Enhancement Concentration of Bioethanol Through Packed Sieve Tray Distillation

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Abstract – Bioethanol is one of alternative renewable energy that can be produced by distillation process. Distillation itself is a method of separation and purification that most widely used in the chemical industry. Nowadays, distillation equipment that is commonly used in the industry is sieve tray tower due to its affordable in cost and simplicity in design. Its performance can be improved by the addition of packing on the tray can improve efficiency. This study aims to evaluate the performance of the developed steel wool packing in sieve tray distillation with regards to the bioethanol purity. Our results showed that the addition of the developed packing in each tray significantly increased the concentration of ethanol up to 99.5%.

Index Terms – Bioethanol, Distillation, Steel wool packing, Packed Sieve Tray

INTRODUCTION

Distillation is a method of separation and purification that most widely used in the chemical industry. There are various type of trays, such as sieve tray, valve tray and bubble cap tray. It is widely accepted that sieve tray is best choice technology due to its affordable cost and simplicity in design. Recently it was found that the addition of packing on one singular tray can improve the tray efficiency.

Gorak and Olujić [1] stated that the tray with smaller holes have a better distribution between the vapor-liquid, reduce weeping, and improve the efficiency of the resulting bubble tray for small to large interfacial area. Chen *et al*. [2] have researched the performance of sieve tray combined with mesh packing, and has concluded that the tray efficiency increase between 5 to 40% with the addition of 30 mm mesh packing on the tray, and packed sieve tray having a low entrainment and high pressure drop. Later, Baeyens *et al*. [3] conducted a study which stated that the efficiency of a sieve tray was significantly increased by the addition of mesh packing. They suggested that the addition of packing increased the interfacial area and a vapor-liquid contact.

This study develops a steel wool packing, adds it on each trays distillation column, and evaluates its effects on the purity of bioethanol product.

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MATERIALS AND METHODS

I. Preparation of Synthetic Feed

Feed that was used for the distillation process in this study is a synthetic feed, which is composed of a mixture of ethanol (6% v/v), glycerin (0.07% v/v), acetate acid (0.0236% v/v), amyl alcohol (0.015% v/v), acetone (0.015% v/v) and water (93.876% v/v) in 13 L of total solution. This composition is conditioned in such a way to mimic the product from the molasses fermentation.

II. Distillation Process

The distillation process in this study is employing multi-component batch distillation method, by specifically using a sieve tray column that is modified by the addition of packing. This particular modified sieve tray column is known as packed sieve tray distillation column. Here 16 trays are used as a model in this packed sieve tray distillation column. A developed steel wool type packing that is currently used in this study, is varied by its height, *i.e*. 3 and 5 cm. In the distillation process, the procedure is initiated by pouring 13 L of that of prepared synthetic feed into the distillation column at atmospheric condition, with maintained reflux ratio of 3. The temperature at the boiler was kept at 100 °C. During the distillation process that approximately is lasted up to 1 hour the purity of the resulted ethanol was monitored by alcoholmeter. The corresponding pressure drop in this packed sieve tray column was also monitored.

RESULT AND DISCUSSION

Fig. 1 shows that the addition of steel wool packing on each 16 trays, significantly increased the purity of ethanol. To be precise, the purity of ethanol was improved from 94.6% to 99.5%, as compared to that of without packing.

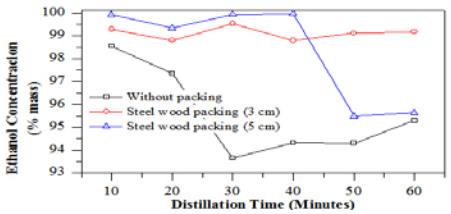

Figure 1. The comparison of the purity of ethanol from the sive tray distillation column that are using steel wool packing and without using that of packing.

The addition of packing in each 16 trays was found to increase the ethanol concentration product. This can be explained by the fact that the contact between the liquid and the vapor is improved, thus causing better mass transfer between liquid and vapor in the sieve tray distillation system. When the contact between the vapors occurs, the water content will be retained on the packing. However, the content of ethanol in the vapor will pass and condensed to distillate. So that the condensed distillate ethanol concentration would be higher [4].

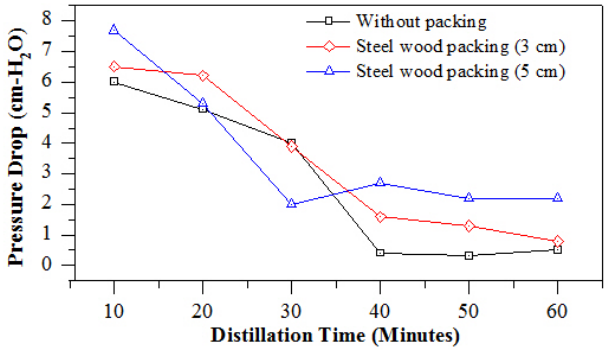

Figure 2. The comparison of the resulting pressure drop in a sive tray distillation column that are using steel wool packing and without using that of packing.

From Figure 2, it can be seen that with the addition of packing on trays, can increase the pressure drop. To be precise, the higher packing system will increase the pressure drop in a sieve tray distillation column. The increasing of total pressure drop in the column due to the growing interfacial area, so that the vapor columns that rise to the top will be in contact with the packing which then becomes liquid and drops down [5].

CONCLUSION

This study showed that the potential of using a developed steel wool packing that is added on each tray to produce bioethanol via a sieve tray distillation process. We found that bioethanol with purity of 99.5% can be produced in this study.

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