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INVESTIGATING THE EFFECTS OF SOME PARAMETERS ON HYDROGEN SULPHIDE STRIPPING COLUMN USING ASPEN HYSYS

Saidat Olanipekun Giwa[1], Abdulwahab Giwa[2] and Hale Hapoglu[1]
[1]Department of Chemical Engineering, Faculty of Engineering, Ankara University, Ankara, Turkey
[2]Department of Chemical Engineering, Faculty of Engineering, Middle East Technical University, Ankara, Turkey
E-Mail: agiwa@metu.edu.tr

ABSTRACT

This work has been carried out to investigate the effects of fresh water volumetric flow rate, column tray number, wastewater feed tray number and boil-up ratio on the stripping column used for the purification of wastewater containing hydrogen sulphide as the main impurity. The stripping column was modelled with the aid of Aspen HYSYS using Electrolyte NRTL as the Fluid Package. The wastewater feed and the stripping liquid (fresh water) feed were passed into the stripping column at a temperature of $25^{o}C$ and a pressure of 1 atm. From the results obtained from the investigations carried out, it was revealed that pure water was obtained as the bottom product of the stripping column used for the purification of the wastewater but the mass fractions of the hydrogen sulphide and the purified water in the top product were found to vary with the changes in the parameters considered. So, it is recommended that the values of the parameters should be chosen for the treatment of the wastewater containing hydrogen sulphide based on whether hydrogen sulphide is expected to be in low or high concentration in the top product of the column.

Keywords: hydrogen sulphide, wastewater, Aspen HYSYS, electrolyte NRTL, boil-up ratio.

1. INTRODUCTION

Petrochemical industries are among the most important industries exposed to great developments as a result of increasing demand for petrochemical products during the last few years (Mirbagheri *et al*., 2010). However, extensive use of these products has led to the increase in the pollution of almost all environmental resources (Shokrollahzadeh *et al*., 2008).

Petrochemical industries cause considerable water and air pollutions by discharging their effluents into various receiving bodies such as public sewers and rivers. Large amount of wastewater is produced from petrochemical processes like desalting, hydrocracking, hydroskimming, and vapour condensate (Tobiszewski *et al*., 2012). Consequently, a wide variety of pollutants including refractory organics are usually encountered in petrochemical wastewater. These organics are highly toxic and inhibitory to microbial activity (Guo *et al*., 2009). This kind of wastewater is characterized by high chemical and biological oxygen demand (COD and BOD), large amounts of suspended particulate matter, oil and grease, ammonia and sulphides (Diya'udeen *et al*., 2011). The last-mentioned class of pollutants, that is, the sulphides, especially hydrogen sulphide (H_2S), is particularly often given serious attentions because of its significant negative effects on the environment.

Hydrogen sulphide is a highly toxic compound that can form in any aqueous system which contains both organic matter and sulphate. Such conditions are found in natural systems (e.g. the Black Sea) and can arise as a result of anthropogenic activities, including aquacultural practices and the production of anaerobic sewage and industrial wastewaters (Poulton *et al*., 2002).

Hydrogen sulphide, which is the most important form of sulphur, exists in equilibrium with bisulphide (HS^-) and sulphide (S^{2-}) in aqueous solution and can volatilize to hydrogen sulphide (H_2S) gas (Lyn and Taylor, 1999). As the most reduced form of sulphur, sulphide has a high oxygen demand of 2 mol O_2/1 mol S_2. This normally results in depletion of oxygen where sour wastewater is discharged (Henshaw and Zhu, 2001). To aquatic animal life, H_2S is a highly toxic compound in very low concentrations and has been the cause of mass fish mortality in aquaculture systems. The threshold limit value for fresh or salt water fish is 0.5 ppm (Poulton *et al*., 2002; Henshaw and Zhu, 2001; Altaş and Büyükgüngör, 2008).

Methods for sulphide removal in common use today are physicochemical processes which include direct stripping, oxidation or chemical precipitation (Buisman *et al*., 1990; Janssen *et al*., 1999; Altaş and Büyükgüngör, 2008).

The direct stripping method is carried out in a column known as "stripping column". The column can be arranged with different trays or filled with a packed material. If it is arranged with trays, it is referred to as "tray stripping column", but if it contains a section of any type of a packed material, then, it is known as "packed stripping column".

There are many parameters (factors) like number of trays (in the case of a tray stripping column), stripping liquid flow rate, wastewater feed tray, boil-up ratio, and so on) affecting stripping column which also affect how the column is used to separate pollutants from wastewater.

In this work, it is desired to investigate how stripping liquid volumetric flow rate, number of column tray, wastewater feed tray number and boil-up ratio affect the tray stripping column used to separate hydrogen sulphide from wastewater containing hydrogen sulphide as

the main pollutant using the stripping column model developed with the aid of Aspen HYSYS.

