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## RESEARCH

# The Effect of Downstream Flow Resistance for Kerosene and Water Separation on Efficiency T-Junction

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**Abstract:** This study aims to determine the separation of kerosene and water in a piping installation. It is very important to do research because it can reduce problems that arise in the distribution of drilling oil to further processing and distribution. T-Junction is a method used in this study, because the separator method is rarely used. The separation of kerosene and water types in the test using the T-Junction method, variations in downstream flow resistance of 42%, 57% and 72% resulted in a large kerosene separation efficiency of 100% at a mixed superficial velocity of 0.35 m/s,  $J_w = 0.25$  m/s  $J_k = 0.10$  m/s and at mixed superficial velocity 0.47 m/s,  $J_w = 0.22$  m/s  $J_k = 0.25$  m/s, while 99% efficiency occurs at mixed superficial velocity 0.20 m/s,  $J_w = 0.10$  m/s and  $J_k = 0.10$  m/s. Water cut also greatly influences the phase separation. The lower the water cut, the higher the peak separation efficiency achieved

**Keywords:** Water, downstream, superficial velocity, kerosene, T-Junction.

## 1. Introduction

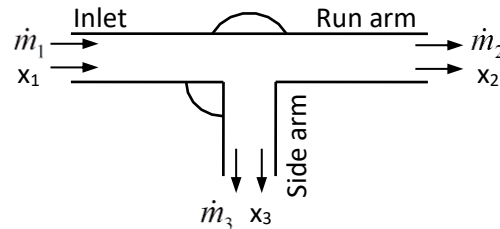
T-junction is a method used to separate fluids based on their density in piping installations, the method is a substitute for separator technology. The separator is a closed and pressurized vessel useful for separating fluids based on their density (Setiawan; & Pratiwi, 2018). When an immiscible two-phase flow (gas-liquid or liquid-liquid) flows in the pipe and meets the T-junctions, almost the volume this enters is not the same (Saieed; et al., 2016). Because volume fluid flow is not the same, maldistribution will occur. Phase maldistribution or uneven phase distribution occurs if the fluid flows unevenly in the T-junctions, some of which flows to the sidearm (vertical branch) but flows to the run arm (horizontal) but in unequal amounts. Phase maldistribution has negative and positive consequences for the equipment used. On the negative side, the occurrence of phase maldistribution will cause a decrease in the efficiency of the equipment used downstream of the T-junction (Pao; et al., 2017).

The maldistribution phase that occurs can be used as a useful tool in the partial separator phase (Ejaz; et al., 2020). In offshore oil drilling locations, a separator needs to separate crude oil from other elements (gas, water, mud) contained in the bowels of the earth (Suminar; & Nurcahyo, 2020). The separator is shaped like a tube and is tightly closed against pressure and has only an inlet and outlet, and is equipped with a pressure gauge. The separation ratio is influenced by various factors including the pressure in each branch (sidearm and run arm), the mass inertia of the liquid, the flow pattern in the upstream section, and the geometry of the T-junction (Ejaz; et al., 2020).

Separation of the gas-liquid two-phase flow in the annular flow pattern at the T-junction. The liquid that flows to the sidearm comes from the film layer on the main pipe wall. This happens because the liquid in the film has the same flux momentum as the gas and the two



are relatively easy to separate. In contrast, the liquid that drops in the gas stream has a higher flux momentum so it is not easy to separate (Yao; et al., 2017). At the T-junction, it is difficult to predict the amount of fluid flowing to the sidearm or to the run arm. Some important things in the liquid phase separation process include the geometry of the T-junctions, the flow pattern in the upstream T-junction, the slope of the sidearm, the mass flow rate of the fluid, and the gas fraction that flows into the sidearm (Verma; & Ghosh, 2020).



**Figure 1.** Variables related to flow separation at the T-junction.

Figure 1 is a picture of the placement of the inlet, run arm, and sidearm positions (Pao; et al., 2017). The liquid-liquid phase separation is kerosene and water in the horizontal position of the T-junction and the vertical upward sidearm. In the separation of kerosene and water, the highest efficiency of the T-junction is when the inlet is in a starfish flow position, the efficiency is low when the flow pattern is dispersed, measurement is based on the size of the mass fraction flow coming out of the sidearm. The phase separation can also be measured based on different mass fractions, the percentage of water in the mixture or water cut, and the superficial velocity of the mixture at different flow patterns (Ejaz; et al., 2020).

