PERFORMANCE EVALUATION OF A CRUDE OIL DESALTER

A CASE STUDY OF CRUDE DISTILLATION UNIT ONE OF KADUNA REFINERY AND PETROCHEMICAL COMPANY

BY

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because the feed stock inlet is lower than in units of other designs. The petroleum settling conditions are considerably improved here. Moreover, in a horizontal electrical desalter with the petroleum fed in under the bottom electrode, the petroleum interacts with the layer of settled brine, and the large particles of water separates even before the petroleum gets into the electrical field between the electrodes.

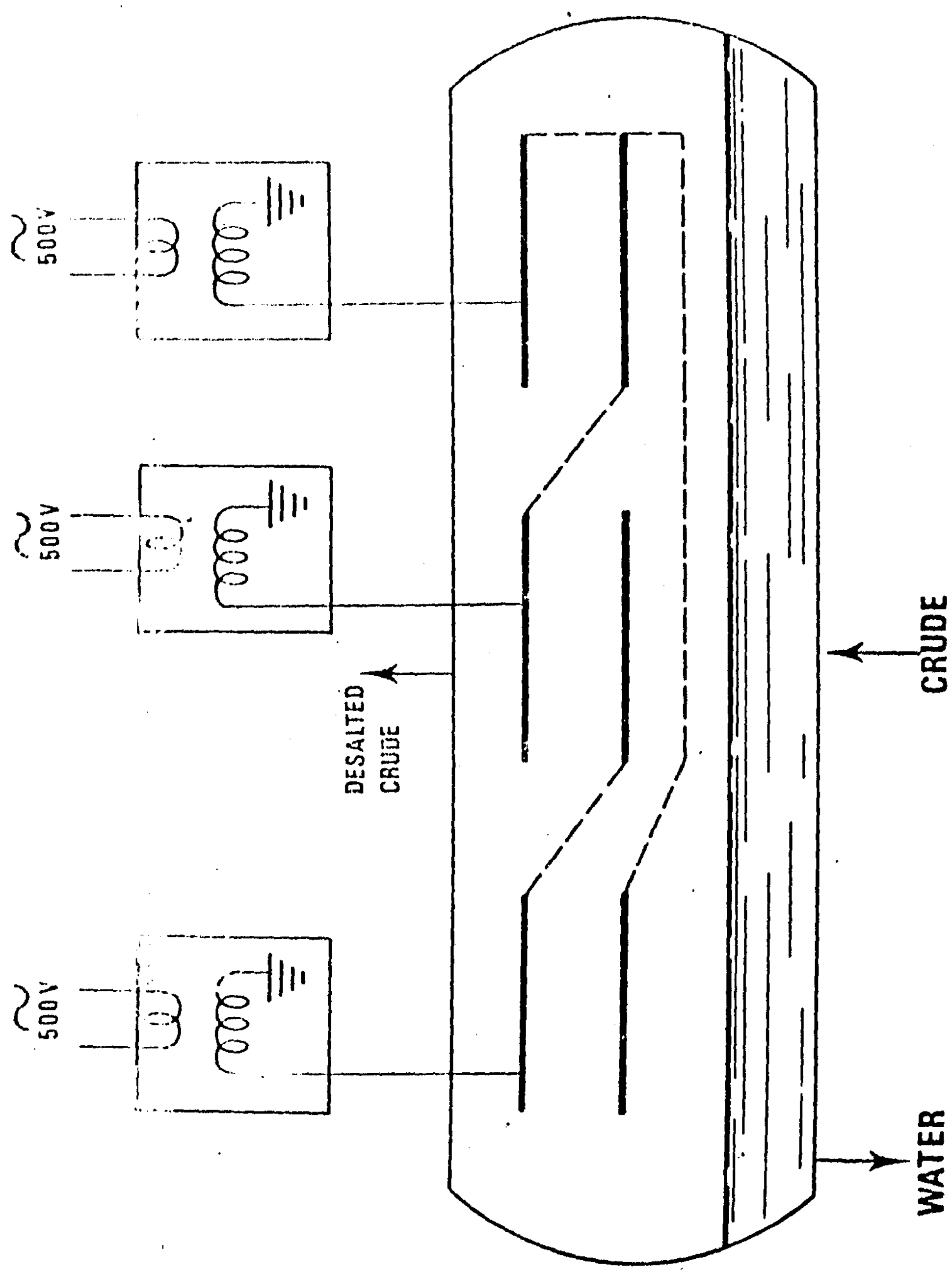
The specification of various models of horizontal electrical desalters are given below:-