2. MODELING PROCEDURE

The Aspen HYSYS (Aspen, 2011) model of the tray stripping column used in this work is as shown in Figure-1 below. The column comprised fresh water used as the stripping liquid and the wastewater that was purified.
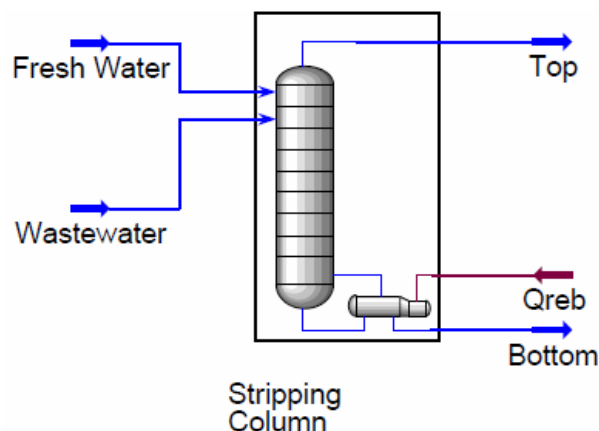

Figure-1. Aspen HYSYS tray stripping column for the purification of wastewater containing hydrogen sulphide.

The data used for the development of the tray stripping column Aspen HYSYS model used in this work is as given in Table-1 shown below.

Table-1. Simulation parameters for Aspen HYSYS tray stripping column.

Parameter	Value
Fresh water feed	
Flow rate (mL/min)	30 and varied
Temperature (°C)	25
Pressure (atm)	1
Composition (Mass fraction)	
Water	0.999
Air	0.0007
Carbon dioxide	0.0003
Wastewater feed	
Flow rate (mL/min)	30
Temperature (°C)	25
Pressure (atm)	1
Composition (Mass fraction)	
Water	0.9
Hydrogen sulphide	0.05
Air	0.035
Carbon dioxide	0.015
Property method	Electrolyte NRTL
Column	
Type	Tray
No. of tray	15 and varied
Fresh water feed tray	1
Wastewater feed tray	5 and varied
Boil-up ratio	0.15 and varied
Tray space (m)	0.1
Column diameter (m)	0.05
Internal type	Sieve

In addition, the details of the reactions defined in the chemistry of the purification process of the column are as outlined in Table-2 below.

Table-2. Chemistry of the purification process.

S/N	Reaction	Type	Basis	Reaction constants
	$H_2O + CO_2 \leftrightarrow HCO_3^- + H^+$	Stoichiometry	Molal	$\ln(K_{eq}) = 235.482 - \dfrac{120921}{T} - 36.7816\ln(T)$
	$H_2O \leftrightarrow OH^- + H^+$	Water	Molal	$\ln(K_{eq}) = 140932 - \dfrac{134459}{T} - 22.4773\ln(T)$
	$H_2S \leftrightarrow H^+ + HS^-$	Stoichiometry	Molal	$\ln(K_{eq}) = 218599 - \dfrac{129954}{T} - 33.5471\ln(T)$
	$HCO_3^- \leftrightarrow CO_3^{-2} + H^+$	Stoichiometry	Molal	$\ln(K_{eq}) = 220067 - \dfrac{124317}{T} - 35.4819\ln(T)$
	$HS^- \leftrightarrow H^+ + S^{-2}$	Stoichiometry	Molal	$\ln(K_{eq}) = -5.7254 - \dfrac{8585.47}{T}$

3. RESULTS AND DISCUSSIONS

The results obtained from the simulations carried out in Aspen HYSYS environment for the stripping of hydrogen sulphide from the wastewater considered are given in Tables 3-6 for the effects of fresh water volumetric flow rate, number of tray of the column, wastewater feed tray and boil-up ratio respectively. Also given in Figures 2-9 are the mass fractions of hydrogen

sulphide and purified water present in the top products of the column, as obtained from the simulations.

In Table-3, as can be seen, the volumetric flow rate of fresh water was varied from 5 to 90 mL/min with a step of 5 mL/min and the responses obtained from the stripping column in form of the mass fractions of the top and the bottom products are given. From the table, it was discovered that pure water was obtained as the bottom

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product of the column because the mass fraction of the water present in the bottom product was 1.0000 for all the flow rates investigated. However, the situations were not the same in the top product because there were varying mass fractions of the components present there. Actually, the components of interest in the products (top and bottom products) were the hydrogen sulphide and the purified water present in them. As such, the variations of hydrogen sulphide and purified water were plotted against the volumetric flow rate of fresh water used for the purifications as shown respectively in Figures 2 and 3.

Table-3. Compositions of top and bottom products obtained from the simulations using different flow rates of fresh water.

