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Connect Two Crude Oil Distillation Units with One Crude Oil De-Salter in Dewania Refinery

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Abstract

Crude oil, which exported to refineries, already contains salt, water, and fouling crude oil received with salt content not less than 50 ppm. Dewania refinery with a capacity of 20,000 BPSD, which serves with two crude distillation units, each unit with a capacity of 10,000 BPSD, which operate without crude desalter. In an aim to reduce the effects of salts, water and, fouling associated with crude oil, two crude distillation units connected with one crude oil desalter with a capacity of 20,000 BPSD (one desalter). crude oil desalter transferred from (Daura Refinery) to Dewania refinery, in aim to reduce salt content from 50ppm to 5 ppm and mitigate water and other fouling. Crude oil desalter installed in the middle distance between two crude distillations units (90 m from each unit isometric piping). Crude oil, which is pumped by a charge pump to preheated in crude oil distillation unit with a train of heat exchangers. When the pipeline size increased from 4" to 6", which reduces the pressure dropped from 0.946 to 0.15 bar for each transfer pipeline and in consequence, the total pressure drop reduces from 11.011 to 10.215 bar for the whole unit. In an aim to reduce the heat dissipated from surface of transfer pipeline. Each transfer pipeline insulated with calcium silicate insulator, the thickness of insulator increased from 38mm to 50mm in an aim to reduce heat loss from -101.56 watts/m to -84.282 watts/m, which reduced temperature difference between the surface pipeline and environment from 13 to 10°C.

Keywords: Crude oil, Distillation, Desalter, Connect two crude distillation units.

1. Introduction

Crude oil, is extracted from the deep earth [1], and consist of a mixture of hydrocarbons also contains many associated materials like salt, water, metals, and fouling [1]. These associated materials can be considered harmful materials for the downstream process equipment; heat exchangers and heating furnaces [1, 2]. The Salts can be considered the main source of corrosion issue due to the hydrolysis reactions of sodium chloride, magnesium chloride, and calcium chloride salts [1, 3, 4], hydrochloric acid which initiated [1, 3, 4] can corrode the equipment (head and trays of distillation column, and heat exchangers) [4].

Salts, water, and fouling can be reduced by many methods such as: electrical desalting, electrical – chemical desalting, gravitational [2, 5], electrical chemical desalting can be considered the most effective method [6].

Crude oil desalter (COD) already available at upstream processes like (crude oil field), which reduces the salt content from 100 to 50 PPM, it also available at the downstream process like (crude distillation unit) (CDU). COD reduces salt content from 50 to 5 PPM [1], de – emulsifier and, water injected to the crude oil streamline after preheated by heat exchangers train to at least 120° C [2, 3], and then enter to COD, heat reduces the viscosity of crude oil in aim to simplify water removal.

Water added to crude oil at the same temperature is used mainly to wash the crude oil, and dissolve the salts associated with the crude oil [7]. The de-mulsifier material, which already added to crude oil to reduce interfacial tension of water droplets interface initiated inside crude oil (breaks droplet film), that facilitate coalescence process of water droplets with each other and in final result reduces the salt content in the crude oil [7, 8].

Applied pressure in the COD not less than 10bar (g), in aim, to avoid crude oil evaporation [1, 2]. The crude oil, de – emulsifier, and water mixed with mixing valve or static mixer [9], mixture enter the bottom of COD vessel through distributor, a vessel equipped with high voltage electrical transformer, that transformer converts AC to DC with two electrical grids, electrical voltages applied in crude oil desalting process varies from 15kv to 21kv DC voltage [10, 11]. In order to charge water drops suspended in heated crude oil, water drops charged with positive charges (+) and negative (–) charges, the drops then attract to each other's coalescence of water drops occur in aim to enlarge the size of water drops, which in consequence will raise the weight of water drops, water drops then fall by gravity. Crude oil exits from the top through the perforated pipe, effluent water exits from the bottom [11, 12].

