

Influence of the weighing bar size to determine optimal time of biodiesel-glycerol separation by using the buoyancy weighing-bar method

R Tambun*, Y Sibagariang, J Manurung

Department of Chemical Engineering, Universitas Sumatera Utara, Padang Bulan, Medan 20155, Indonesia

*E-mail: rondang@usu.ac.id

Abstract. The buoyancy weighing-bar method is a novel method in the particle size distribution measurement. This method can measure particle size distributions of the settling particles and floating particles. In this study, the buoyancy weighing-bar method is applied to determine optimal time of biodiesel-glycerol separation. The buoyancy weighing-bar method can be applied to determine the separation time because biodiesel and glycerol have the different densities. The influences of diameter of weighing-bar by using the buoyancy weighing-bar method would be experimentally investigated. The diameters of weighing-bar in this experiment are 8 mm, 10 mm, 15 mm and 20 mm, while the graduated cylinder (diameter : 65 mm) is used as vessel. The samples used in this experiment are the mixture of 95 % of biodiesel and 5 % of glycerol. The data obtained by the buoyancy weighing-bar method are analyzed by using the gas chromatography to determine the purity of biodiesel. Based on the data obtained, the buoyancy weighing-bar method can be used to detect the separation time of biodiesel-glycerol by using the weighing-bar diameter of 8 mm, 10 mm, 15 mm and 20 mm, but the most accuracy in determination the biodiesel-glycerol separation time is obtained by using the weighing-bar diameter of 20 mm. The biodiesel purity of 97.97 % could be detected at 64 minutes by using the buoyancy weighing-bar method when the weighing-bar diameter of 20 mm is used.

1. Introduction

The determination of biodiesel purity is one of the important stages in the biodiesel industry. During this time, generally the determination the purity of biodiesel is analyzed by using the gas chromatography [1, 2]. The gas chromatography can give the accuracy result in determination the purity of biodiesel, but the price of the equipment is expensive. To overcome this problem, the buoyancy weighing-bar method (BWM) will be used to predict the separation time of biodiesel and glycerol mixtures. The BWM is a new sedimentation method which is developed from the sedimentation balance, and this method has proven accuracy in determination particle size distribution. This method is simple in operation and low-cost of equipment. The principle of this method that measurement the density change in a suspension due to liquid migration is measured by weighing buoyancy against a weighing bar hung in the suspension. This apparatus consists of an analytical balance with a hook for under-floor weighing and a weighing bar, which is used to detect the density change of suspension [3-8]. The BWM can also be used to predict the fine particles by combining with the Rosin-Rammler equation [9]. In the present study, we are going to develop the BWM for



liquid-liquid systems with the different density to determine the separation time of biodiesel and glycerol mixtures by investigating the influence of the weighing bar size. The principle of this experiment is analogous to distributions of the settling particles and floating particles. In this experiment, the initial buoyant mass of the weighing bar depends on the mixtures of liquid between the top and bottom of the weighing bar in a suspension [3-8].

2. Material and Methods

The experiment is illustrated at figure 1. The weighing-tools is weighing-bar which is composed of aluminum (density: 2700 kg/m^3). The diameters of weighing-bar in this experiment are 8 mm, 10 mm, 15 mm and 20 mm, and the length is 210.0 mm and submerged length is 200.0 mm. The samples consist of 95 % of biodiesel (methyl ester, $\rho = 0.8791 \text{ g/cm}^3$) and 5 % of glycerol ($\rho = 1.26 \text{ g/cm}^3$) are placed in a 1000 ml graduated cylinder (diameter: 65.0 mm). The analytical balance (minimum readout mass 0.1 mg) has a below-balance-weighing hook for hanging measurement. Using a hanging wire, which does not extend due to the weight of the weighing bar, the weighing bar is hung from the analytical balance. The room temperature is approximately 298 K. After thoroughly stirring the suspension using an agitator, the weighing bar is set with the balance. The measuring data, which consist of time and the corresponding mass of the bar, are recorded. The measuring time is 2 hours and the data are collected in 60-second intervals. As comparison method, the gas chromatography is used to analyze the purity of biodiesel.