Flow rate (mL/min)	Composition (Mass fraction)							
	Top				Bottom			
	H_2O	H_2S	Air	CO_2	H_2O	H_2S	Air	CO_2
5	0.1023	0.4480	0.3148	0.1349	1.0000	0.0000	0.0000	0.0000
10	0.1171	0.4397	0.3102	0.1330	1.0000	0.0000	0.0000	0.0000
15	0.1318	0.4315	0.3056	0.1310	1.0000	0.0000	0.0000	0.0000
20	0.1452	0.4241	0.3015	0.1292	1.0000	0.0000	0.0000	0.0000
25	0.1584	0.4167	0.2974	0.1275	1.0000	0.0000	0.0000	0.0000
30	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
35	0.1838	0.4026	0.2895	0.1241	1.0000	0.0000	0.0000	0.0000
40	0.1960	0.3958	0.2857	0.1225	1.0000	0.0000	0.0000	0.0000
45	0.2078	0.3892	0.2821	0.1209	1.0000	0.0000	0.0000	0.0000
50	0.2192	0.3829	0.2785	0.1194	1.0000	0.0000	0.0000	0.0000
55	0.2303	0.3767	0.2751	0.1179	1.0000	0.0000	0.0000	0.0000
60	0.2410	0.3708	0.2718	0.1165	1.0000	0.0000	0.0000	0.0000
65	0.2514	0.3650	0.2685	0.1151	1.0000	0.0000	0.0000	0.0000
70	0.2616	0.3594	0.2654	0.1137	1.0000	0.0000	0.0000	0.0000
75	0.2714	0.3539	0.2623	0.1124	1.0000	0.0000	0.0000	0.0000
80	0.2809	0.3486	0.2593	0.1111	1.0000	0.0000	0.0000	0.0000
85	0.2902	0.3435	0.2565	0.1099	1.0000	0.0000	0.0000	0.0000
90	0.2991	0.3385	0.2537	0.1087	1.0000	0.0000	0.0000	0.0000

From Figure-2, it was discovered that the mass fraction of hydrogen sulphide present in the top product decreased with increase in the volumetric flow rate of fresh water used. This is an indication that much water is required to reduce the concentration of hydrogen sulphide present in the top product before passing the top gas into the atmosphere. This is actually necessary in order to reduce the negative side effects of hydrogen sulphide on the environment.
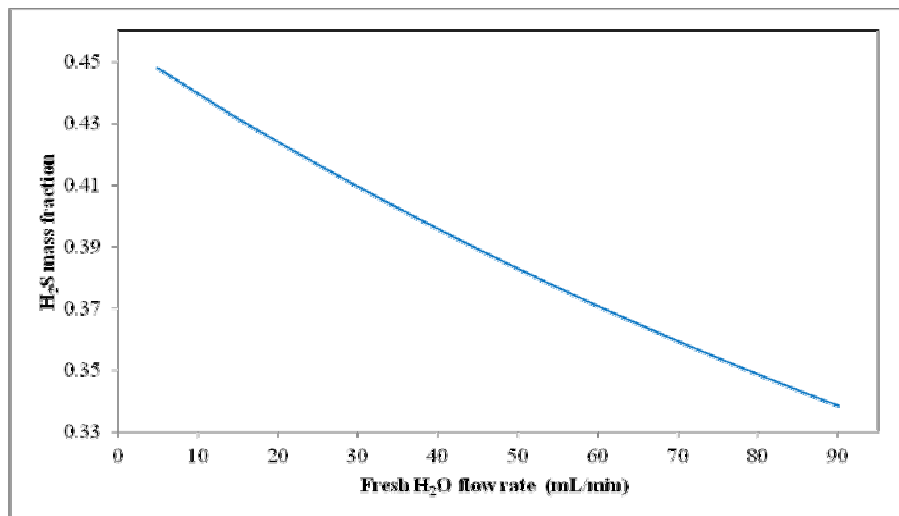
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Figure-2. Mass fraction of hydrogen sulphide versus fresh water flow rate.

Figure-3 shows the trend of the mass fraction of the purified water present in the top vapour of the stripping column with respect to the volumetric flow rate of fresh water used for the separation. As can be observed from the figure, the relationship between the purified water present in the top vapour was found to be directly proportional to the volumetric flow rate of fresh water used because the increase in the volumetric flow rate of fresh water caused an increase in the mass fraction of the purified water found in the top vapour of the column. This showed that the more fresh water passed into the column for separation, the more purified water moved (evaporated) to the top of the column. This means that, if the aim is to obtain as little water as possible in the top vapour in addition to hydrogen sulphide, less fresh water should be used as the stripping liquid passed into the column and vice versa.

Considering the two figures (Figures 2 and 3) discussed above, it has been discovered that while the mass fraction of hydrogen sulphide present in the top product was inversely proportional to the volumetric flow rate of fresh water (stripping liquid) used for the separation, that of the purified water contained in the top product was directly proportional to it (volumetric flow rate of fresh water).
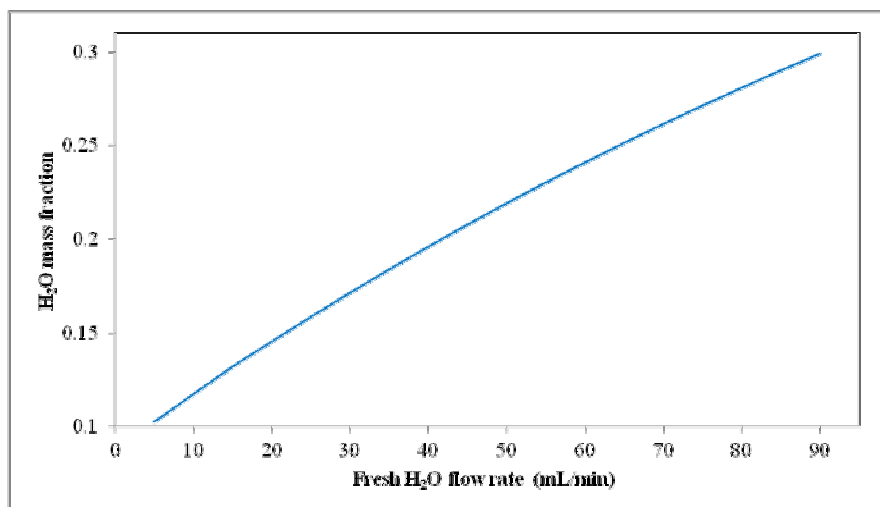