2. Connecting two CDUs with one COD

Two CDUs were connected to COD at Dewania refinery with a capacity of 10,000 BPSD each, which makes the total capacity of 20,000 BPSD where the COD with a capacity of 20,000 BPSD. Dewania refinery, which receives Basrah Medium crude oil with API gravity of 30.4 with specifications as in **Table 1**, the location of COD installed between the two CDUs, It was in the middle 90 m from each unit isometric piping.

Two CDUs connected to COD with connection was through a common header with the size of 8" SCH-40. Each supply pipeline from CDU with the size of 6" SCH-40, and the same size for return pipeline (from COD to CDUs) is the same as the supply pipe with the value of 6".

Property	Value	Test method
API gravity	30.4	ASTM D-1298
Specific Gravity @ 15.6°C	0.872	ASTM IP
Kinematic Viscosity cst		ASTM D 445
At 10°C	24.5	
At 21.1 °C	14.07	
At 37.8°C	7.1	
At 50 °C	4.8	
Sulfur Content Wt%	2.9	ASTM – 4294
H ₂ S Wt%	0.0015	ASTM D5705

Property	Value	Test method
Pour Point °C	Less than –30	ASTM D-97
RVP kg/cm ²	0.5	ASTM D-323
Water & Sediments Content Vol %	0.1	IP – 75
Salt Content PPM	50	IP – 77
Carbon Residue (R.B) Wt%	5.5	ASTM 524
Asphaltenes Content Wt%	1.89	JPI-5S-45-95
ASH Content Wt%	0.015	ASTM D – 482
Vanadium PPM	81.86	ASTM – D 6728
Nickle PPM	23.91	ASTM D – 6728
K UOP Characterization Factor	12	UOP Method 375
Water Content Vol %	0.05	IP – 74
Distillation		IP – 24
Temperature °C	Vol %	
IBP = 38°C	0	
Rec@ 50 °C	2.0	
@75°C	5	
@100 °C	11	
@125°C	17	
@150°C	22	
@175°C	27	
@200°C	32	
@225°C	37	
@250°C	41	
@275°C	45	
@300°C	49	
Total Distillation Vol %	51.0	

Table 1.
Basrah Medium Crude Oil Specifications.

3. Materials and methods

3.1 Pressure drop

The Connection of the two CDUs with one COD with the pipeline will make a pressure drop in the system. The pressure drop happens due to the flow of crude oil through the pipeline along the distance between the two connection points [13].

Pressure drop of the whole system includes the following: further factors that influence and caused pressure drop in the system, as will discuss herein below and takes consideration of the following factors.

If the pipeline size is 4" used as in the original connection in the unit, the pressure drop calculation will be as following:

- The Pressure drop of the 4" SCH-40 pipeline evaluated according to Darcy's Eq. (1) [13]. The pressure drop is 0.946 bar for each supply and return

system pipeline. The velocity value of the crossing from the CDU to COD is 2.4464 m/sec.

$$\Delta P = \lambda \cdot \frac{\sum L_e}{De} \cdot \frac{V^2}{2} \cdot \rho \tag{1}$$

Pressure drop of each piece of equipment in the COD system as following:

- The pressure drop across heat exchangers E-211A~C of 1.65 bar, E-216 of 0.689 bar [14].
- The pressure drop across the mixing valve is 1.723 bar [15].
- The pressure drop across the heating furnace is 5.514 bar [14].
- The pressure inlet to mean distillation column C-101 is 1.36 bar (g) [14].

The total pressure drop of one CDU with a capacity of 10,000 BPSD, which connected, to the COD capacity of 20,000 BPSD equal to 11.896 bar (calculated).

Therefore, if two CDUs connected to COD the capacity would be 20,000 BPSD. Hence total pressure drop for each unit is equal to 11.011 bar.

Differential pressure of charge pump is equal to 12.131 bar [14].

If the pipeline size 4" replaced with pipeline size of 6" in an aim to supply crude oil to COD and return to CDUs.

A pressure drop of 6" SCH-40 was evaluated according to Darcy's Eq. (1) [13]. The pressure drop is 0.15 bar, for each supply and return system pipeline. The velocity value is 1.085 m/sec, so the total pressure drop if only one 10,000 BPSD CDU connected to 20,000 BPSD COD equals 11.11 bar.