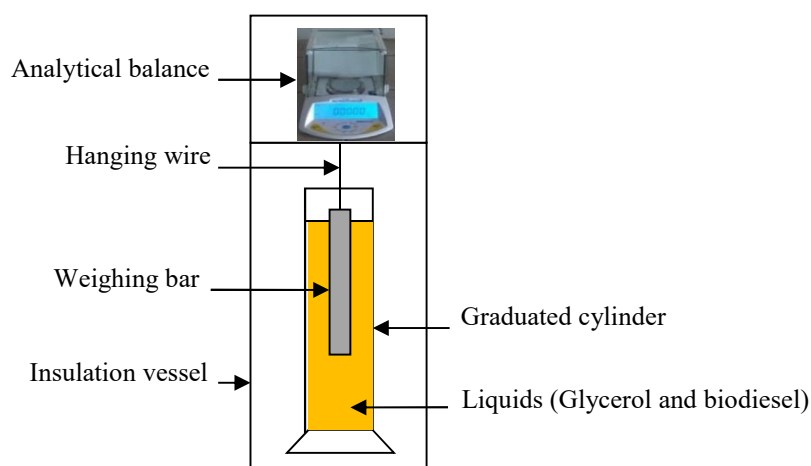


Figure 1. Illustration of experiment apparatus

3. Results and Discussion

Figure 2 shows the change with time in the apparent mass of weighing-bar when the weighing-bar diameter of 8 mm is used. The figure shows that the apparent mass of the weighing-bar increased until all the glycerol settled below the lower end of the weighing-bar, and then the apparent mass of the weighing-bar become constant. The change in the apparent mass is due to the change in the buoyant mass against the weighing-bar as well as glycerol settling. Figure 2 shows us that the BWM can detect the separation time of biodiesel-glycerol after 18 minutes of measurement, where at this time the mass of weighing-bar diameter of 8 mm starts to become constant and the purity of biodiesel is 96.92%. In this experiment, the initial of biodiesel purity is 99.85%, so the measurement error of BWM using weighing-bar diameter of 8 mm to detect the separation time of biodiesel-glycerol is 2.93%. Figure 3 shows the change with time in the apparent mass of weighing-bar when the diameter of weighing-bar of 10 mm is used. The figure shows that the apparent mass of the weighing-bar increased until all the glycerol settled below the lower end of the weighing-bar, and then the apparent mass of the weighing-bar become constant. The change in the apparent mass is due to the change in

the buoyant mass against the weighing-bar as well as glycerol settling. Figure 3 shows us that the BWM can detect the separation time of biodiesel-glycerol after 14 minutes of measurement, where at this time the mass of weighing-bar diameter of 10 mm starts to become constant and the purity of biodiesel is 96.81%. In this experiment, the measurement error of BWM using weighing-bar diameter of 10 mm to detect the separation time of biodiesel-glycerol is 3.04 %.

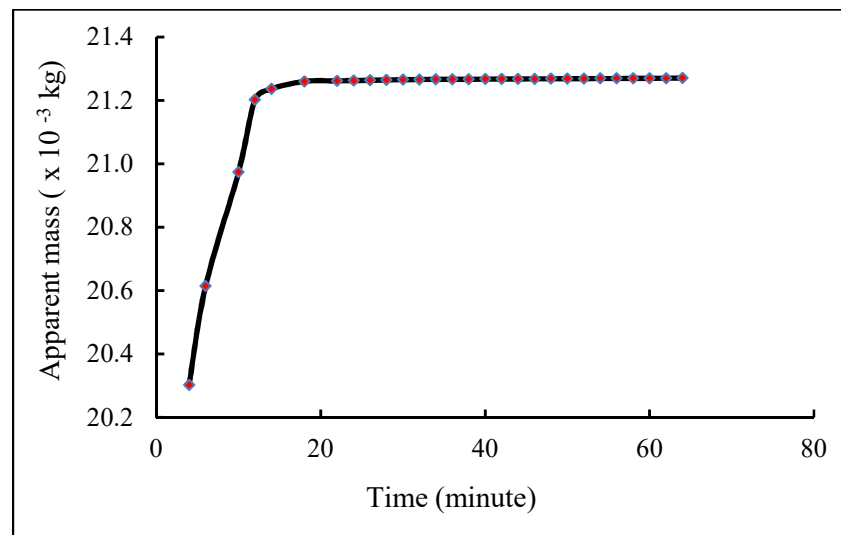


Figure 2. Apparent mass of the weighing-bar as a function of time when using the weighing-bar diameter of 8 mm