Figure-3. Mass fraction of purified water versus fresh water flow rate.

Table-4 shown below contains the mass fractions of the top and the bottom products obtained when the developed Aspen HYSYS model of the stripping column was simulated by varying the number of column tray. From the table, it was also found that pure water (mass fraction of 1.0000) was present in the bottom product, but the top product was not pure. From the table, the mass fractions of purified water, hydrogen sulphide, air and carbon dioxide contained in the top product varied as the number of column tray was varied. To know the nature of

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the variations, the mass fractions of the main pollutant (hydrogen sulphide) of the wastewater and the purified water contained in the top product of the stripping column were plotted against the number of column tray and the

plots are as shown in Figures 4 and 5, respectively for the hydrogen sulphide and the purified water in the top product of the column.

Table-4. Compositions of top and bottom products obtained from the simulations using different number of trays.

No. of tray	Composition (Mass fraction)							
	Top				Bottom			
	H_2O	H_2S	Air	CO_2	H_2O	H_2S	Air	CO_2
5	0.3145	0.3388	0.2427	0.1040	1.0000	0.0000	0.0000	0.0000
6	0.1727	0.4088	0.2929	0.1255	1.0000	0.0000	0.0000	0.0000
7	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
8	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
9	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
10	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
11	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
12	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
13	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
14	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
15	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
16	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
17	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
18	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
19	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
20	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
21	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
22	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000

From Figure-4 in which the variation of hydrogen sulphide present in the top product with respect to the number of column tray is shown, it was discovered that the mass fraction of hydrogen sulphide first increased and, later, decreased a bit with increase in the number of

column tray up till when 7 trays were used, after which it remained constant. This is indicating that column tray number greater than 7 did not have any effect on the composition of the top product obtained from the column.
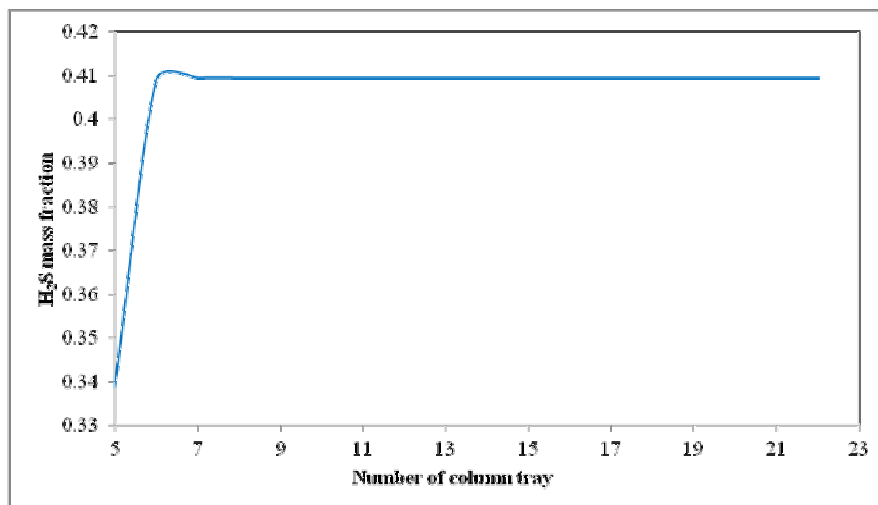

Figure-4. Mass fraction of hydrogen sulphide versus number of tray of the stripping column.

