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Modelling and Thermodynamic Design of Bio-Ethanol Production Plant from Corn via Aspen Plus

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ABSTRACT

Bioethanol is one of the most promising biofuels from renewable resources. There are several biomass materials which can be the source of bioethanol production. From those renewable sources, corn was selected as a favorable feed for bioethanol production plant. This is because of corn is the most produce agriculture compare to other biomass materials. Aspen plus v8.8 was used for modelling and thermodynamic design in this work. The result shows that 0.63 million barrels of ethanol per year can be produced from 249278 lb/h corn.

KEY WORDS: *Modeling, Bioethanol, Corn, Aspen Plus.*

1.0 INTRODUCTION

Society has arisen to tap new renewable energy sources from agriculture on a commercial scale that impacts energy markets. Biofuels are the fuels which can be produced from biological based such as agricultural rather than geological based such as petroleum. Bioethanol is one of the most promising biofuels from renewable resources [1]. Bioethanol can be obtain from corn, sugar cane, sugar beet, grass, wood, wheat and other biomass materials [2]. In this subtopic, corn was selected as a source of bio ethanol production because it is the greater amount each year than any other grain around the world [3].

Ethanol fuel is widely used in Brazil and in the United States, and together both countries were responsible for 87.1% of the world's ethanol fuel production [4]. The demand of fuel in the transportation sector is around 34 billion barrel a year worldwide in 2015. It is important to produce more biofuel from renewable resources to significantly achieve the fuel demand in the world. It is well known that the increasing of corn use as a source of bioethanol may contribute to increasing food prices and global hunger [5]. Therefore economical available agricultural biomass such as corn stover, corn fiber, or other residues is selected as a source of bioethanol. The aim of this work is modeling of a grind corn to ethanol plant process via aspen plus software.

2.0 METHODOLOGY

Ethanol production from corn comprises the following main stages: Milling, liquefaction, saccharification, fermentation, distillation, dehydration and centrifugation. The aspen plus v8.8 was used to design these stages. Every stage has its own duty for ethanol production from corn. During milling process corn kernel will be reduced to particle size distribution. The particle size distribution of the corn slurry depend on the type of the mill used, screen size and the corn kernel hardness. The liquefaction stage is a main step in starch hydrolysis to release poly-saccharides. The enzymatic hydrolysis of polysaccharides to fermentable sugars

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will be done in the saccharification process. Both of the liquefaction and saccharification stage are called depolymerisation of starch. In the fermentation step, the sugers are converted to the ethanol and carbon dioxide. The distillation and dehydration processes will increase the ethanol concentration to 190 proof (95%) pure (undenatured) ethanol and 200 proof, anhydrous, (≥99.5%) respectively. Centrifugation process separates solids from liquid out of beer column bottoms stream.

This category includes the models and methods used to calculate the chemical and thermodynamic equilibrium, and the physical properties of all streams. The models used to calculate physical properties in Aspen Plus are grouped into property methods named after the central model, for example, Ideal, Redlich-Kwong-Soave, and NRTL (Non-Random Two Liquid). The property method used in this model is NRTL. Physical Properties are usually the most important and often the most difficult part of a simulation. The accuracy of physical property calculations strongly influences the reliability of the results and ultimately affects the estimated cost of process equipment.

The components which were used in the modelling are water, ethanol, carbon dioxide, glucose, starch (solid), C5poly (solid), C6poly (solid), PROTINS (solid), oil (solid), NFDS ($C_6H_{12}O_6$), XYLOSE and PROTSOL. Solid component types represent non-library chemicals with user specified property parameters. Conventional components such as NFDS, XYLOSE, and PROTSOL originate as 'clones' of glucose and are later modified with their own property parameters. For example, the molecular weight of XYLOSE is modified to that of xylose (C5) in a Pure Component paragraph. The reactions which maight takes place in the bioethanol production from corn have been simplified as follow:

Saccharification:
$STARCH + WATER \rightarrow GLUCOSE$
$99\%\ conversion\ of\ starch$

Fermentation
$GLUCOSE \rightarrow 1.9\ Ethanol + 1.9\ CO_2 + 0.06\ NFDS$
$100\%\ conversion\ of\ glucose$

$NFDS \rightarrow PROTSOL$
$molar\ extent\ 3.31\ lbmol/hr\ at\ 25\ mmgal/yr$

Saccharification and fermentation reactors are simplified to continuous operations. Conversions and molar extents are adjustable parameters in the model. No attempt has been made to model the action of enzymes and yeast in the reactors.