Model	23r 50-2	23r -160	23r-16/3	23r-200-2p
Volume, M^3	50	160	160	200
Capacity, M^3/h	130	350	320	550
Internal diameter,mm	3400	3400	3400	3400
Rated, pressure, MPa	1.8	1.8	1.8	1.8
Rated temperature, °C	160	160	160	160

The model 23r-160 desalter has one inlet for the feed stock, while the models 23r-160/3 and 23r-200-2P have two inlets.

SIMPLIFIED ELECTRICAL
SCHEME OF
PETRECO DESALTER

Figure A



CHAPTER THREE

3.0 RESEARCH METHODOLOGY

This research work was carried out by gathering information (Data) on the performance of the crude oil desalter submit under crude distillation unit one (CDU-1) of Kaduna Refinery and petrochemical company (K.R.P.C), a subsidiary of Nigerian National petroleum Corporation (N.N.P.C). The data include analysis carried out on the crude oil before entering the desalter and after going through the desalter, analysis done on the crude are: specific gravity 15/4oC, viscosity Kinematic at 100oF or 37.8oC, salt content, and Basic sediments & water content (BS&W).

The frequent low efficiency of the crude oil desalter in CDU-1, prompted an evaluation based on its performance in order to trace the problems and come up with solutions to the anomalies. This work set to look critically into the performance factors, and come up with the most economic ways of achieving high efficiency inview of the strategic importance attached to the desalter in the crude oil distillation units of all refineries the world over.

The low efficiency of the crude oil desalter is partly the reason why Kaduna Refinery and Petrochemical company was shut down. Before the crude gets to the fractionator it must pass through the desalter in order to get rid of the salt, sediment, water and other impurities present in the crude oil, hence any of these that escapes goes into the fractionator and to all other units in the refinery with their attendant consequences. High water content results in to pressure build up in the distillation apparatus, decrease in productivity, and excessive heat is spent to heat and evaporate the water, salts mainly chlorides are deposited in the tubes of heat exchangers and furnaces, which require frequent cleaning of the tubes and lowers the heat transfer coefficient. Calcium and magnesium chlorides hydrolyze with the formation of Hcl which corrodes the metal of the technological apparatus.

$$Mgcl2 + 2H_2 0 \underline{\text{heat}} Mg(H0)_2 + 2Hcl$$

$$Cacl_2 + 2H_2 0 \text{ heat } Ca \ (H0)_2 + 2Hcl$$

Finally, the salts accumulating in the residual petroleum products fuel oil and tar, detract from their quality.

3.1 TYPE OF CRUDE PROCESSED IN CRUDE DISTILLATION UNIT ONE (CDU-1) OF KADUNA REFINERY

The feedstock to CDU-1 is a mixture of Nigerian indigenous crude oils. The crude oils are naphthenic in nature i.e they contain important quantities of naphthenes such as cycloparaffins (saturated closed ring hydrocarbons). It has naturally low poour point i.e It can be cooled to lower temperatures than paraffinic oil before solidification occurs. It is very good for the production of fuels as it has low sulphur content. The attached table 1 shows the crude oil general inspection data for UQCC crude oil,-and Excravos crude oil and the 50/50 mixed crude oil.

TABLE 1: **CRUDE OIL GENERAL INSPECTION DATA-SOURCE: KRPC LIBRARY.**

	CRUDE OIL		
	UQCC	ESCRAVOS	50/50 MIXED
API GRAVITY, API	30.03	36.3	33.3
SPECIFIC GRAVITY, 15/15°C	0.874	0.8433	0.8587
TOTAL SULPHUR, wt. %	0.24	0.16	0.20
METALS			
NICKEL, PPM	3.0	5.3	4.1
VANAGIUM, PPM	0.7	0.9	0.8
POUR POINT, °C	-27	2	
VISCOSITY 37,8°C,CS	6.18	3.85	4.8
REID VAPOR PRESSURE	0.245	0.288	