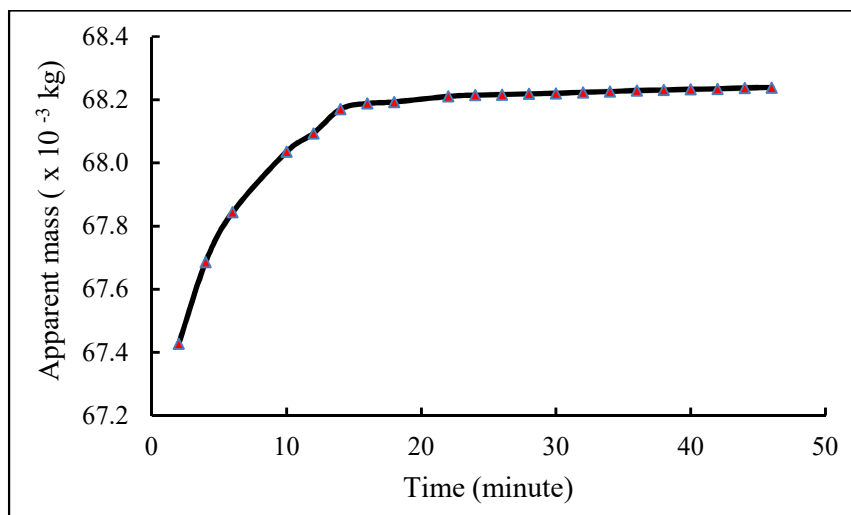


Figure 3. Apparent mass of the weighing-bar as a function of time when using the weighing-bar diameter of 10 mm

Figure 4 shows the change with time in the apparent mass of weighing-bar when the weighing-bar diameter of 15 mm is used. The figure shows that the apparent mass of the weighing-bar increased until all the glycerol settled below the lower end of the weighing-bar, and then the apparent mass of the weighing-bar become constant. The change in the apparent mass is due to the change in the

buoyant mass against the weighing-bar as well as glycerol settling. Figure 4 shows us that the BWM can detect the separation time of biodiesel-glycerol after 36 minutes of measurement, where at this time the mass of weighing-bar diameter of 15 mm starts to become constant and the purity of biodiesel is 97.15%. In this experiment, the measurement error of BWM using weighing-bar diameter of 15 mm to detect the separation time of biodiesel-glycerol is 2.70 %.

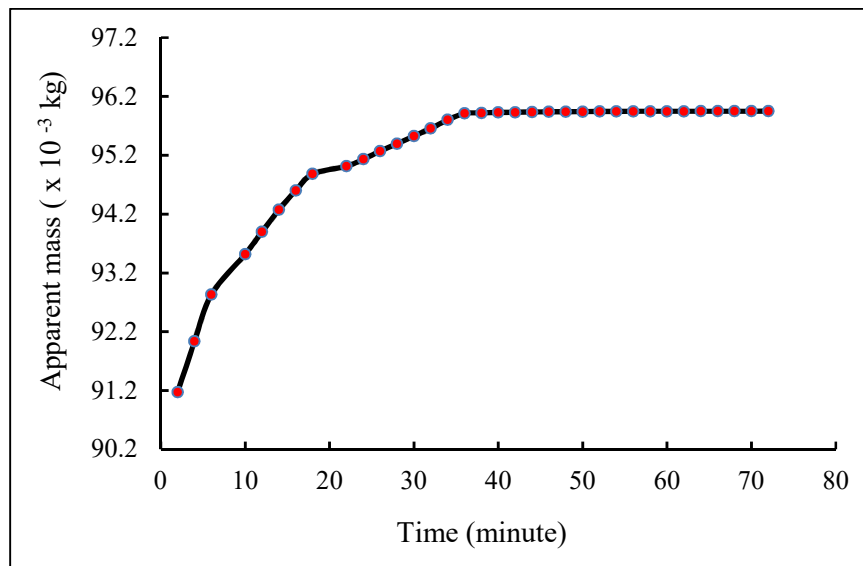


Figure 4. Apparent mass of the weighing-bar as a function of time when using the weighing-bar diameter of 15 mm

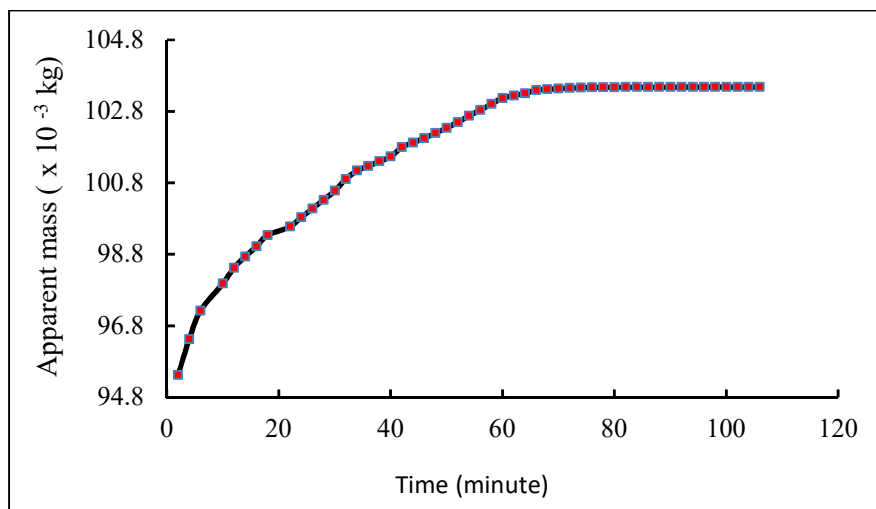


Figure 5. Apparent mass of the weighing-bar as a function of time when using the weighing-bar diameter of 20 mm