## 2. Research Method and Materials

This research uses kerosene and water, pressurized fluid lines use transparent pipes with a diameter of 1.5 inches and specifically for the inlet line with a diameter of 0.75 inches. To produce pressurized fluid using a liquid fluid pump with the following specifications: Model: PS 22 BI Max, discharge: 60 ltr/min, total head: 40 m, output: 200 watts, V/Hz/Ph: 220/50/1, 2850 rpm. Time measurement using a stopwatch, liquid fluid in the form of kerosene, and water is mixed first and mixed with a mixer before being tested. The flow of kerosene and water using a flow meter of 1000 lt/hour. Plexiglass pipe material with an inner diameter of 14 cm and a height of 110 cm as a measuring tank and separator, which serves to assess the mass fraction that comes out of the two outlets and to separate the mixture of kerosene and water so that it can be reused in further tests. Measurement of the pressure difference between the inlet-run, inlet-sidearm, and run-sidearm using a manometer. The kerosene is first pumped from the storage tank into the drainpipe until full, then water is pumped from the storage tank into the pipeline so that kerosene and water, it the mixed in the mixer. After the kerosene and water are mixed in the mixer, then the flow rate of the two is adjusted using a flowmeter with a value according to the research test matrix.

**Table1.** Research test matrix.

| No. | Superficial velocity of water<br>$J_w$ (m/s) | Superficial kerosene velocity $J_k$<br>(m/s) |
|-----|--|--|
| 1   | 0,10   | 0,10   |
| 2   | 0,15   | 0,12   |
| 3   | 0,20   | 0,14   |
| 4   | 0,25   | 0,16   |
| 5   | 0,30   | 0,18   |
| 6   | 0,35   | 0,20   |
| 7   | 0,40   | 0,22   |

The mixed stream then flows into the test section, and the mass fraction of the mixture leaving the two outlets is measured. Measurements are made by accommodating the mass fraction of the mixture that comes out of each outlet simultaneously for a predetermined time and then putting it into the measuring tank. The mass fraction of the finished mixture is separated in a separator, after separating the kerosene and water, it is then put back into the holding tank to be used again for further data collection.

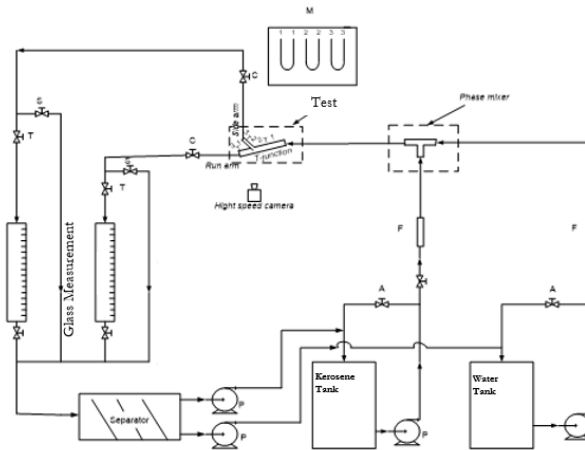


Figure 2. Test fluid flow.

The mass fraction of the finished mixture is separated in a separator, after separating the kerosene and water, it is then put back into the holding tank to be used again for further data collection.

### 3. Results and Discussion

From the research results, the phase separation is presented based on the ratio of the kerosene fraction and the water fraction that flows into the sidarm. Because it will be influenced by the basic properties of kerosene and water. Kerosene has a density of 796 kg/m<sup>3</sup>, velocity of 0.0021 Pa.s. Water has a density of 998 kg/m<sup>3</sup> and has a velocity of 0.001 Pa.s. (Zhi; et al., 2020). Water cut conditions and the superficial velocity of the mixture influence the results of the phase separation. The smaller the water cut value, the better the phase separation. The phase separation that occurs in the downstream flow resistance setting is either 42%, 57%, and 72% at a mixed superficial velocity of 0.53 m/s; 0.48m/s, and 0.31 m/s where 90% of the kerosene flows to the sidarm.