	CRUDE OIL		
	UQC C	ESCRAVO S	50/50 MIXED
API GRAVITY, APS	30.03	36.3	33.3
SPECIFIC GRAVITY, 15/15°	0.874	0.8433	0.8587
total sulphur, wt. c/o	0.24	0.16	0.20
METALS			
NICKEL, PPM	3.0	5.3	4.1
VANADIUM, PPM	0.7	0.9	0.8
POUR POINT, °C	-27	2	
VISCOSITY C37,8°C, CS	6.18	3.85	4.8
REID VAPOUR PRESSURE C37, 8°C kg/cm²	0.245	2.288	

CERTIFICATION

This is to certify that this project "performance evaluation of a crude oil desalter " is the original work of Yisa Gimba carriedout wholly by him under supervision, and submitted to the department of chemical engineering, F.U.T Minna.

Supervisor Mr.A. Gani	15/12/98 Date
Head of Department DR.J.O. Odigure	Date
External examiner	Date

DEDICATION

This project is dedicated to my parents Mr. Abraham Yisa and Mrs. Sarah Yisa; and also to my brothers and sisters.

ACKNOLEDGEMENT

My gratitude goes to the Almighty God for His guidance and protection throughout the riod of my study.My appreciation goes to my supervisor Mr.A Gani, the head of department emical engineering Dr. J.O. Odegure, and to the management and staff of Kaduna refinery and trochemical company for allowing me access to their facilities.

My gratitude goes to my Father Mr. Abraham N. Yisa, my mother mrs. Sarah Yisa for their oral and financial support through out the period of my study. My appreciation also goes to my sters Rachel, Rebecca, Christiana and Comfort for their inspiration. Also pesthumously to my late rother Philip.

ABSTRACT

The purpose of this work is to evaluate the performance of a crude oil desalter and also to ign a crude oil desalter. Usually the material balance, heat balance, efficiency, and performance tors are evaluated to achieve the aim. The area of the case study of this work is crude distillation t one (CDU-1) of Kaduna refinery and petrochemical company.

The data obtained for the evaluation include analysis done on the crude oil before and after e electrical desalter over a period of one month. From the gathered data, the efficiency of the salter over the period was determined and also the performance factors evaluated. Under the uipment design the mass flow-rates, heat balance, equipment sizing and cost analysis were done.

From the efficiency evaluated for each day over the 32-day period the lowest efficiency was 5.66% (for day 13) and the highest was 90.32% (for day 8) and the average efficiency over the eriod was 65.69% which is below the design value of 95%. The inlet flow-rate was 339520kg/h, and utlet (tops) was 311241.79kglh and outlet (bottoms) 28278. 208kglh. The quantity of heat required o achieve separation was found to be 108877. 2736 MJ/h.

A crude oil deslter is an equipment within the crude istillation units of refineries which is used to get rid of alts, water, sedimcnts and other impurities from crude oil. From the results arrived at, an efficient desalting process can be achieved if all the performance factors are put in order.

The recommendations made include proper insulation of the desalter to reduce to the bearest minimum heat loss to the environment, because the heat loss was found to be high, and also double desalting process where two desalters are used in series is advocated for higher efficiency of the desalting process.

TABLE OF CONTENTS

CHAPTER THREE

CHAPTER FOUR

CHAPTER FIVE

CHAPTER SIX

NOTATIONS

CDU	Crude Distillation Unit
B.S.& W	Basic Sediments and Water
P.P.M	Parts Per Million
P.T.B	Pound per Thousand Barrerls
E	Desalter Efficiency
ρ	Density
Q	Heat Content
M	Mass
Cp	Specific Heat Capacity
e	Minimum thickness
D	External Diameter
Di	Internal diameter
L	Desalter Length
V	Deslater Volume
r	Desalter radius
G	Mass flow-rate
Re	Reynold's number
d	Pipe Diameter
μ	Viscosity
Ce	Purchased equipment cost
Cf	Fixed capital cost
fl	Lang factor
£	Pound Sterling
$	Dollar

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

The presence of water and salts in petroleum delivered for refining harmfully affects the operation of the refinery. When the water content is high, the pressure in the petroleum distillation apparatus grows, its productivity decreases, and excessive heat is spent to heat and evaporate the water. Salts, mainly chlorides have a still more adverse effect. They are deposited in the tubes of the heat exchangers and furnaces, which requires frequent cleaning of the tubes and lowers the heat transfer coefficient. Calcium and Magnesium chlorides hydrolize with the formation of hydrochloric acid. The latter corrodes the metal of the technological apparatus. Finally, the salts accumulating in the residual petroleum products- fuel oil and tar (residual stock), detract from their quality.