If two CDUs each one of capacity 10,000 BPSD connected with COD of capacity 20,000 BPSD, the total pressure drop for each unit is equal to 10.215 bar.

3.2 Heat loss

Crude oil, which received in CDU pumped by charge pump to train of heat exchangers E-211A~C, E-216, E-215, in an aim to preheat crude oil up to 130°C out at the point out of exchanger E-211 B, crude oil exported to COD in an aim to reduce salt content. COD is already outside the battery limit with a distance not less than 90 m in terms of length, the temperature of crude oil should not be less than 110°C [2, 3, 15]. In an aim to reduce heat loss from the outer surface of 6" pipeline, and reduces the pipe surface temperature within the required range, the pipe should be insulated with suitable insulation material in aim to reduce the heat loss to the atmosphere and in consequence, reduce the fuel consumption in the furnace.

It should note that all parts of the unit with a temperature more than 60°C insulated with calcium silicate (insulation material) [10], with specification as shown in **Table 2** in different thickness and wrap with an aluminum sheet with a

Property	Value
Density kg/m ³	245
Specific heat (CP) kj/kg.k.sec	1.03
Conductivity (k) w/m.k	0.07

Table 2.
Specifications of Calcium Silicate Insulator.

thickness of gage 24 and according to the temperature of the surface and the service.

According to Baker, How [14]. The economical thickness of this type of insulation is 38 mm, heat loss and outer surface temperature estimated according to heat transfer calculations as follows:

4. Calcium silicate insulation thickness of 38 mm

Heat transfer by conduction, convection calculation as in Eqs. (2)-(6) [16] in aim to estimate heat loss and out surface temperature.

The heat transfer rate is -101.56 w/m and the temperature distribution of the pipe section as shown in **Figure 1** will be as follows:

The pipe internal temperature is 130°C; the surface temperature of the calcium silicate insulation will be 43.18°C, the metal surface temperature is 43°C if the ambient temperature is 30°C.

$$Q = U.A.\Delta T \tag{2}$$

$$\frac{1}{U} = \frac{R4}{hi R4} + \frac{1}{ho} + \frac{R4 \ln \frac{R2}{R1}}{K1} + \frac{R4 \ln \frac{R3}{R2}}{K2} + \frac{R4 \ln \frac{R4}{R3}}{K3} \tag{3}$$

$$Nu = \frac{hidi}{kf} = 0.023.RE^{0.8}.Pr^{0.333}.\left(\frac{\mu}{\mu w}\right)^{0.14} \tag{4}$$

$$Re = \frac{\rho.v.di}{\mu} \tag{5}$$

$$Pr = \frac{cp.\mu}{k} \tag{6}$$

Figure 1.
Temperature distribution through 38 mm insulation layer.

5. Calcium silicate insulation thickness of 50 mm

In an aim to reduce the heat dissipated, insulation thickness increased to 50 mm instead of 38 mm. In consequence, the Heat loss reduced to -84.478 w/m , and the temperature distribution of the pipe section as in **Figure 2** will be as follows: internal temperature is 130°C , insulation and metal wrap surface temperature is 40.1°C and 40°C respectively.

Figure 2.
Temperature distribution through 50 mm (calcium silicate) insulation layers.

6. Control system

Connection of two CDUs with one COD process flow diagram as shown in **Figure 3**, control system philosophy modified in aim to cover the addition of COD, the capacity of the unit would have controlled as before by FIC-101, the (valve Coefficient) C.V of control valve checked with this modification i.e. the pressure drop added to the system. This can be checked by evaluation of C.V as in Eq. (7) [17] the C. V value is 23.55 and the C.V value of FIC-101 is 90, which means FIC-101 is valid to be used even with the new addition of equipment.

$$C.V = 1.16.Q.\sqrt{\frac{Sp.Gr}{\Delta P}} \quad (7)$$

Control the COD with Two CDUs connected has many scenarios and as follows.

