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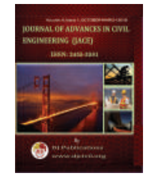

RESEARCH ARTICLE

Design and Simulation of Hydrogen Peroxide Plant

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ABSTRACT

The main aim of our project is to design a chemical plant for production of hydrogen peroxide (H_2O_2) in order to achieve a capacity of 10,000 ton per year. The raw materials used in this plant are 2-ethyl anthraquinone, hydrogen, 2-ethyl hydroquinone and oxygen. Selection of the most suitable method for production of hydrogen peroxide is the important task for a design engineer. In addition, world market of hydrogen peroxide and the prices of feedstock and its impact on process selection are addressed. Moreover, the choosing of best methodologies were investigated and compared where one method needed to be assigned as the production method. Material balance and energy balance, design of equipment's plant, process engineering and economics, plant layout, storage and handling were studied. Finally the results are compared using simulation software HYSYS.

Keywords: Hydrogen Peroxide, Plant design, Material balance, Energy balance, Simulation.

1. INTRODUCTION

Hydrogen peroxide is one of the aromatic compounds with chemical formula H_2O_2 which in pure structure is colourless liquid and slightly more viscous than water. Hydrogen peroxide is used for industrial applications, domestic uses, use as propellant, improvised explosive device/home-made bomb precursor, pulp and paper industry, mining, textile bleaching, controlling fungus on fish and eggs, waste water treatment, healing wounds etc. The production methods that can be used for manufacturing hydrogen peroxide are anthraquinone process, hydrogenation process, autoxidation process, electrochemical process, as well as wet chemical process [1].

The motivation behind the design of production plant of hydrogen peroxide is that there is no industry in Oman that produce hydrogen peroxide. Oman only imports hydrogen peroxide from other countries such as India, Egypt, as well as China [2].

2. PROCESS DESCRIPTION

2.1. Manufacturing processes

- Anthraquinone process
- Autoxidation process
- Electrochemical process
- Wet chemical process

2.2. Selection of process

In this paper we use autoxidation process to manufacture hydrogen peroxide because it has more advantageous properties than others. The fundamental properties of this process are as shown below [3];

- Low cost of raw materials
- Recycling of raw materials
- Less power requirement
- Easy availability of raw materials
- Obtain pure and stable hydrogen peroxide
- High industrial applicability

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- Economical for large scale production

The raw chemicals that are used for manufacturing hydrogen peroxide are:

- 2-ethyl anthraquinone
- 2-ethyl hydroquinone
- Hydrogen
- Water
- Oxygen

3. DESIGN AND SIZING EQUIPMENT

Design of the main units in the hydrogen peroxide plant is presented. These include the hydrogenator reactor and binary distillation. The other units in the plant are sized as in [4, 5, 9].

3.1. Design for distillation column

The working principle of distillation column is separation of the mixture depending on the relative volatility and boiling point of each material [8]. Table 1 shows the sizing results for distillation column.

Table 1.Sizing results for distillation column

Number of Trays	15
Feed tray from Top	11
Top Section Diameter	1.72 m
Bottom Section Diameter	0.676 m
Active Area	1.953 m^2
Stiffener Area	0.0347 m^2
Actual Number of Trays	23 Trays
Overall Column Length	12.9 m

3.2. Hydrogenation reactor design

In the hydrogenation reaction 2-ethyl anthraquinone react with hydrogen that are provided from the bottom of the reactor where hydrogenation reaction is an exothermic reaction taking place at 40°C. The amount of heat evolved during the process is equal to 304348.033 KJ/hr [10, 11]. Table 2 shows the sizing results for hydrogenation.