The oil-fields contain salt water, part of which is separated from the other substances and is found in the bottom layers and part mixed together with the oil in the sedimentary layers. During extraction this water is brought to the surface together with the crude-oil in different percentages. Swift lifting along the pipes of the well results in the stirring of crude - water mixture which increases the fine dispersion of the water inside the crude oil. The geological conformation of the oil-field, its degree of depletion and the methods of extraction will condition the quantity of water, sediments and other impurities that will be extracted together with the crude oil.

In general the contaminants present in crude may be classified as either oil soluble or oil insoluble. Included in the oil soluble category are those hydrocarbons which are chemically combined with sulphur, nitrogen, oxygen, and some metals, notably nickel and vanadium. The oil insoluble category comprises: inorganic chlorides, metal sulphides, metal oxides, carbonates, sand and silt. Effective desalting can remove most of these contaminants.

Consequently, prior to delivering petroleum to a refinery it must be freed of water and salts. The first stage of water and salt removal is performed at the field petroleum treatment plants. Depending on the degree of their preparation at fields, three groups of petroleum are distinguished that differ in their content of residual water (0.5 - 1.0%) and chlorides (1000 - 1800mg/litre). At refineries, the second stage of dehydration and desalting is lowered to 0.05 - 0.1%, and that of salts to 3-5 mg/litre and less.

The most elementary means of desalting is by natural or enhanced de-watering in crude with little or no tendency to form stable emulsions can be desalted and de-watered by this method, although heavier crudes require the addition of emulsion breaker or demulsifier to separate the water with its associated salt.

Historically the first desalting units were chemical desalters. In the chemical desalting process, a demulsifier and wash water are mixed with the crude, the resultant emulsion is heated and allowed to separate by gravity in a vessel sufficiently large to provide up to two(2) hours retention time.

An important advance in crude oil desalting was made in 1937 with the introduction of electrical desalting. Today the vast majority of refineries have electrical desalters. Single stage desalting (using one vessel) is most common, although double desalting is employed by a few refineries. Double salting is used where very high salt contents are regularly encountered. Single - stage electrical desalting is the most popular method,however, and this coverage will therefore concentrate on this process.

The desalter employed in crude distillation unit on (CDU-1) of Kaduna refinery is an hemispherical horizontal drum which has an end to end length of 15,200mm and a dimension of 3,250mm x 12,200mm. It has two generating transformers. The desalting process is carried out by means of chemical and electrostatic systems.

The efficient performance of the desalter is enhanced by some basic instruments which includes: the mixing valve; the interface level controller; and effluent draw off valves.

The chemicals employed in the desalting process are:

(1) Demulsifier and (2) caustic soda (NaOH).

The working principle of desalting with petreco low velocity desalter is based on four main factors which includes: temperature (and its relation with pressure), dielectric nature of crude oil, high voltage electric field effect and settling time.

The working temperature of the desalter is about $130^{oC \text{ and the pressure near to } 10Kg/cm2}$, the unit itself is usually inserted in series to the exchange train at the point where the two conditions are satisfied.

The desalting process is a process where by water is injected into crude oil (normally 3 - 8% wt) and finely dispersed by means of special mixing valve in order to dissolve and dilute the various impurities. This water - crude oil mixture enters the electric desalter where under certain conditions of temperature and pressure the salty water is separated by setting aided by a high voltage electric field generated by special transformers which causes the coalescence of the salty water droplets which eventually collect at the bottom of the vessel and hence discharged.

1.1 THE NEED FOR DESALTING

Desalting is essentially a purification process to which crude oil is subjected before it enters distillation column. This process is necessary to remove from the crude, the soluble inorganic salts and insoluble materials, naturally present in all crudes, which will create prcessing problems in down stream units.

