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The Determination of the Quantity of CO_2 Produced in a Local Ethanol Plant using Aspen HYSYS Software

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Abstract— *The study was presented in two parts: Part 1 and part 2. Part-1 is titled "An in-depth study of CO_2 and the major techniques involved in the production of CO_2" while part 2 is titled "The determination of the quantity of CO_2 produced in a local ethanol plant using Aspen Hysys software". Some selected equipments in an ethanol plant were stated. These equipments are the CO_2 absorber, the CO_2 separator, the bear absorber and the ethanol separator. A description of the flow of carbon dioxide produced in the fermentation process and some other products through the equipments were made. Carbon dioxide was collected at the top of the carbon dioxide absorber for storage and use. The modeling and simulation of the selected equipments of the ethanol plant using the Aspen Hysys software was carried out. It has been shown that the conditions and quantity of carbon dioxide released from the fermentation process in an ethanol plant can be determined using the Aspen Hysys software. The mole fraction of carbon dioxide produced was 0.9665 and the molar flow was 65.46kgmole/h. The temperature and pressure conditions are 26.14 ^0C and 101.3 kPa respectively.*

Keywords— *Absorber, Aspen Hysys, Carbon dioxide, ethanol, fermentation, modeling, Separator, simulation.*

I. INTRODUCTION

Carbon dioxide (CO_2) is a substance containing one carbon atom and two oxygen atoms in its molecule. This substance (CO_2) is both useful and harmful depending on the use, availability and where it is used or to be used. There are many sources of carbon dioxide. The overall aim of this study is focused on how carbon dioxide is produced, the determination of the quantity of carbon dioxide produced, the storage and use of carbon dioxide. The study was presented in two parts: Part 1 and part 2. Part-1 is titled "An in-depth study of CO_2 and the major techniques involved in the production of CO_2" while part 2 is titled "The determination of the quantity of CO_2 produced in a local ethanol plant using Aspen HYSYS software". Some of the topics discussed in part 1 were "the physical and chemical properties of CO_2, various technologies in the production of CO_2, techniques in removing, storing and re-using the CO_2 produced and its harmful effects in the atmosphere and to the human life". Details are presented in literatures [1,3,4,5,9,10,11,13]

So, here, part 2, titled "The determination of the quantity of CO_2 produced in a local ethanol plant using Aspen HYSYS software" is presented.

II. MATERIALS AND METHODS

The Ethanol plant

Fig. 1 shows an ethanol plant. Carbon dioxide is produced in an ethanol plant through the process of fermentation. A detail ethanol plant and the description of the fermentation process can be seen elsewhere [8,1]

Fig. 2 shows some selected equipment in an ethanol plant. These equipments are the CO_2 absorber, the CO_2 separator, the bear absorber and the ethanol separator. Carbon dioxide produced in the fermentation process and some other products in the fermentor are sent to the Carbon dioxide separator where the other products and beer are sent to the bear absorber while carbon dioxide was separated at the top of the separator to the carbon dioxide absorber where water was used as the absorbent. Carbon dioxide was collected at the top and other substances were sent to the fermentor. Products from the top of the beer absorber are taken to the ethanol separator where ethanol is produced at the top of the ethanol separator.

III. THE USE OF ASPEN HYSYS SOFTWARE

Aspen Hysys software is a powerful tool for modeling and simulation of Engineering processes and platforms. Details of its description and how it works are shown in some literatures [2,7,12,14,6]

IV. THE USE OF ASPEN HYSYS SOFTWARE IN THE DETERMINATION OF THE QUANTITY OF CARBON DIOXIDE PRODUCED

The Aspen Hysys when started can perform so many operations including the following:

- Selections of components.
- Defining and selection of a fluid Package.
- Enter and re-enter Simulation Environment.
- Adding and specifying material streams.
- Adding unit operations (equipments).

Fig. 3 shows the modeling of the selected equipment of the ethanol plant using the Aspen Hysys software.