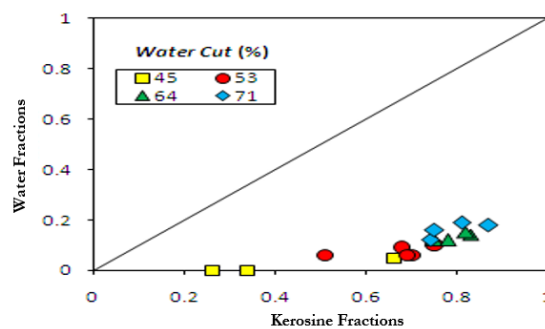


Figure 3. Phase separation at 42% downstream flow resistance.

The variation of flow resistance downstream is 42%, 57%, and 72% of the total flow that flows downstream. The water cut conditions are 45%, 53%, 64%, and 71%. The results of the kerosene-water phase separation (fig 3) show that if there is a flow resistance downstream of 42%, the amount of kerosene is about 88% that enters the sidarm. The rest is water entering the sidarm.

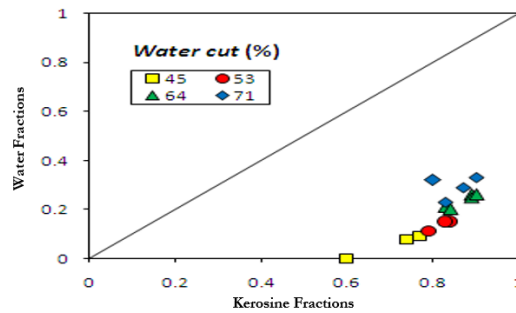


Figure 4. Phase separation in resistance.

While Fig 4 shows that kerosene flows more easily into the sidearm when the flow resistance downstream is 57%, but the amount of water fraction still enters the sidearm.

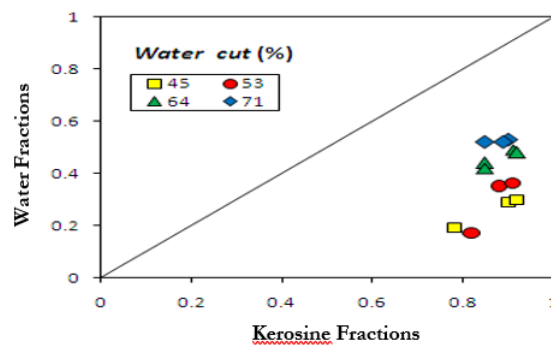


Figure 5. Phase separation on 72% downstream flow resistance.

The separation efficiency obtained shows the same graphic trend, both water cut 45%, 53%, 64%, and 71%. Fig 5 describes the test results, where the mass fraction that flows into the sidearm lies on the second ideal separation line which shows that pure water flows into the run arm and the mixture flows into the sidearm. This condition occurs when the flow resistance is set downstream through a valve. In addition, the regulation of superficial kerosene velocity and superficial water velocity results in the formation of different flow patterns at the T-junction inlet which affects the efficiency of phase separation (Yang; et al., 2019)(Hamad; et al., 2015). In this study, at a superficial water velocity of 0.1 m/s and a kerosene flow velocity of 0.1 m/s, the flow is stratified. The increase in oil velocity to 0.2 m/s results in a stratified flow and a mixture interface or three layers. Superficial velocity affects flow and pressure patterns, flow and pressure patterns affect efficiency (Gunawan, 2017). The highest phase separation efficiency of 100% occurs when the downstream flow resistance setting is 42% at a superficial mixed velocity of 0.35 m/s ( $J_w = 0.25$  m/s and  $J_k = 0.10$  m/s), the downstream resistance setting 57% 100% efficiency occurs at a mixed superficial velocity of 0.47 m/s ( $J_w = 0.25$  m/s and  $J_k = 0.22$  m/s), while the downstream resistance setting 72% 99% efficiency occurs at a mixed superficial velocity 0.20 m/s ( $J_w = 0.10$  m/s and  $J_k = 0.10$  m/s), the flow pattern formed is stratified, as can be seen in Fig 6. Water cut also greatly influences the phase separation. The lower the water cut, the higher the peak separation efficiency achieved (Samal; & Ghosh, 2021).

