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Effects of inner angle of bowl, flow rate and speed on the efficiency of glycerol separation from the raw biodiesel using cylindrical bowl centrifuge

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Abstract

The centrifugal technique has been widely used for separation of fluids with moderately high viscosities because it provides an efficient separation in short residence times. In this work, the cylindrical bowl centrifuge was selected for separation of raw biodiesel and glycerol. In addition, the inner angle of bowl, flow rate and speed were investigated on their effects on the efficiency of separation. The experimental results showed that the inner angle of bowl and the flow rate affected the efficiency of separation significantly. The increase of inner angle of bowl (from 90 to 135 degree) and flow rate (from 50 to 200 ml/min) provided the increase of separation efficiency. In term of speed, the efficiency of separation was increased when increasing the speed from 1,800 rpm to 2,100 rpm. On the other hand, the efficiency of separation was decreased when increasing the speed from 2,100 rpm to 2,400 rpm. The efficiency of cylindrical bowl centrifuge was in the ranges of 29.17-39.83%, 52.83-61.83% and 84.6-91.4% for bowl inner angles of 90, 120 and 135 degree, respectively. The bowl inner angles of 135 degree, flow rate of 200 ml/min and speed of 2,100 rpm were appropriate conditions for glycerol separation from the raw biodiesel using cylindrical bowl centrifuge.

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Keywords: Centrifuge; Raw biodiesel; Separation; Efficiency

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1. Introduction

Biodiesel is an alternative fuel which produces less CO, hydrocarbons and particulates emissions than conventional diesel [1]. It can be obtained by a transesterification reaction of triglycerides with methanol by using a homogenous base catalyst, such as sodium hydroxide (NaOH) or potassium hydroxide (KOH) [2]. This reaction gives glycerol as a by-product. After the transesterification reaction has been completed, the important major process step that follows is the glycerol separation from the biodiesel because the glycerol causes severe diesel engines problems such as plugging of filters, coking on injectors, more carbon deposits, excessive engine wear, oil ring sticking, engine knocking, and thickening and gelling of lubricating oil [3]. Moreover, the unused reactants such as methanol and catalyst, and any solids that may have formed are also removed.

Traditionally, gravitational settling was used for the separation of glycerol from raw biodiesel after the reaction. However, this method provides the long time for separating [4]. Nowadays, several different separations of raw biodiesel techniques have been studied. A centrifuge is one of alternative techniques which is widely applied to separate glycerol from raw biodiesel. The cylindrical bowl centrifuge is one of centrifuges which have been interested in separation. For conventional separation with cylindrical bowl centrifuge, the wall inner angle of cylindrical bowl which was used is 90 degree. This wall inner angle provided the high slope. The outward movement from bowl of raw biodiesel is difficult, leading the low amount of raw biodiesel and resulting in the low efficiency of separation. The lower slope of wall inner angle of cylindrical bowl may increase the amount of raw biodiesel to overflow from the bowl, leading to the higher efficiency of separation. Moreover, the flow rate and the speed of rotation are important factors that also affected the efficiency of separation.

As mentioned above, the objective of this work was to investigate the effects of inner angle of bowl (90, 120 and 135 °), flow rate (50, 100 and 200 ml/min) and speed (1,800, 2,100 and 2,400 rpm) on the efficiency of glycerol separation from the raw biodiesel using cylindrical bowl centrifuge.

2. Materials and methods

2.1. Production of mixture (biodiesel + glycerol)

A reactor with a capacity of 1,000 ml was used to produce the mixture. A 9:1 molar ratio of methanol to oil and KOH as catalyst (1% w/v) was used in this study. The desired amounts of KOH and methanol were added to the reactor and mixed together. Subsequently, the oil preheated at 60 °C was added to the mixture under a stirring rate of 500 rpm. The operating temperature was 60 °C and the reaction time was 45 min. The mixture was then taken to the separation process.

2.2. Preparation of separation

The mixture was separated by cylindrical bowl centrifuge which is shown in Figure 1 consisting of stainless steel cylindrical bowl of 200 mm diameter and 50 mm height, a solution warm tank with 0.8 kW heaters, a 1/2 HP motor and a chemical pump with a capacity of 13.8 L/h. About 1,000 ml of mixture was added into a mixture warm tank with maintained temperature of 60 °C. The motor was started to centrifuge the cylindrical bowl at conditional speed testing such as 1,800, 2,100 and 2,400 rpm. The chemical pump was then turned on to feed the mixture into the cylindrical bowl with three bowl inner angle such as 90, 120 and 135 °. The flow rate conditions were 50, 100 and 200 ml/min. When the mixture was already moved from a mixture warm tank, the cylindrical bowl was continually centrifuged for 40 s and the motor was stopped. The amount of separated raw biodiesel was measured. Each procedure was analyzed three times and the averages were reported.