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Given in Figure-5 is the mass fraction of the purified water obtained from the top product of the stripping column studied in this work as a function of column tray number. Similar but the reverse order of the observation made in the case of the relationship between the hydrogen sulphide present in the top product and the column tray number was noticed in this case. That is, the mass fraction of the purified water decreased and, later, increased a bit with increase in the number of column tray and remained constant as from column tray number 7.
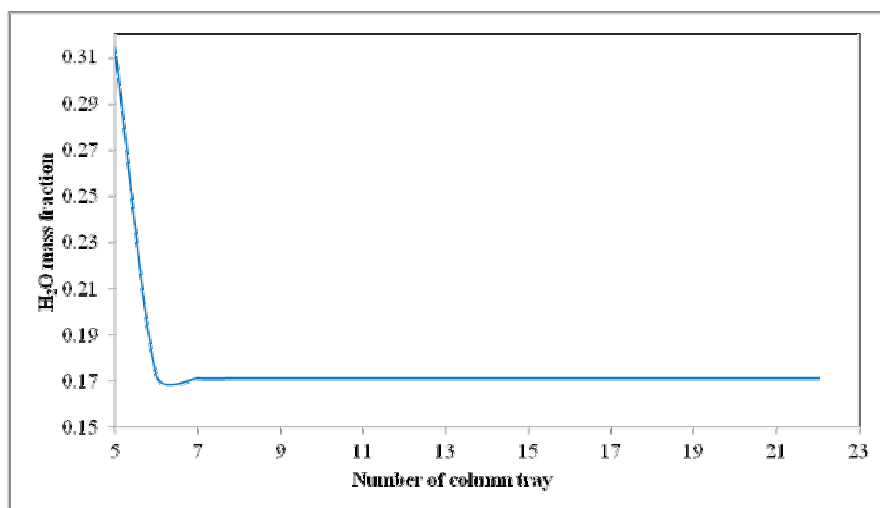

Figure-5. Mass fraction of purified water versus number of tray of the stripping column.

As can also be observed, the behaviour of hydrogen sulphide and purified water have been found to be in inverse relationship of each other, similar to what was observed in their behaviours (Figures 2 and 3) towards the volumetric flow rate of fresh water (stripping water) used.

Also investigated and the results of which are given in Table-5 are the compositions of the top and the bottom products when the wastewater feed tray number was varied. As usual, pure water was obtained as the bottom product. The mass fractions of hydrogen sulphide and purified water versus wastewater feed tray number are graphically shown in Figures 6 and 7, respectively.

Table-5. Compositions of top and bottom products obtained from the simulations using different wastewater feed tray no.

Wastewater feed tray no.	Composition (Mass fraction)							
	Top				Bottom			
	H_2O	H_2S	Air	CO_2	H_2O	H_2S	Air	CO_2
2	0.1710	0.4097	0.2935	0.1258	1.0000	0.0000	0.0000	0.0000
3	0.1713	0.4096	0.2934	0.1258	1.0000	0.0000	0.0000	0.0000
4	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
5	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
6	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
7	0.1713	0.4095	0.2934	0.1258	1.0000	0.0000	0.0000	0.0000
8	0.1713	0.4095	0.2934	0.1258	1.0000	0.0000	0.0000	0.0000
9	0.1713	0.4096	0.2934	0.1258	1.0000	0.0000	0.0000	0.0000
10	0.1712	0.4096	0.2934	0.1258	1.0000	0.0000	0.0000	0.0000
11	0.1712	0.4096	0.2935	0.1258	1.0000	0.0000	0.0000	0.0000
12	0.1712	0.4096	0.2935	0.1258	1.0000	0.0000	0.0000	0.0000
13	0.1711	0.4096	0.2935	0.1258	1.0000	0.0000	0.0000	0.0000
14	0.1726	0.4089	0.2930	0.1256	1.0000	0.0000	0.0000	0.0000
15	0.3149	0.3386	0.2426	0.1040	1.0000	0.0000	0.0000	0.0000

From Figure-6, it was discovered that the mass fraction of hydrogen sulphide was found to remain almost constant when the wastewater feed tray number was varied from 2 to 13 after which it increased a bit and finally decreased when the tray number was 15. This observation has shown that very low mass fraction of hydrogen sulphide can be obtained in the top product of the column by passing the wastewater into the column from a tray far away from the stripping liquid (fresh water feed) tray.
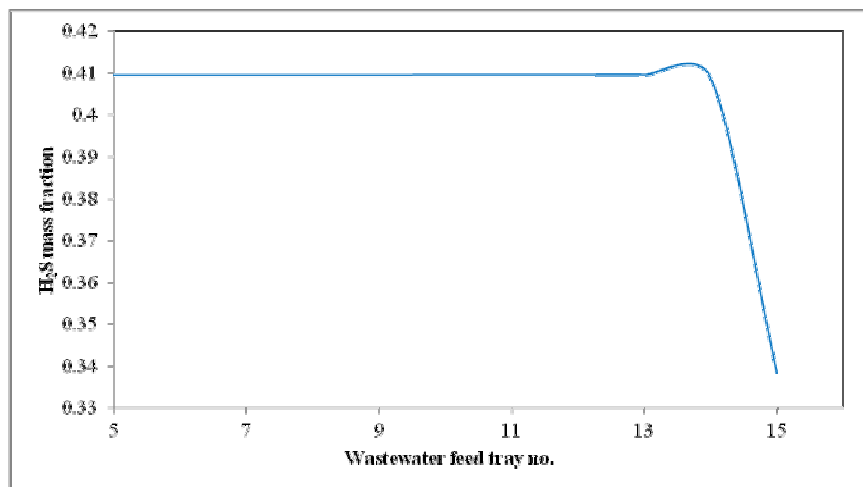

Figure-6. Mass fraction of hydrogen sulphide versus tray number of the wastewater feed.