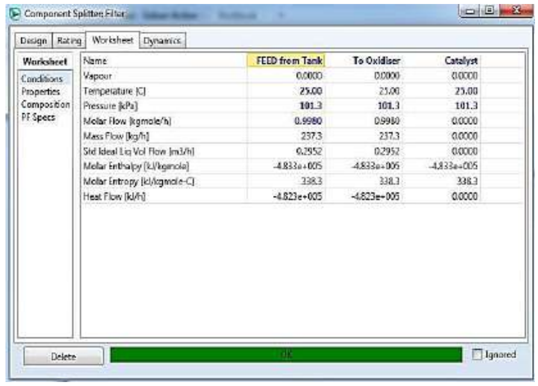
Table 2.Sizing results for hydrogenation

Number of Pallets	2747715 pallets
Spacing in the Reactor	0.54639 m
Diameter of the Reactor	1.34 m
Length of the Reactor	1.676 m
Pitch Circle Diameter (B)	597.336 mm
Thickness of the flange	26.49 mm
Maximum wall thickness	3 mm
Internal Diameter of pipe	19.03 mm
Area of compensation provided by head (A_s)	221.43 mm^2
Area of compensation by the portion of the nozzle external to head (A_0)	429155.55 mm^2

4. STORAGE AND HANDLING

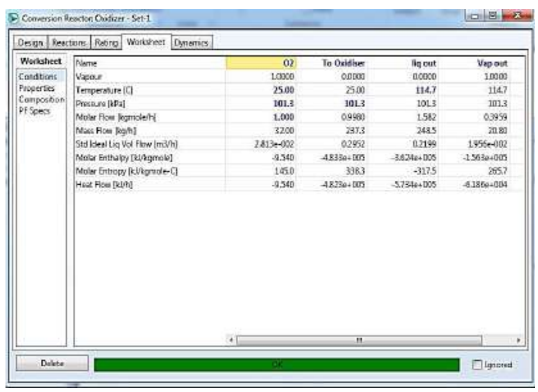
The following points need to be kept in mind while handling hydrogen peroxide.

- Try not to get in eyes or skin or on dress.
- Try not to inhale fog.
- Try not to taste or swallow.



Name	FEED from Tank	To Oxidiser	Catalyst
Vapour	0.0000	0.0000	0.0000
Temperature [C]	25.00	25.00	25.00
Pressure [kPa]	101.3	101.3	101.3
Molar Flow [kgmole/h]	0.9980	0.9980	0.0000
Mass Flow [kg/h]	237.3	237.3	0.0000
Std Ideal Liq Vol Flow [m3/h]	0.2952	0.2952	0.0000
Molar Enthalpy [kJ/kgmole]	-4.833e+005	-4.833e+005	-4.833e+005
Molar Entropy [kJ/kgmole-C]	338.3	338.3	338.3
Heat Flow [kJ/h]	-4.823e+005	-4.823e+005	0.0000

Figure 1.HYSYS result for filter

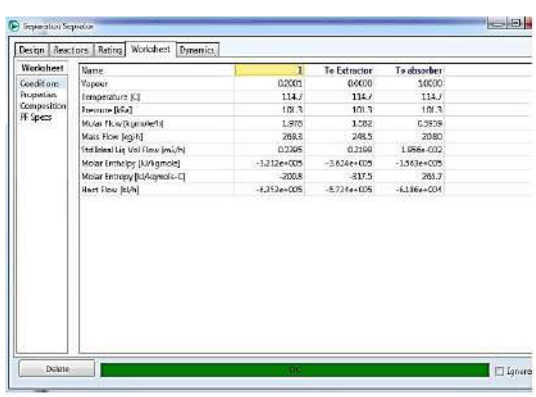


Name	O2	To Oxidiser	liq out	Vap out
Vapour	1.0000	0.0000	0.0000	1.0000
Temperature [C]	25.00	25.00	114.7	114.7
Pressure [kPa]	101.3	101.3	101.3	101.3
Molar Flow [kgmole/h]	1.000	0.9980	1.582	0.3959
Mass Flow [kg/h]	32.00	237.3	248.5	20.80
Std Ideal Liq Vol Flow [m3/h]	2.813e-002	0.2952	0.2199	1.956e-002
Molar Enthalpy [kJ/kgmole]	-9.540	-4.833e+005	-3.624e+005	-1.563e+005
Molar Entropy [kJ/kgmole-C]	145.0	338.3	-317.5	265.7
Heat Flow [kJ/h]	-9.540	-4.823e+005	-5.734e+005	-6.186e+004

Figure 2.HYSYS result for oxidizer

- Wash completely in the contest of heavy usage.
- Utilize only up to the satisfactory level.