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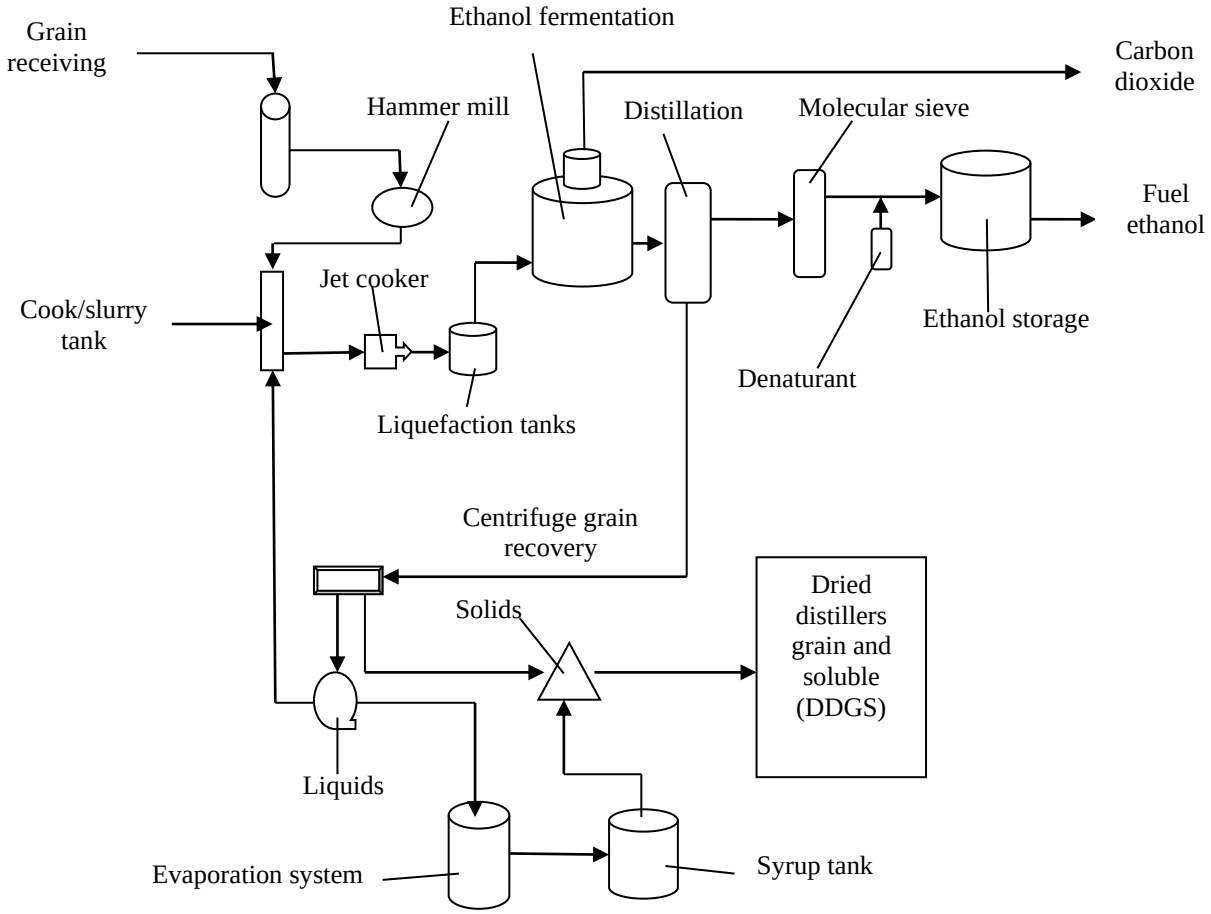

