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Designing a Methodology for Optimisation of Heater Treater

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Abstract

Emulsions refer to mixture of two or more immiscible liquids. For an emulsion to form the components should be immiscible with each other. Various equipments are available in the oil and gas industry. Heater treaters are predominantly used in the oil industry. Heater treater, as the name implies, heat the feed to break the emulsion. There are two types of heater treaters i.e. horizontal heater treaters and vertical heater treaters. Vertical heater treaters are used when the flow is coming from the single well. When the flow is coming from the number of wells, horizontal heater treater is used. In this paper, an attempt has been made to design horizontal heater treater for the crude oil coming from a loosely consolidated, water drive sandstone reservoir in offshore South Louisiana field. As the flow is coming from 10 wells, therefore horizontal heater treater is used. In designing of treater three equations are used i.e. settling equation, retention time equations for heat required. An adequate solution of the dimensions and the fire tube rating of the heater treater has been provided at the end of the paper.

Keywords

Emulsion, heater treater, horizontal heater treater, dimensions of heater treater, fire tube rating.

Introduction

Emulsions are normally encountered in the oil and gas industry and these are needed to be broken. Emulsion refers to the heterogeneous mixture of two or more immiscible liquids with one liquid dispersed as droplets into the other liquid. They can be liquid /liquid, liquid/gas etc. In liquid/liquid emulsion both the liquid forming emulsion should be immiscible with one another. In liquid/gas emulsion gas should be immiscible with liquid [1]. In oil and gas industry crude oil/water emulsions are normally encountered. This type of emulsion is called normal emulsion if water is dispersed phase and oil is dispersing phase. If reverse process takes place, then it is called reverse emulsion i.e. if water is dispersing phase and oil is dispersed phase [2]. Emulsions can be stable as well as unstable. Emulsions which can be separated easily by agitation are called unstable emulsion. The emulsion which cannot be separated easily is known as stable emulsions [3]. The type depends upon the density of the crude oil. Crude oils with low API gravity form more stable emulsion than crude oils having higher API gravity [4]. Different types of methods are employed to break different emulsions like heating, de-emulsification, agitation, electrostatic coalescence, water washing, filtering, gravity settling, centrifugation and distillation [5]. By heating the crude oil, it reduces the viscosity of crude oil which in turn reduces the viscosity of crude oil and thus water droplets coalesce faster and settle down [6]. De-emulsification refers to the use of chemical de-emulsifier which helps in destabilising the emulsion, increasing the coalescence of water droplets which in turn breaks the emulsion. Agitation increases the collision between the water droplets which in turn increases the coalescence between the water droplets and helps in resolving the emulsion. In electrostatic coalescence three phenomenon helps in separating out the emulsion i.e. polarization of water droplets in the line of the electric charge, attraction of water droplets by the electrode due to induced charge, weakening of the film of the emulsifier around the water droplets [7]. In water washing, emulsion is processed from the bottom of the vessel which travels upwards to the top of the vessel through water resulting in coalescence of water droplets which settles at the bottom of the vessel [8]. Filtering refers to the selection of proper pore size and wetting the filtering material with oil and keeping it submerged in oil and resulting in breaking of emulsion. Gravity settling refers to the separation of oil and water due to the density differences [9]. Various types of equipments used to break the emulsion are free water knock-out drum (FWKO), settling tanks, electrostatic coalesces, horizontal and vertical heater treater. In FWKO, three different types of layers are formed when agitated i.e. the top layer containing pure crude oil with small amount of water dispersed in it, the bottom layer containing clean water with oil dispersed in it and the layer of emulsion in between the top and bottom layer. As the coalescence takes place the layer of emulsion vanishes. Settling tank are also called gun barrels [10]. They treat the emulsion by heating. Nowadays gun barrels are replaced by vertical heater (fig1). In this type of treaters, flow is entered from the top of the vessel. The upper section is called gas separating section. This section consists of inlet diverter and mist extractor. When the flow enters, it first passes through the inlet diverter where most of the separation takes place and then it passes through the mist extractor where the residual gas is vented off through the gas vent line. Now the flow comes downwards around the coalescence where coalescence of water droplets takes place and then it settles down and is collected in the water outlet line. The middle portion consists of the treated oil [10]. It should be made sure that steam does not enter that steam does not enter the fire tube. In this paper major emphasis is given on the designing of horizontal heater treater. Horizontal heater treater is depicted in the fig 2.