1. If only one unit is in service: This situation is very easy in terms of the control system; because this type of operation is related to one unit and the crude oil exported to COD and imported back after desalting.
2. If two units is in service: In this situation, crude oil exported to the COD from two units and imported back to the CDUs after the desalting process

Figure 3.
Process Flow Diagram of Connection of Two CDUs with One COD.

completed; if one unit is drop (switched off) for any reason (for example emergency case), when both units are in service, simple control system installed as shown in **Figure 3** and as following:

Check valve of (6" X 300#) swing type and pressure switch, with rang (0–16 bar), were installed at the export line (supply line of crude oil to desalter). 3" X 300# control valve with C.V equal to 90 normally closed, air to open installed at import line (pipeline back from desalter) work as an on–off controller connected to the pressure switch.

Mechanism of the system: When one of two units is dropped, then no signal passes from the pressure switch (signal off). The electrical relay would open, the solenoid valve would close which already installed at the air supply line to the control valve, and the control valve type is normally closed air to open, if no air supply, then the valve would shut. Only one unit would be in the service, crude oil would not pass to the other unit.

7. Water injection

Crude oil, which contains salts. The process water was used to dissolve associated salt. The amount of process water required varies from 5 to 7 vol % [15]. When two units in service the total amount of water would be used of 5 vol %, this is the

minimum recommended amount of water to be used, if any drop (CDU switched off) to any unit the amount of water will be within the maximum required amount for one unit.

8. Conclusions

1. Replacing transfer pipeline size, between CDUs Supply to COD and return from 4" to 6"; will reduce pressure drop from 0.946 to 0.15 bar.
2. Running two CDUs connected to one COD is better than one; pressure drop will be less due to the divided of pressure drop of mixing valve with two units.
3. Install 50 mm (calcium silicate) insulation material. Better than 38 mm, which reduces heat dissipated from -101.56 to -84.478 w/m, consequence metal foil surface temperature of the pipeline was reduced from 43 to 40°C.
4. Process water which was injected as wash water with an optimum concentration, 5 v% for two units in service. Any unit drops the total amount of process water will be the maximum required amount for one unit.
5. Two crude distillation units can be connected to one crude oil desalter if the summation of unit capacities equal to or less than crude oil desalter capacity.

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Symbols

Abbreviations

CDU	Crude Distillation Unit
COD	Crude Oil De – Salter
PPM	Part Per Million
BPSD	Barrel per Stream Day
MRC	Midland Refineries Company
SCH	Pipe Schedule
API	American Petroleum Institute
RE	Reynold Number
R.V.P	Reid Vapor Pressure kg/cm^2
Pr	Prandtle Number
Nu	Nussalt Number
C.V	Valve Coefficient
Vol %	Volume Percentage
Wt %	Weight Percentage
Sp.gr	Specific Gravity

Greeks

ΔP	Pressure Drop (bar)
λ	Friction Factor
ρ	density kg/m^3
μ	Viscosity Pascal.sec

Letters

Le	Equivalent length m
De	Equivalent Diameter m
di	Internal Diameter of Pipe m
V	Velocity m/sec
U	Over All Heat Transfer Coefficient $\text{w/m}^2.\text{K}$
A	Area m^2
ΔT	Temperature Difference in K
hi	Internal Fluid Convection Heat Transfer Coefficient $\text{kJ/m}^2.\text{K}$
ho	Air Convection Heat Transfer Coefficient $\text{kJ/m}^2.\text{K}$
K1	Iron Conduction Heat Transfer Coefficient kJ/m.K
K2	Calcium Silicate Insulation Conduction Heat Transfer Coefficient kJ/M.K
K3	Aluminum Conduction Heat Transfer Coefficient kJ/M.K
Kv	Kilo Volt
R1	Radius of Internal Pipe m
R2	Radius of External Pipe m
R3	Radius of Insulation M
R4	Radius of Aluminum Metal Cover M
Kf	Crude Oil Conduction Heat Transfer Coefficient kJ/m.K
Cp	Specific Heat kJ/kg.K
Q	volumetric flow rate m^3/h

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