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CRUDE INCOMPATIBILITY PROBLEMS AT HEAVY CRUDE UNIT DESALTER

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Attock Refinery Limited (ARL) is based at Rawalpindi, Pakistan and operates a 40,000 Barrels per Stream Day (BPSD) refinery. The Heavy Crude Unit (HCU) of ARL is a fully integrated two-stage 10,000 BPSD Atmospheric and 5,700 BPSD Vacuum Distillation Unit. A 3-stage desalter designed to reduce salt and BS&W content from 2,000 parts per thousand barrels (PTB) and 2% to less than 5 PTB and 0.1% respectively, is part of HCU. The feedstock is a composite blend of 14 local Heavy Crudes received at the Refinery. Although in the past this desalter had been giving good performance, over the last one year, period since August 2005, at least nine shutdowns of the unit took place due to salt slippage and consequential tube leakages at the overhead Crude-Naphtha vapor Heat Exchanger where partial condensation of naphtha takes place. Final condensation is achieved in trim condenser. High salted water carry-over with the crude caused increased hydrolysis, formation of Hydrochloric acid and increase of tail water chlorides. Salt contents at the outlet of 3rd desalter at times increased up to 400 PTB with 3.2% BS&W during the above mentioned upsets, as compared to normal 5-10 PTB. Fallout from this loss of desalter control was the creation of large quantities of slop due to draining of strong water oil emulsion from the desalters. Individual crudes of the blend were analyzed for affinity of water and emulsion stability. It was observed that 3 of the 14 crudes formed very strong while the remaining crudes formed weak oil water emulsion, which easily separated water from oil in desalter without any operational problem. Study was further narrowed down to one crude evaluation. Alkaline earth metallic naphthenate surfactants were detected and isolated as responsible for the strong water oil and sediments emulsion. The isolated crude was next withdrawn from the Heavy Crude blend. As soon as it was isolated and its ratio in heavy crude tank came down to 0.7 %, the problem began to be controlled, along with other operational measures taken, namely, increase of demulsifier dosage 50 liters/day in first desalter vessel and also 10 liters/ day in third desalter vessel, start of low chlorides tail water injection in desalter wash water, discontinuation of ammonia injection, and addition of Neutralizer and Filmer. This paper gives a detailed analysis of the problem and how it was successfully tackled by the Engineers & Chemists at ARL.

Keywords: Heavy crude, Desalter, ARL

1. Introduction

Attock Refinery Limited (ARL) is based at Rawalpindi, Pakistan and is part of the Attock Group of Companies, a fully vertically integrated group engaged in exploration and production of crude oil and natural gas, refining of crude oil and marketing of a wide range of petroleum products.

ARL is one of the few refineries in the world processing a complicated mix of forty (40) different types of crude oils of API ranging from 10 to 64. These crudes are processed in 3 different crude mixes, namely Light Sweet, Light Sour and Heavy. The nameplate crude capacity of ARL is 40,000 Barrels per Stream Day (BPSD). It has four distillation units namely, HBU-20,000, HBU-5,000 (both processing Light Sweet crude), Lummus-5,000 (Light Sour) and HCU-10,000 BPSD capacity (Heavy Crude). The first two date back to 1981, the Lummus Unit was commissioned in 1939, and the Heavy Crude Unit (HCU) came on-stream in 1999.

The Heavy Crude Unit (HCU) of ARL is a fully integrated two-stage 10,000 BPSD Atmospheric and 5,700 BPSD Vacuum Distillation Unit. Its feed is a blend of 14 different heavy crudes of 10 to 41 API gravities with a final charge blend of ‘25’ API gravity. (The American Petroleum Institute gravity, or API gravity, is a measure of how heavy or light petroleum liquid is compared to water.) Crude oil is passed through a three stage Howe Baker desalter. Desalter design data is given in Table 1.

2. The Problem

Heavy Crude Unit (HCU) three-stage desalter had been giving good performance since its installation. However, since early 2006, the desalters started giving poor performance, which resulted in at least nine shutdowns of the unit due

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to Crude/Naphtha Heat Exchanger tube leakage.

The basic reason for Heat Exchanger leakages was formation of strong oil water emulsion in the desalters and subsequent slippage of salts from the desalter outlet. During this period of desalter upset the salt contents at the outlet of third desalter at times increased upto 400 PTB with 3.2% BS&W as compared to design value of 1.6 PTB. Loss of desalter control also created large quantities of slop due to draining of strong water oil emulsion.