The relationship observed between the mass fraction of the purified water and the wastewater feed tray number is shown graphically in Figure-7. As can be seen from the graph (Figure-7), when the wastewater feed tray number was varied starting from 2, the mass fraction of the purified water was observed to be approximately constant up till tray number 13. At tray number 14, there was a slight decrease in the mass fraction followed by a significant increase in the mass fraction of the purified water in the top product when the tray number was 15 (see Figure-7).
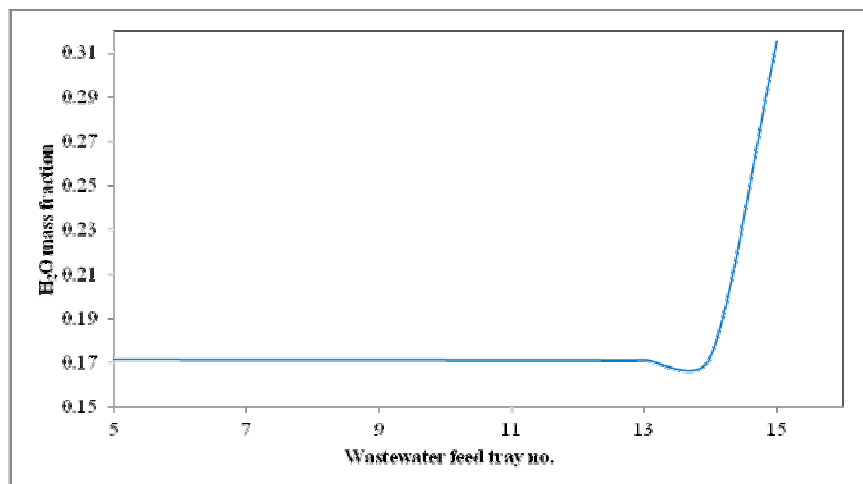

Figure-7. Mass fraction of purified water versus tray number of the wastewater feed.

Apart from the region of the graphs shown in Figures 6 and 7 that was approximately constant, the inverse behaviours of the hydrogen sulphide and the purified water present in the top product has been witnessed again in this case of wastewater feed tray number.

The effects of boil-up ratio, which is defined as the fractional amount of liquid that is boiled back into the column to the amount of liquid leaving the stripping column (from the bottom), was also investigated in this work by varying the boil-up ratio from 0.14 to 0.3 at a step of 0.005 and simulating the Aspen HYSYS stripping column developed. The results of the simulations, that is, the compositions of the top and the bottom products, are as given in Table-6.

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It was seen from Table-6 that pure water was obtained as the bottom product of the separation, just as it was given from the other investigations discussed before. However, in the top product, the mass fractions of purified water, hydrogen sulphide, air and carbon dioxide were found to vary as the boil-up ratio was varied. The variations were investigated further by considering the components of interest (hydrogen sulphide and purified water) present in the top product. The considerations were carried out by plotting the mass fractions of hydrogen sulphide and purified water against the boil-up ratio of the column as shown respectively in Figures 8 and 9.

Table-6. Compositions of top and bottom products obtained from the simulations using different boil-up ratio.