3.0 RESULTS

This is a model of a process for production of ethanol from corn. It uses batch fermentors, with product dehydration by molecular sieves. The six-effect evaporator is driven by heat of condensation from the rectifier overhead vapor. Hot process condensates and scrubber water are used for mashing. Very little waste water is produced. Mash concentration is adjustable using design spec ethanol by setting target to desired final ethanol concentration (g/l) in fermentors. Annual ethanol production is adjustable using Fortran block scale. The process flow diagram of Aspen plus is shown in Fig. 1. According the result from this this modelling, by using total wet corn of 249278 lb/hr, around 0.63 million barrel ethanol per year can be produced.

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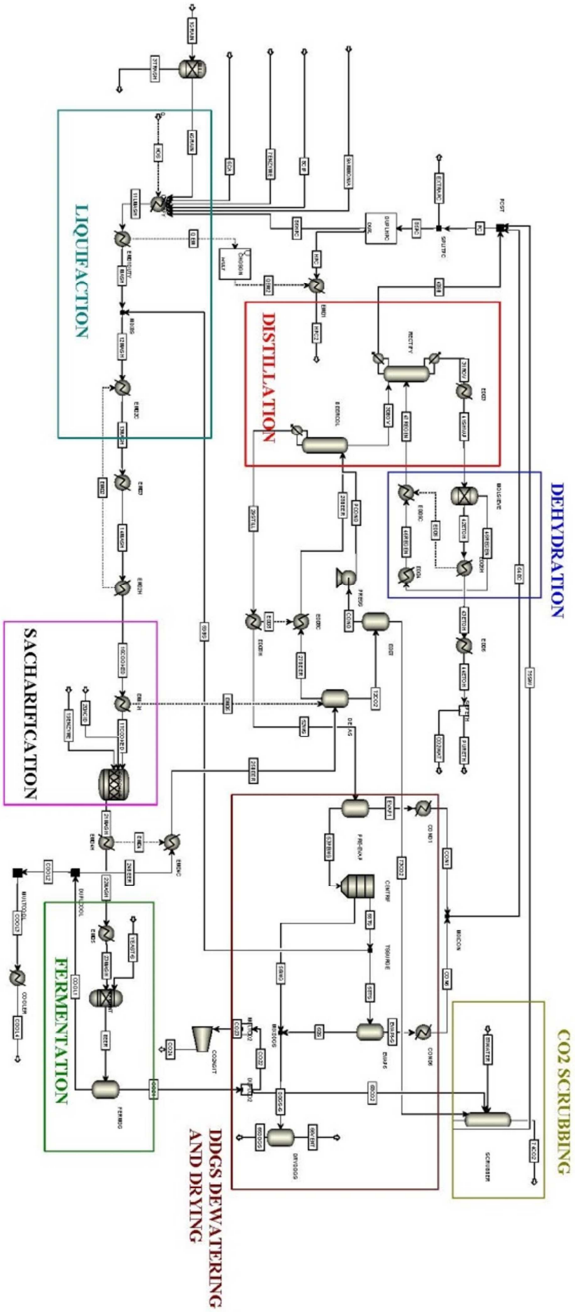

Figure 1 The Aspen Plus simulation flow sheet of bioethanol production from corn

3.0 CONCLUSION

Current fuel ethanol research and development deals with process engineering trends for improving biotechnological production of ethanol. In this work, Aspen plus v8.8 was used to model a bioethanol production plant using biological waste feed such as corn stover, corn fiber, or other residues. There are several stages which take place in order to produce ethanol from corn such as milling, liquefaction, saccharification, fermentation, distillation, dehydration and centrifugation. The results show that 99.5% of ethanol with annual capacity of 0.63 million barrels ethanol per year can be produced from corn waste.

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