Table 1. Desalter design data

Capacity	6000	BPD
BS&W at Inlet Maximum	30	Vol.%
Salts Inlet Maximum	2000	PTB
Salts Outlet Maximum	1.6	PTB
Blend Viscosity @ 100°F	96.3	CST
Blend Viscosity @ 210°F	24	CST
Inlet Temperature	143-146	°C
Inlet Pressure	200-220	psig
Process water rate	8-9	Feed Vol. %
Size (Outer Diameter)	9.5	Ft
Pressure drop each stage (Vessel)	3-5	PSI

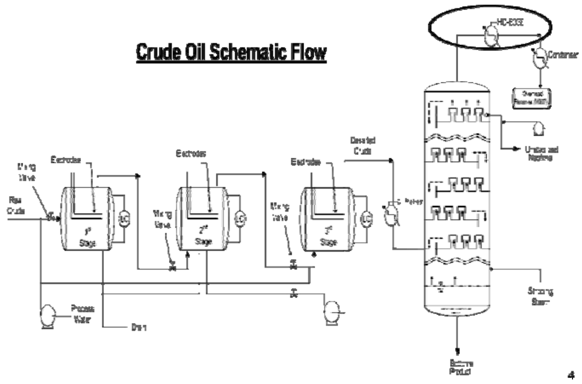
High saltwater carry- over with the crude increased hydrolysis of salts causing subsequent formation of Hydrochloric acid, which lowered the pH of overhead tail water from average 7 to 2- 3. Tail water chlorides also increased from average 10-20 ppm to many hundreds ppm.

Due to this acidic shift of tail water pH neutralizer, 50 ppm) and Filmer (5 -15 ppm) was discontinued because pH could not be maintained within specified range. A 15-16 % ammonia solution was injected in overhead system to bring the pH within 6-7 range.

Wash water sometimes needed to be completely shut off due to carry over of water along with crude. Setting of desalter voltage initially was at 14/18/18 KVA, which was brought down to 10/10/14 KVA. Mixing valve delta P is 6-10 psig.

In other words, Salt removal efficiency reduced to 10% of the inlet salts. BS& W at desalter outlet also reached upto 90% of inlet. In spite of all these disturbances, desalter voltage remained undisturbed. pressure of the desalter fluctuated a lot along with the tower pressure during the problem and reached up to 16 kg/cm^2g at desalter and 2 kg/cm^2g in the tower.

This problem was getting serious since it was not only resulting in plant shutdowns but also commercial loss to the company. It was treated by ARL's team of engineers and chemists as a challenge to identify the root cause of the problem and subsequently solve it.



3. Research and Development (R&D)

First of all, the team analyzed all possible aspects of the problem starting from crude oil till the operating parameters of the desalter. To start with, all crude details were obtained when the desalter was giving its optimum performance.

It was observed that problem first surfaced in January 2006 and coincided with the advent of new crude named "Makori". It was, therefore, decided to remove the Makori crude oil from heavy crude blend but the problem persisted. This led us to test all 14 crudes for their water affinity and emulsion stability. Types of crudes charged at HCU during the problem with their blending percentage and other properties are mentioned in Table 2.

From individual crude analysis it was observed that Chanda and Rajian-III crude formed very strong emulsion while Rajian-III with other crudes formed weak oil water emulsion which easily separated water from oil in desalter without any operational problem.

Based on this laboratory work, the study was further narrowed down to "Chanda" crude oil. A team was deputed to study the complete life cycle of Chanda crude from its production from the well head till the receipt at the refinery.

Table 2. Crude Blend

Crude Name	Blend Ratio, Vol. %	Sp. Gr. @ 60°F [1]	API Gr.	BS&W Vol.% [2]	Salts PTB [3]	Asphaltenes, Wt.% [4]
Bhangali	1.20	0.8680	32	0.05	0.1	3.31
Turkwal	4.90	0.8490	35	0.25	0.1	1.07
Minwal	0.80	0.9674	15	1.32	141	18.67
Fimkassar	4.10	0.8800	29	0.20	0.15	3.28
Kal	13.37	0.8980	26	4.00	819	7.09
Balkassar	2.47	0.9060	25	0.20	0.1	6.48
Joyamair	0.24	0.9780	13	0.40	0.1	19.50
Chak Naurang	3.60	1.0024	10	41	5,400	20.76
Rajian-I	3.03	0.9070	25	0.90	87	8.57
Rajian-II	6.23	0.9290	21	4.20	355	9.58
Rajian-III	4.80	0.9690	15	34	6,767	7.42
Adhi Sakassar	15.35	0.8400	37	0.10	0.22	0.44
Pindori	24.11	0.8220	41	0.10	0.18	0.02
Chanda	15.80	0.8330	38	0.10	0.1	0.10