In any case, subsequent addition of substance will anticipate tainting in appropriate precautionary measures. All the precautionary strategies should consequently be coordinated towards keeping up the same level of immaculateness and flexibility from tainting as is kept up amid the assembling procedure. Capacity of hydrogen peroxide



Name	1	To Extractor	To absorber
Vapour	0.2001	0.0000	1.0000
Temperature [C]	114.7	114.7	114.7
Pressure [kPa]	101.3	101.3	101.3
Molar Flow [kgmole/h]	1.978	1.582	0.3959
Mass Flow [kg/h]	269.3	248.5	20.80
Std Ideal Liq Vol Flow [m3/h]	0.2395	0.2199	1.956e-002
Molar Enthalpy [kJ/kgmole]	-3.212e+005	-3.624e+005	-1.563e+005
Molar Entropy [kJ/kgmole-C]	-200.8	-317.5	265.7
Heat Flow [kJ/h]	-6.352e+005	-5.734e+005	-6.186e+004

Figure 3.HYSYS result for separator

ought to be regarded to its unique delivery holder or to appropriately outline compartments made of good materials, which have been completely passivized. Hydrogen peroxide that has been recuperated from the first holder ought to be under ordinary conditions [6]. The main factors which need to be taken in to account are factory ventilation and dodge pollution. The holders should be kept shut and should be stored away from acids, alkalis, reducing agents, combustibles, etc. [7]. Figures 1 to 6 shows the HYSYS results.

5. PLANT LAYOUT

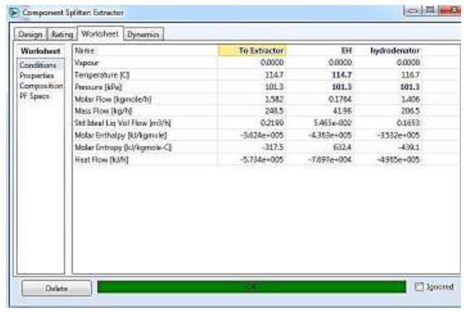


Figure 4.HYSYS result for extractor

Figure 5.HYSYS result for hydrogenator

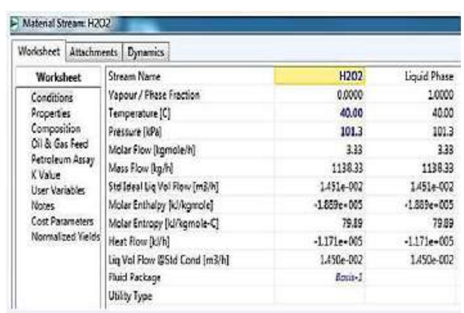


Figure 6.HYSYS result for distillation

Plant outline gathers the physical strategy of machines, sorts of apparatus and other cutting edge workplaces, on the generation line floor in such a path, to the point that they will be dealt with gainfully. While setting up any new industry we need to mastermind the range of various units in the business authentically, so that the advancement cost and the operational cost can be minimized. Grasping an outline that gives the most restricted continued running of partner channel amongst equipment, and insignificant measure of assistant work can minimize the cost of improvement [4].

6. CONCLUSION

At the end from this project, the overall process plant has been studied for the required capacity of hydrogen peroxide which is 10000 ton per year. Anthraquinone process has been selected for manufacturing hydrogen peroxide. Moreover, the calculation of martial and energy balance [12] has been done for each equipment. Furthermore, the calculation design of binary distillation and hydrogenator reactor has been done. Also, design of the process has been done using HYSYS.

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