Increase The Sugar Concentration of The Solution Sugar by Reverse Osmotic Membrane

S Redjeki1, N Hapsari2, Iriani3
1,2Chemical Engineering department faculty of engineering, UPN Veteran East Java
3Industrial Engineering department faculty of engineering, UPN Veteran East Java

*sri4tk@yahoo.com

Abstract. Sugar is one of the basic needs of people and food and drink industry. As technology advances and the demand for efficient usage of sugar rises, crystal sugar is seen as less advantageous than liquid sugar. If sugar is always dissolved in water before use, then it will be more efficient and practical for consumers to use sugar in liquid form than in crystal form. Other than that, liquid sugar is also attractive to consumers because it is economical, hygienic, instantly soluble in hot and cold water, fresher and longer-lasting, able to thicken and enrich the texture of foods and drinks, and functions as sweetener, syrup, and flavor enhancer. Liquid sugar is also more beneficial for sugar producers because of simpler production process, cheaper production cost, and similar yield with no extra cost. In sugar production, separation process is found in most of its stages and therefore the use of membrane technology for separating solute and water content has a good potential. In this research, water content reduction of sugar solution was done in order to increase the sugar concentration of the solution. The parameters of this research were 4%, 5%, and 6% starting concentration of sugar solution; 20, 40, and 60 minutes of process time; and 85 and 60 PSI ΔP. The best result was acquired on 4% starting concentration, 60 PSI ΔP, and 60 minutes process time.

1. Introduction
Sugar is one of main ingredients of food in Indonesia. On average, people in Indonesia consume sugar as much as 12-15 kg a year (BPS, 2015). As the population increases, the need for sugar will also keep increasing. The crystal sugar in Indonesia is commonly from sugar cane. As technology advances and the demand for efficient usage of sugar rises, crystal sugar is seen as less advantageous than liquid sugar. If sugar is always dissolved in water before use, then it will be more efficient and practical for consumers to use sugar in liquid form than in crystal form. Other than that, liquid sugar is also attractive to consumers because it is economical, hygienic, fresher and longer-lasting, instantly soluble in hot and cold water, able to thicken and enrich the texture of foods and drinks, and functions as sweetener, syrup, and flavor enhancer. Liquid sugar is also more beneficial for sugar producers because of simpler production process, cheaper production cost, and similar yield with no extra cost.

The process of increasing the concentration of sugar solution is done by reducing its water content, therefore it is a separation process and benefits from the use of reverse osmosis (ro) membrane. Reverse osmosis is able to separate water content from its solution because membranes, being semi-permeable, let through only water. However, the shortcoming of using a membrane is it will experience “fouling” or clogging on its surface, which will reduce its performance.
Some researches have been done on purification process of sugar solution from sugar cane using ultrafiltration (UF) membrane, such as: the effects of fouling on cane sugar cleansing by Redjeki et. al. (2010), and cane sugar cleansing using UF membrane by Suprihatin (2007). The researches were able to make the cane sugar clearer, although there was no increase in sugar concentration because UF membrane isn’t capable of doing that. In the research of Sudaryati, et. al. (2014), glucose syrup was purified using UF membrane with a similar result: the glucose syrup became clearer but its concentration wasn’t increased significantly. Therefore, the goal of this research was to increase the concentration of sugar solution using reverse osmosis membrane.

2. Methods

The used ingredient was sugar solution made from crystal sugar. The sugar solution was diluted three times into solutions with 4%, 5%, and 6% sugar concentration. The operation times of the dilutions were 20, 40, and 60 minutes, the pressures (ΔP) were 85 and 60 PSI.

Procedure:

Before and after each experiment, the used membrane was washed to maintain its stability. The washings were performed using aquadest until the permeate that came out of the membrane was completely clean and its flux was constant. Each experiment was conducted in 60 minutes by circulating the sugar solution through the membrane, the permeate was contained and the concentration of the sugar solution was measured every 20 minutes. Each experiment was conducted on two ΔP’s, which were 85 and 60 psi.

3. Results and Discussion

The experiment was done with parameters as planned based on reviews. The concentrations of the sugar solution were from 4% to 7%, because the pores of the membrane got blocked at concentrations greater
than 7% which was indicated by very small flux values. At ΔP of less than 60 psi, the membrane could not withstand the ΔP.

**Figure 2.** Graph time vs % sugar concentration increase for ΔP=60 PSI

**Figure 3.** Graph time vs % sugar concentration increase for ΔP=85 PSI

The influence of process time on sugar concentration for 85 and 60 psi ΔP can be seen in Picture 2 and Picture 3. For 4% starting concentration and 60 psi ΔP, the sugar concentration kept increasing until it reached 90% concentration, whereas it only reached 80% concentration with 85 psi ΔP. This shows that ΔP had a greater influence on the performance of the membrane at lower starting sugar concentration (4%). At 5% starting sugar concentration, the concentration increase was a bit lower which was caused by fouling that clogged the membrane. With 6% starting sugar concentration, there was a reduction in the increase of sugar concentration and clogging caused by fouling started to happen at 40 minutes process time and 60 psi ΔP, and the clogging caused the sugar concentration to keep dropping until it reached 10% at 60 minutes process time.

With 7% starting sugar concentration and 85 psi ΔP, there was very little permeate going out of the membrane because the membrane got clogged instantly. The condition was better with 60 psi ΔP as the sugar concentration could still be increased, even though the increase was smaller than with 4% and 5%.
starting concentration. The poorer performance of the membrane at higher starting sugar concentration (7%) shows that the used membrane is capable of handling only lower starting sugar concentrations, therefore a different membrane design is needed to handle higher starting concentrations. A good design of the system for increasing sugar concentration will improve the performance of the membrane as it will reduce the clogging on the membrane’s surface. According to Wenten in Dian Kusumanto in Kompas, 2013, ro membrane is only able to separate water from cane sugar up to 60% or 2/3 of the total content. The sugar content of cane sugar is 10 to 12%.

4. Conclusion
The design of ro membrane used in this research was of oriental 400 commercial Reverse Osmosis type. The design is only usable for sugar concentration not greater than 7% and it works best when used on 4% sugar concentration because it is able to raise the concentration to 90% with 60 minutes process time.

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