Figure 5 shows the change with time in the apparent mass of weighing-bar when the weighing-bar diameter of 20 mm is used. The figure shows that the apparent mass of the weighing-bar increased until all the glycerol settled below the lower end of the weighing-bar, and then the apparent mass of the weighing-bar become constant. The change in the apparent mass is due to the change in the

buoyant mass against the weighing-bar as well as glycerol settling. Figure 4 shows us that the BWM can detect the separation time of biodiesel-glycerol after 64 minutes of measurement, where at this time the mass of weighing-bar diameter of 20 mm starts to become constant and the purity of biodiesel is 97.97%. In this experiment, the measurement error of BWM using weighing-bar diameter of 20 mm to detect the separation time of biodiesel-glycerol is 1.88 %. Thus, we confirm that the separation time of biodiesel-glycerol can be detect by using BWM when the weighing-bar diameters of 8 mm, 10 mm, 15 mm and 20 mm and ratio 95% : 5% of biodiesel and glycerol are used, but the most accuracy result is obtained by using the weighing-bar diameter of 20 mm.

4. Conclusions

This study has experimentally investigated the application of BWM to detect the time separation of biodiesel-glycerol mixtures, the following results are obtained:

1. The buoyancy weighing-bar method could determine the separation time of biodiesel-glycerol when ratio 95% : 5% of biodiesel and glycerol is used.
2. The weighing-bar diameter of 20 mm give the more accuracy result than the weighing-bar diameter of 8 mm, 10 mm, and 15 mm in detecting the separation time of biodiesel-glycerol when ratio 95% : 5% of biodiesel and glycerol is used.
3. The mass of weighing-bar diameter of 20 mm starts to become constant when the biodiesel purity is 97.97%, while the weighing-bar diameter of 8 mm, 10 mm, and 15 mm start to become constant when the biodiesel purity are 96.92 %, 96.81 %, 97.15 %, respectively.

References

- [1]. M Holčápek, P Jandera, J Fischer, B Prokeš 1999 Analytical monitoring of the production of biodiesel by high-performance liquid chromatography with various detection methods *Journal of Chromatography A* **858** (1) pp 13-31
- [2]. S N Fedosov, J Brask, X Xu 2011 Analysis of biodiesel conversion using thin layer chromatography and nonlinear calibration curves *Journal of Chromatography A* **1218** (19) pp 2785-2792
- [3]. Motoi T, Ohira Y, Obata E 2010 Measurement of the floating particle size distribution by buoyancy weighing-bar method *Powder Technology* **201** pp 283–288
- [4]. Obata E, Ohira Y, Ohta M 2009 New measurement of particle size distribution by buoyancy weighing-bar method *Powder Technology* **196** pp 163–168
- [5]. Ohira Y, Furukawa K, Tambun R, Shimadzu M, Obata E 2010 Buoyancy weighing-bar method: a particle size distribution measurement using new settling method *Journal of the Sedimentological Society of Japan* **69** pp 17-26
- [6]. Tambun R, Motoi T, Shimadzu M, Ohira Y, Obata E 2011 Size distribution measurement of floating particles in the allen region by a buoyancy weighing-bar method *Advanced Powder Technology* **22** pp 548–552.
- [7]. Tambun R, Nakano K, Shimadzu M, Ohira Y, Obata E 2012 Sizes influences of weighing bar and vessel in the buoyancy weighing-bar method on floating particle size distribution measurements, *Advanced Powder Technology* **23** pp 855-860
- [8]. Tambun R, Shimadzu M, Ohira Y, Obata E 2012 Definition of the new mean particle size based on the settling velocity in liquid *Journal of Chemical Engineering of Japan* **45** (4) pp 279-284
- [9]. Tambun R, Furukawa K, Hirayama M, Shimadzu M, Yamanaka S, Ohira Y 2016 Measurement and estimation of the particle size distribution by the buoyancy weighing-bar method and the Rosin-Rammler equation *Journal of Chemical Engineering of Japan* **49** (2) pp 229-233