Fig 6. shows the peak separation efficiency reaching 95% at a superficial mixed velocity of 0.42 m/s ( $J_w = 0.2$  m/s and  $J_k = 0.22$  m/s). the downstream flow resistance setting of 42%, it shows the highest phase separation efficiency which can be achieved at 64% water cut. Fig 7 shows the flow pattern of kerosene and water.

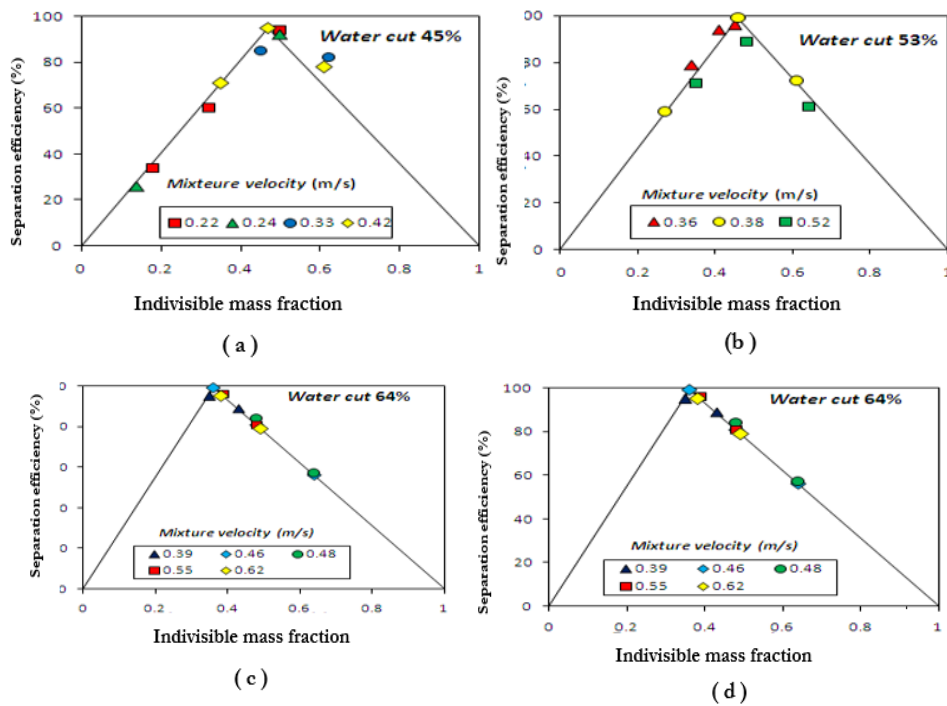


Figure 6. The efficiency phase separation on downstream flow resistance is 42%, 57%, and 72%.  
 a) Water cut 45%. b) Water cut 53%. c) Water cut 64%. d) Water cut 71%.

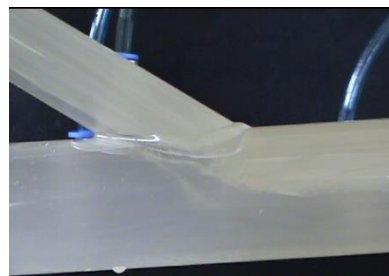


Figure 7. Stratified flow pattern at  $J_w = 0.25$  m/s.

#### 4. Conclusion

At downstream flow resistance of 42%, 57% and 72% resulted in a large kerosene separation efficiency of 100% at a superficial mixed velocity of 0.35 m/s ( $J_w = 0.25$  m/s and  $J_k = 0.10$  m/s) and at mixed superficial velocity 0.47 m/s ( $J_w = 0.22$  m/s and  $J_k = 0.25$  m/s), while 99% efficiency occurs at mixed superficial velocity 0.20 m/s ( $J_w = 0.10$  m/s and  $J_k = 0.10$  m/s). Water cut also greatly influences the phase separation. The lower the water cut, the higher the peak separation efficiency achieved.

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