Boil-up ratio	Composition (Mass fraction)							
	Top				Bottom			
	H_2O	H_2S	Air	CO_2	H_2O	H_2S	Air	CO_2
0.14	0.0360	0.4764	0.3413	0.1463	1.0000	0.0000	0.0000	0.0000
0.145	0.1079	0.4409	0.3159	0.1354	1.0000	0.0000	0.0000	0.0000
0.15	0.1713	0.4095	0.2934	0.1257	1.0000	0.0000	0.0000	0.0000
0.155	0.2272	0.3819	0.2736	0.1173	1.0000	0.0000	0.0000	0.0000
0.16	0.2766	0.3575	0.2562	0.1098	1.0000	0.0000	0.0000	0.0000
0.165	0.3184	0.3368	0.2413	0.1034	1.0000	0.0000	0.0000	0.0000
0.17	0.3557	0.3184	0.2281	0.0978	1.0000	0.0000	0.0000	0.0000
0.175	0.3889	0.3020	0.2164	0.0927	1.0000	0.0000	0.0000	0.0000
0.18	0.4187	0.2873	0.2058	0.0882	1.0000	0.0000	0.0000	0.0000
0.185	0.4455	0.2740	0.1963	0.0841	1.0000	0.0000	0.0000	0.0000
0.19	0.4698	0.2620	0.1877	0.0804	1.0000	0.0000	0.0000	0.0000
0.195	0.4921	0.2510	0.1798	0.0771	1.0000	0.0000	0.0000	0.0000
0.2	0.5122	0.2411	0.1727	0.0740	1.0000	0.0000	0.0000	0.0000
0.205	0.5306	0.2320	0.1662	0.0712	1.0000	0.0000	0.0000	0.0000
0.21	0.5476	0.2236	0.1602	0.0687	1.0000	0.0000	0.0000	0.0000
0.215	0.5632	0.2159	0.1547	0.0663	1.0000	0.0000	0.0000	0.0000
0.22	0.5777	0.2087	0.1495	0.0641	1.0000	0.0000	0.0000	0.0000
0.225	0.5912	0.2020	0.1447	0.0620	1.0000	0.0000	0.0000	0.0000
0.23	0.6039	0.1957	0.1402	0.0601	1.0000	0.0000	0.0000	0.0000
0.235	0.6156	0.1900	0.1361	0.0583	1.0000	0.0000	0.0000	0.0000
0.24	0.6265	0.1846	0.1322	0.0567	1.0000	0.0000	0.0000	0.0000
0.245	0.6367	0.1795	0.1286	0.0551	1.0000	0.0000	0.0000	0.0000
0.25	0.6463	0.1748	0.1252	0.0537	1.0000	0.0000	0.0000	0.0000
0.255	0.6554	0.1703	0.1220	0.0523	1.0000	0.0000	0.0000	0.0000
0.26	0.6639	0.1661	0.1190	0.0510	1.0000	0.0000	0.0000	0.0000
0.265	0.6720	0.1621	0.1161	0.0498	1.0000	0.0000	0.0000	0.0000
0.27	0.6796	0.1583	0.1134	0.0486	1.0000	0.0000	0.0000	0.0000
0.275	0.6869	0.1548	0.1109	0.0475	1.0000	0.0000	0.0000	0.0000
0.28	0.6937	0.1514	0.1084	0.0465	1.0000	0.0000	0.0000	0.0000
0.285	0.7002	0.1481	0.1061	0.0455	1.0000	0.0000	0.0000	0.0000
0.29	0.7064	0.1451	0.1039	0.0445	1.0000	0.0000	0.0000	0.0000
0.295	0.7123	0.1422	0.1019	0.0437	1.0000	0.0000	0.0000	0.0000
0.3	0.7180	0.1394	0.0999	0.0428	1.0000	0.0000	0.0000	0.0000

From Figure-8, it was noticed that the increase in the boil-up ratio of the column resulted in decrease in the mass fraction of hydrogen sulphide present in the top product of the stripping column. In other words, in order to lower the concentration of hydrogen sulphide present in the top product (probably, before being discharged into the atmosphere), high boil-up ratio is required.
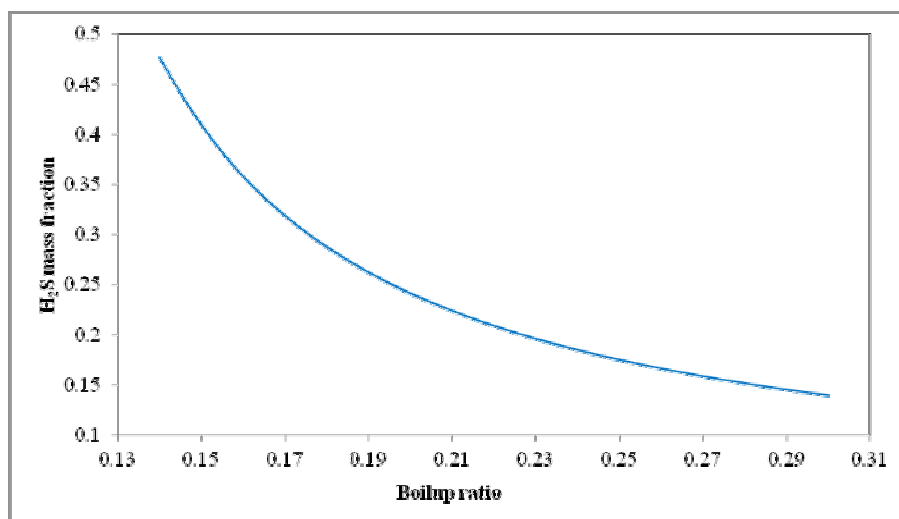

Figure-8. Mass fraction of hydrogen sulphide versus boil-up ratio.

According to the results given in Figure-9 for the relationship between the mass fractions of the purified water and the boil-up ratio, the mass fraction of the purified water present in the top product of the stripping column was found to increase with increase in the boil-up ratio of the column. This has revealed that the more the boil-up ratio was being increased, the more the pure water present in the bottom of the column was being evaporated and being moved to the top tray of the column.
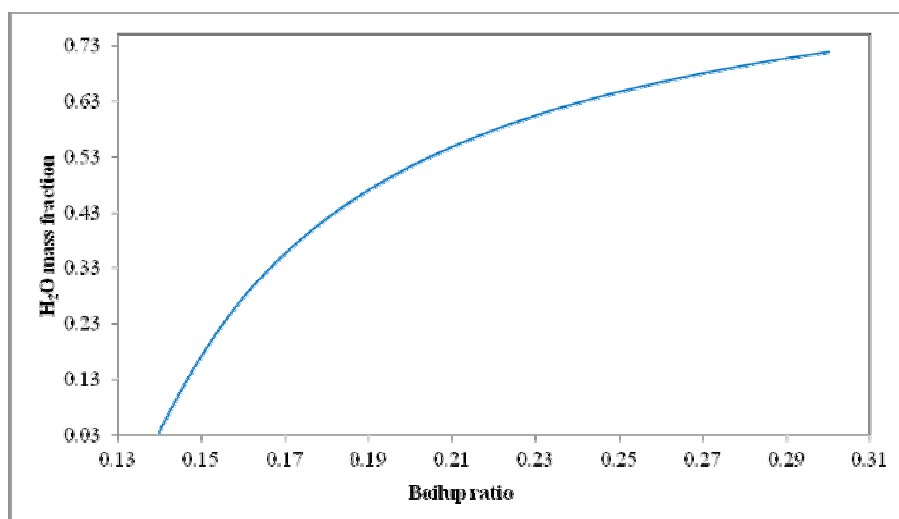

