guo, J. Zhang, and C. Tang, "Oil Water Two Phase Flow Inside T-Junction", Journal of Hydrodynamic, vol. 20 (2), 2008, pp. 147-153.

5. L. C. Walters, H. M. Soliman, and G. E. Sims, “Two-Phase Pressure Drop and Phase Distribution at Reduced Tee Junctions”, Int. Journal of Multiphase Flow, vol. 24, 1997, pp. 775-792.
6. E. Wren, and B. J. Azzopardi, “Affecting The Phase Split at a Large Diameter T-junction by Using Baffles”, Int. Journal of Multiphase Flow, vol. 28, 2004, pp. 835-841.
7. L. Yang, B. J. Azzopardi, and A. Belghazi, “Phase Separation of Liquid-Liquid Two Phase Flow at a T-junction”, AIChE Journal, vol.52 (1), 2006, pp. 141-149.
8. L. Yang, and B. J. Azzopardi, “Phase Split of Liquid-Liquid Two Phase Flow at a Horizontal T-junction”, AIChE. J., vol.52(1), 2007, pp. 141-149.

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