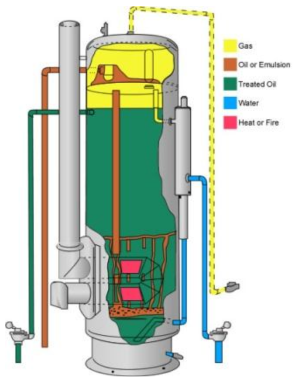

Fig. 1: Vertical heater treater

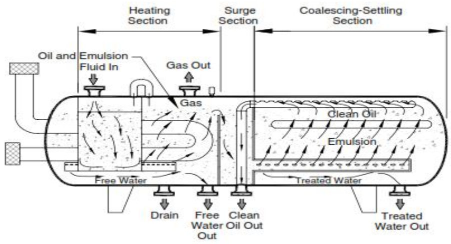

Fig. 2: Horizontal heater treater

Horizontal heater treater is divided into three sections i.e. heating section or degassing section, surge section and coalescing section. Oil is entered through the front section of the treater and then it is flashed where the gas is separated out through the inlet diverter and mist extractor. The oil settles down in oil water interface where the process of water washing takes place where the free water is separated. Free water refers to the water that does not contain any emulsified particles. Now the oil comes in contact with fire tubes and then goes to the surge section. In surge section only part of the emulsion is separated out. Then oil enters the coalescing section where rest of the separation takes place. This section should be sized most efficiently as this part of the treater defines the efficiency of the heater treater. The spreader is installed which distributes the flow evenly throughout the section. Treated oil is collected on the collection device located at the top whereas water droplets fall at the bottom through the rising oil and therefore water is collected at the bottom and oil is collected at the top of the horizontal heater treater [11, 12]. In this paper, an attempt has been made to design the horizontal heater treater for de-emulsification of crude oil from water. Main focus is given on the coalescing section as this section determines the cost of heater treater. These calculations are done if laboratory data is unavailable. At the end of the paper an economical solution is given with full validation.

Methodology and Optimisation

For designing a horizontal heater treater, the input parameters required are oil gravity (^{0}API), oil flow rate (bbl/day), gas gravity, number of wells, inlet oil temperature (^{0}F) and Inlet BS & W (percent). After obtaining these parameters, settling equation (at various temperatures) and retention time equation are solved. After this, heat required is estimated followed by selection of adequate d and L_{eff} is done. For solving the settling equation, difference in specific gravity of oil and gas, viscosity of oil, diameter of water droplet in microns at different temperatures is required. The viscosity of oil (µ) is calculated from the following equations

$\mu = 10^X$ [1]

$X = Y[T]^{-1.163}$ [2]

$Y = 10^z$ [3]

$Z = 3.0324 - 0.02023*G$ where G = gas gravity [4]

The drop diameter at 1% water cut (BS & W) is calculated by using equation 5

$d_m = 200\ \mu^{.25}$ [5]

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The settling equation is given by

$$d*L_{eff}= 438[Q_0\mu / (\Delta S.G)*(d_m)^2] \quad [6]$$

Using equation 6, combination of d and L_{eff} are drawn at different temperatures.

The next step is to solve the retention time equation (eq. 7). In the absence of laboratory data, retention time can be taken between 20 to 30 minutes.

$$d^2L_{eff} = [Q_0[t_r]_0 / 1.05] \quad [7]$$

Combination of d and L_{eff} at retention time is plotted on the same graph.

Heat required to raise the temperature of the feed to the selected temperature substituting the initial temperature as feed in temperature is given by equation 8.

$$q = 16\ Q_0\Delta T\ [0.5(S.G)_o+0.1] \quad [8]$$

Next step is followed by selection of adequate combination of d and L_{eff}. Shade all the area below the line of retention time. A point can be chosen that comes out of the shaded area and requires minimum heat. Minimum heat required would be the fire tube rating of the heater treater.

Calculations

The input parameters are shown in table 1.

s.no.	Parameters	Value
1.	Specific gravity of oil	30^0 API
2.	Specific gravity of gas	0.6
3.	Treating temperature	90^0F
4.	BS&W(water cut)	1%
5.	Oil flow rate(per well)	500 bpd
6.	Number of wells	10

Table 1: Input parameters.

The parameters for the settling equation are given in table 2.

s.no.	Temperature	Δ S.G.(specific gravity)	μ(viscosity)	d_m(drop diameter)	dL_{eff}
1.	90	0.276	31	472	1104
2.	110	0.276	15	394	767
3.	130	0.276	9	346	597

Table 2: Settling equation parameters

Where,

ΔS.G. = difference in the specific gravity of gas and oil
μ = viscosity of oil, cp
d_m = diameter of the water droplet to be settled down, in microns
d = diameter of the heater treater,inches
L_{eff} = length of the coalescing section, feet

The value of μ is calculated with the help of equations [1,2,3,4] and the value of d_m is calculated from the equation [5] .

Now, calculation of retention time equation has been made. In this case, we have taken retention time i.e. t_r= 20 minutes.

Next is to solve the retention time equation
d^2L_{eff} = [5000[20] / 1.05]= 95238

A combination of d and L_{eff} has been made for both retention time equation as well as the settling equation. Combination for settling equation is given in table 3.