Figure-9. Mass fraction of purified water versus boil-up ratio.

It has been noticed from the investigations of the effects of boil-up ratio on the purification of the wastewater containing hydrogen sulphide that, with all the boil-up ratios considered, the response of the mass fractions of hydrogen sulphide and purified water found in the top of the stripping column were inverse to each other.

4. CONCLUSIONS

The results obtained from the investigations carried out on some of the parameters (fresh water volumetric flow rate, column tray number, wastewater feed tray number and boil-up ratio) affecting the purification of the wastewater containing hydrogen sulphide as the main impurity (and, of course, a pollutant to the environment) have revealed that pure water was

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obtained as the bottom product of the stripping column used for the purification of the wastewater but the concentration of hydrogen sulphide in the top product was found to vary with the changes in the parameters considered. It is, therefore, proposed that the values of the parameters should be chosen for the wastewater treatment based on whether hydrogen sulphide is expected to be in low or high concentration in the top product of the column.

ACKNOWLEDGEMENTS

Nomenclatures

Bottom   Bottom product
CO_2 Carbon dioxide
H_2O Water
H_2S Hydrogen sulphide
NRTL   Non-Random Two-Liquid
Qreb   Reboiler duty
Top   Top product

REFERENCES

Altaş L. and Büyükgüngör H. 2008. Sulfide Removal in Petroleum Refinery Wastewater by Chemical Precipitation. Journal of Hazardous Materials. 153(1-2): 462-469.

Aspen. 2011. Aspen HYSYS. Aspen Technology. United States.

Buisman C.J.N., Ljspeert P., Janssen A. and Lettinga G. 1990. Kinetics of Chemical and Biological Sulfide Oxidation in Aqueous Solutions. Water Research. 24(5): 667-671.

Diya'udeen B.H., Daud W.M.A.W. and Abdul Aziz A.R. 2011. Treatment Technologies for Petroleum Refinery Effluents: A Review. Process Safety and Environmental Protection. 89(2): 95-105.

Guo J., Ma F., Chang C-C., Cui D., Wang L., Yang J. and Wang L. 2009. Start-Up of a Two-Stage Bioaugmented Anoxic (A/O) Biofilm Process Treating Petrochemical Wastewater Under Different DO Concentration. Bioresource Technology. 100(14): 3483-3488.

Henshaw P.F. and Zhu W. 2001. Biological Conversion of Hydrogen Sulphide to Elemental Sulphur in a Fixed-Film Continuous Flow Photo-Reactor. Water Research. 35(15): 3605-3610.

Janssen A.J.H., Lettinga G. and Keizer A. 1999. Removal of Hydrogen Sulphide from Wastewater and Waste Gases by Biological Conversion to Elemental Sulphur Colloidal and Interfacial Aspects of Biologically Produced Sulphur Particles. Colloids and Surfaces A: Physicochemical and Engineering Aspects. 151(1-2):389-397.

Lyn T.L. and Taylor J.S. 1992. Assessing Sulfur Turbidity Formation Following Chlorination of Hydrogen Sulfide in Ground Water. Journal of American Water Works Association. 84(9): 103-112.

Mirbagheri S.A., Poshtegal M.K. and Parisai M.S. 2010. Removing of Urea and Ammonia from Petrochemical Industries with the Objective of Reuse in a Pilot Scale: Surveying of the Methods of Waste Water Treatment. Desalination. 256: 70-76.

Poulton S.W., Krom M.D., Rijn J.V. and Raiswell R. 2002. The Use of Hydrous Iron (III) Oxides for the Removal of Hydrogen Sulphide in Aqueous Systems. Water Research. 36: 825-834.

Shokrollahzadeh S., Azizmohseni F., Golmohammad F., Shokouhi H. and Khademhaghighat F. 2008. Biodegradation Potential and Bacterial Diversity of a Petrochemical Wastewater Treatment Plant in Iran. Bioresources Technology. 99: 6127-6133.

Tobiszewski M., Tsakovski S., Simeonov V. and Namiesnik J. 2012. Chlorinated Solvents in a Petrochemical Wastewater Treatment Plant: An Assessment of Their Removal Using Self-Organising Maps. Chemosphere. 87(8): 962-968.