ARL's team saw some interesting findings i.e., Chanda crude is discovered from the same area as Makori crude. Moreover, there was some solid material in Chanda which on centrifugation settled down at the bottom and on heating became soluble in the crude oil.

In order to confirm that this solid material is the main culprit for the desalter upset, a large quantity of Chanda crude was centrifuged to get that material isolated for analysis. The solid material exhibited the following properties:

1. The melting point of the solid material was 105°C
2. It was insoluble in water
3. It was insoluble in organic solvents like Toluene / Xylene / Heptane and as well as their mixture
4. This solid material was lighter than water and heavier then Xylene / Toluene / Heptane
5. Isolated solid material was some surfactant which formed an interface between water and crude oil, hence forming a rag layer in the desalter in conjunction with other crudes, sediments, water formed a jelly like appearance.
6. The rag layer did not allow the crude water to pass through and subsequently caused slippage of salts and water from the desalter and ultimate leakage of heat exchanger tubes.

The isolated surfactant from Chanda crude oil and its interface between crude and water is shown in Figures 1 and 2 respectively.

Figure 1. Chanda Isolated Surfactant.

Figure 2. Surfactant Interface.

On further qualitative analysis it was found that this surfactant is Calcium Naphthenate and it hangs at the oil water interface in desalters where it agglomerates into larger masses and forms a rag layer. Other crude oils were also tested for similar behavior, but no such type of surfactants was found.

On the basis of the above-mentioned properties of Chanda crude oil, it was decided to withdraw the Chanda Crude from Heavy Crude blend. Chanda crude was next processed in Light Sweet crude oil. Minor operational shifts were observed at the light crude units due to Chanda being blended there, but this is not significant and easily controlled due to <0.05 Vol.% BS&W at the inlet of light crude desalters. This further confirmed that the main culprit of desalter upset at Heavy Crude Unit is Chanda Crude Oil.

Although the root cause of the problem was identified and isolated from the HCU crude blend and problem of salt slippage and formation of rag layer was solved but that was not the end of the problem. The main milestone for the team was to optimize the HCU desalter operations in such a way that the crudes like Chanda could be processed without any problem. Therefore, following operational changes have been made to run the Chanda like crude oils:

1. Quantity of wash water added at the charge pump was optimized.
2. Delta-P in the mix valve was also adjusted.
3. Demulsifier injection was started in between desalter 2 & 3. This helped a lot to resolve the emulsion.
4. pH at overhead section of fractionators was adjusted between 5.0 and 6.0 and monitoring of pH, iron and chlorides was increased.

After readjusting above parameter limited quantity of Chanda crude was blended and processed at HCU plant.

4. Conclusions

The problem at the Heavy Crude Unit (HCU) three-stage desalter was due to formation of strong oil and water emulsion, which resulted in slippage of salts from the outlet of desalter. High salted water carried over with the crude oil, increased the formation of hydrochloric acid and lowered the pH from 7 to 2-& 3 of overhead tail water. Tail water chlorides also jumped from average 10-20 ppm to many hundreds ppm. This resulted in nine plant shutdowns in one year's time.

Fourteen (14) heavy crude oils were individually analyzed for strong oil and water emulsion formation and it was concluded that the problem is due to incompatibility of a newly added crude oil namely Chanda, . Chanda crude oil life cycle study and laboratory analysis revealed that there is a natural calcium based surfactant present in the crude oil with a melting point of 105°C. This surfactant is insoluble in water and oil and forms an interface between oil and water results in poor desalter performance to separate water and salts.

The Chanda crude oil was removed from the heavy crude blend and was charged on light crude unit without any problem.

Some operational changes were also made to enable limited quantity Chanda charge in HCU crude blend.

The foregoing strategy not only helped solve the problem through a totally in-house effort, it also added flexibility to the Refinery operations, and since then limited quantity of Chanda crude is again being processed at HCU.

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