Fig. 1. An ethanol plant

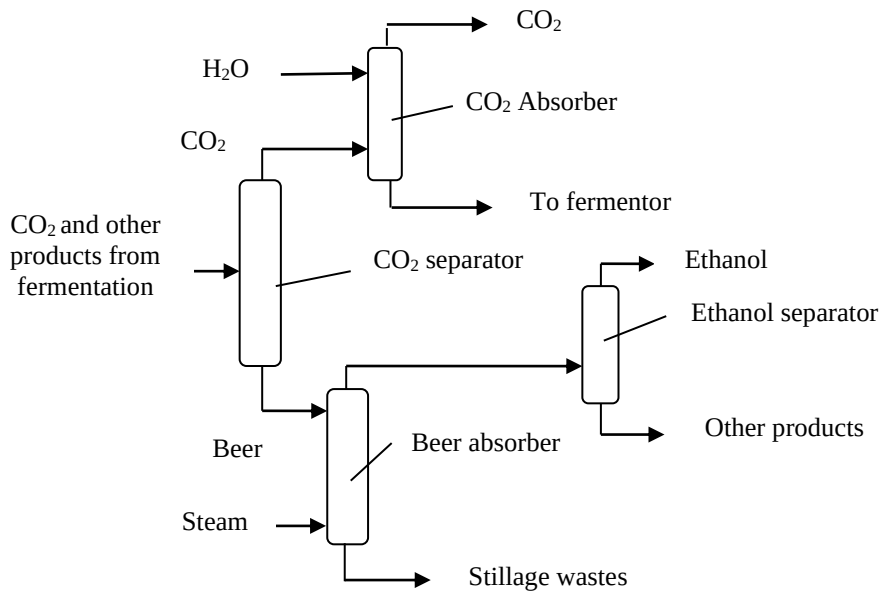

Fig. 2. Selected equipment in a local ethanol plant

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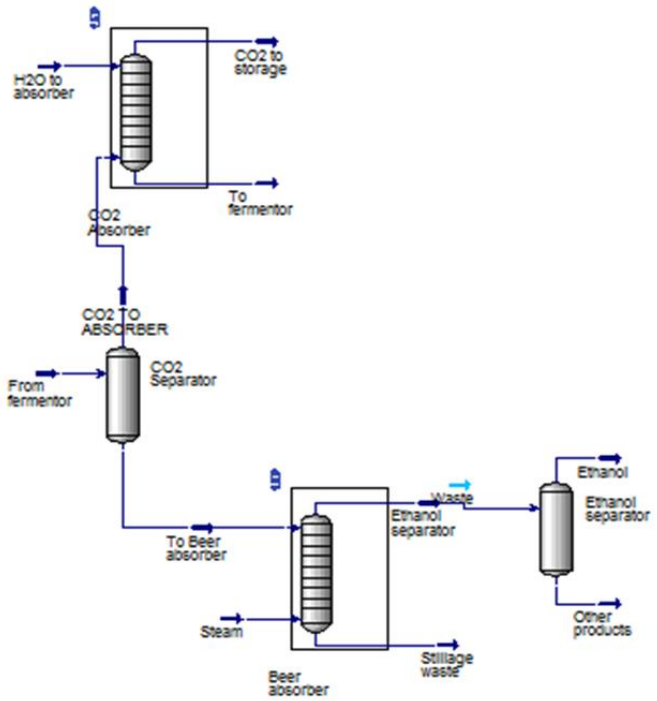

Fig. 3. Modeling of some equipment of the ethanol plant using Aspen HYSYS software

Table 1 shows the data inputted to the Aspen Hysys for the modeling and simulation processes.

TABLE 1. Data inputted to the Aspen Hysys

FLUID PACKAGE: Basis-1

- *Property Package Type:* Nrtl
- *Component List - 1:* Ethanol, H_2O, CO_2, Methanol, 1-Propanol, 1-Butanol, 1-Pentanol and Glycerol

STREAM: From fermentor *(Material Stream)*

- Temperature = 30 ^{0}C
- Pressure = 101.3 kPa
- Molar Flow = 2400 kgmole/h
- Composition Basis (In Mole Fractions): Ethanol = 0.0269; H_2O = 0.9462; CO_2 = 0.0268; Methanol = 0; 1-Propanol = 0; 1-Butanol = 1-Pentanol = 0 Glycerol = 0

UNIT OPERATION: CO_2 Separator *(Separator)*
Feed Stream = From fermentor
Vapour Product = CO_2 TO ABSORBER
Liquid Product = To Beer absorber
Volume = 2 m3
Temperature = 30 ^{0}C
Pressure = 101.3 kPa
Molar Flow = 2400 kgmole/h

Composition Basis (In Mole Fractions): Ethanol = 0.0269; H_2O = 0.9462; CO_2 = 0.0269; Methanol = 0; 1-Propanol = 0; 1-Butanol = 0; 1-Pentanol = 0; Glycerol = 0

STREAM: H_2O to absorber *(Material Stream)*
Temperature = 25 ^{0}C
Pressure = 101.3 kPa
Molar Flow = 130 kgmole/h
Composition Basis (In Mole Fractions): Ethanol = 0; H_2O = 1; CO_2 = 0; Methanol = 0; 1-Propanol = 0; 1-Butanol = 0; 1-Pentanol = 0; Glycerol = 0

UNIT OPERATION: CO2 Absorber *(Absorber)*
Stage Pressure:
StageNumber = 1: *StagePressureValue* = 101.3 kPa
StageNumber = 10: *StagePressureValue* = 101.3 kPa
Specs Summary:
Optional Estimations:
Stage = 1: *Optional Temperature Estimate* = 20 ^{0}C
Stage = 10: *Optional Temperature Estimate* = 30 ^{0}C
STREAM: Steam *(Material Stream)*
Temperature = 140 ^{0}C
Pressure = 101.3 kPa
Mass Flow = 11000 kg/h
Composition Basis (In Mole Fractions): Ethanol = 0; H_2O = 1; CO_2 = 0; Methanol = 0;1-Propanol = 0; 1-Butanol = 0;1-Pentanol = 0; Glycerol = 0

UNIT OPERATION: Beer absorber *(Absorber)*
Stage Pressure:
StageNumber = 1 / *StagePressureValue* = 101.3 kPa
StageNumber = 10 / *StagePressureValue* = 101.3 kPa

V. RESULTS

The simulated results of carbon dioxide are shown in table 2.0.

TABLE 2: Tabulated results

Carbon dioxide from the Absorber
Temperature = 26.14 ^{0}C
Pressure = 101.3 kPa
Molar Flow = 65.46 kgmole/h
Composition Basis (In Mole Fractions): Ethanol = 0; H_2O = 0.0335; CO_2 = 0.9665; Methanol = 0;1-Propanol = 0; 1-Butanol = 0;1-Pentanol = 0; Glycerol = 0

VI. CONCLUSION

Some of the equipments found in a local ethanol plant were modeled and simulated using the Aspen Hysys software. It has been shown that the conditions and quantity of carbon dioxide released from the fermentation process in an ethanol plant can also be measured. In this work, the mole fraction of carbon dioxide produced was 0.9665 and the molar flow was 65.46kgmole/h. The temperature and pressure conditions are 26.14 ^{0}C and 101.3 kPa respectively.

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