S.No	Treating temperature	d	L_{eff}	Heat required
1.	90	132	8.3	0
		120	9.2	
		108	10.2	
		96	11.5	
		72	15.3	
		60	18.4	
2.	110	132	5.81	0.86
		120	6.39	
		108	7.10	
		96	7.98	
		72	10.65	
		60	12.78	
3.	130	132	4.52	1.72
		120	4.97	
		108	5.52	
		96	6.21	
		72	8.29	
		60	9.95	

Table 3: Combination for settling equation

Combination of d and L_{eff} is given in table 4.

Retention time	D	L_{eff}
20	132	5.46
	120	6.61
	108	8.16
	96	10.33
	72	18.37
	60	26.45

Table 4: Combination for retention time equation

In the next step, heat required is calculated.
$q = 16\ Q_0 \Delta T\ [0.5(S.G)_o+0.1]$
$= 16*5000*\Delta T[0.5*(.876)+0.1]=43040*\Delta T$

Putting the values for initial temperature as 90^0F and calculating for treating temperatures of 90^0F,110^0F and 130^0F

q_1=43040*[90-90]=0
q_2=43040[110-90]=0.860800 MMbtu/hour
q_3=43040[130-90]=1.721600 MMbtu/hour

where, q_1,q_2 and q_3 are the heat required for 90^0F,110^0Fand 130^0F respectively
The graph has been plotted for the settling as well as the retention time equations.

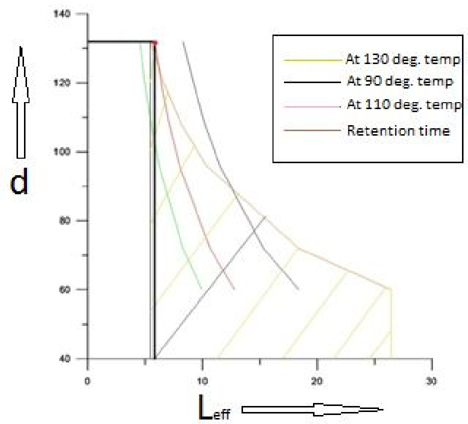

Figure 3: d and L_{eff} at different temperatures

Area for retention time less than 20 minutes has been marked, only one point comes outside that area i.e. for L_{eff}= 5.78 feet and d=132.5 inch the treating temperature can go upto 110^0F if the field conditions changes.

Results and Conclusion

The above study reveals that the length of the coalescing section in a horizontal heater treater should be ideally equal to **5.78 feet** and the diameter should be **132.5 inches**. The fire tube rating should be **0.860800 MMbtu/hour or 20.6592 MMbtu/day**.

References

[1] Kokal, S. L. (2005, February 1). Crude Oil Emulsions: A State-Of-The-Art Review. Society of Petroleum Engineers. doi:10.2118/77497-PA

[2] Minnie, J. (1933, January 1). TREATMENT OF CRUDE OIL EMULSIONS. World Petroleum Congress.

[3] Smith, H. V., Arnold, K. E. (1987, January 1). Crude Oil Emulsions (1987 PEH Chapter 19). Society of Petroleum Engineers.

[4] Augustina, O., Sylvester, O. (2015, August 4). Emulsion Treatment in the Oil Industry: A Case Study of Oredo Field Crude Oil Emulsion. Society of Petroleum Engineers. doi:10.2118/178381-MS

[5] Duerksen, J. H., Hsueh, L. (1983, April 1). Steam Distillation of Crude Oils. Society of Petroleum Engineers. doi:10.2118/10070-PA

[6] Harr, J. D. (1969, January 1). Field Approach To Crude Oil Demulsification. Society of Petroleum Engineers.

[7] Boling, D. R. (1966, January 1). The Use of Electrostatic Coalescence in the Dehydration of Gulf Coast Crudes. American Petroleum Institute.

[8] Kale, H. B., Wyllie, H., Tainsh, H. R. (1951, January 1). Solvent Washing of Wells in the Digboi Oil Field, Assam. World Petroleum Congress.

[9] Cartmill, J. C., Dickey, P. A. (1969, January 1). Flow Of A Disperse Emulsion Of Crude Oil In Water In Porous Media. Society of Petroleum Engineers. doi:10.2118/2481-MS

[10] Ferguson, K. R., Stechmann, R. H. (1980, June 1). Improving Heater Treater Fuel Efficiency. Society of Petroleum Engineers. doi:10.2118/8304-PA

[11] Bartz, D., Gotterba, J. (2015, June 9). Performance Data of a Distributed Flux Burner in a Heavy Oil Heater Treater. Society of Petroleum Engineers. doi:10.2118/174458-MS

[12] Bartz, D., Gotterba, J. (2014, June 10). Results of Field Operation of a Distributed Flux Burner in a Heater Treater in a Northern Canada Heavy Oil Field; Thermal Performance and Firetube Life. Society of Petroleum Engineers. doi:10.2118/170172-MS