1.2 SALT REMOVAL

In desalting we are primarily concerned with salt removal."salt" is a natural containment in crude oil, a large proportion of which is present as an aqueous solution, or brine, produced with the crude oil from the well. Salt may also be present in crystalline form dispersed in the oil. Most of the salts are present as the chlorides of sodium, magnesium and calcium. The typical composition of salt in crude oil is: 70% Nacl , 20% $Mgcl_2$, and 10%$Cacl_2$.

The levels of salt in crude oil can vary from 5-4,000 p.p.m. It is necessary to desalt crude oil because of the unstable nature of magnesium and calcium chlorides. When heated in the preheat train and furnace, these salts hydrolyze to produce hydrogen chloride.

Typically, $Mgcl_2 + 2H_20 \xrightarrow{heat} Mg(0H)_2 + 2Hcl$. The hyrogen chloride dissolves in the over heads water to produce a very corrosive condensate. By desalting the level of hydrolysable salts is greatly reduced, minimising the corrosion potential in the over heads and enabling corrosion control treatment to be effective. It is also necessary to desalt crude to prevent excessive salt fouling of pre-heat exchangers and minimize energy losses and fuel costs.

1.3 BASIC SEDIMENT

This is the term used to describe sand, silt and other debris also found in crude oil. The sand and silt emanate from the formation. Other materials which contribute to the basic sediment may have their origins in drilling mud and rock particles produced during drilling. Solids, such as corrosion products may also appear in the basic sediment, as the result of corrosion of production equipment. Most iron sulphide however occur naturally.

1.4 THE SCOPE AND OBJECTIVE

The petreco low velocity electric desalter has proved to be effective in salt/water and other impurities removal, but the low efficiency often encountered is mainly as a result of lapses in the process operation.

The aim of this project work is to critically look into the performance factors and carryout a thorough evaluation so as to come up with most economical ways of achieving high efficiency of the desalter. The available data on operation is used to evaluate the performance factors and also to compare the factors with the design values so as to optimise the process operation.

The limitations encountered in this project work is in the area of obtaining certain data which were not possible to obtain since the plant was not in operation during the research work.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 DEFINATIONS

Desalting:

Desalting is a process by which salts, sediments and other impurities are removed from the crude oil.

Desalting plant:

An installation that removes salt water and crystalline salt from crude oil streams. Some plants use electrstatic precipitation, others employ chemical process to remove the salt.

Emulsion, crude oil-water

Very small droplets of water suspended in a volume of crude oil, each droplet surronded or encased in a film of oil.

Demulsifier:

A chemical used to "break down" crude oil/water emulsions. The chemical reduces the surface tension of the film of oil surrounding the droplets of water. Thus freed the water settles to the bottom of the tank.

Basic sediment and water (B.S.&W.)

This is the term used to desrbied water, sand, silt and other debris also found in crude oil.

Desalter efficiency.

This is referred to as the amount of salts removed over the total salts content expressed in percentage points.

2.2 METHODS OF DESALTING

2.2.1 TREAPTMENT IN TANKAGE

The most elementary means of desalting is by natural or enhanced dewatering in crude oil storage tanks. light crudes with litle or no tendency to form stable emulsions can be dewatered and desalted by this method although heavier crudes require the addition of an emulsion breaker or demulsifier to separate the water with the associated salt.

DAY		25		26		27		28	
TEST	UNIT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
Specific gravity 15/4oC	kg/l	0.8469	0.8462	0.8446	0.8445	0.8461	0.8452	0.8451	0.8443
Viscosity kinematic AT 100oF or 37.8oC	CSt	3.88	3.64	3.74	3.70	3.88	3.70	3.80	3.62
Salt content	PTB	7.50	2.48	9.45	2.10	10.46	3.12	11.55	2.10
Water & sediment	%Vol	0.1	trace	0.1	trace	0.2	0.1	0.1	trace

DAY		29		30		31		32	
TEST	UNIT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
Specific gravity 15/4oC	kg/l	0.8466	0.8454	0.8445	0.8440	0.8460	0.8453	0.8453	0.8446
Viscosity kinematic AT 100oF or 37.8oC	CSt	3.94	3.71	3.52	3.46	3.56	3.49	3.66	3.57
Salt content	PTB	11.41	2.28	10.04	4.02	4.20	2.10	4.64	1.10
Water & sediment.	%Vol	0.2	trace	0.1	trace	0.1	0.1	0.1	trace

SOURCE: KRPC QUALITY CONTROL LABORATORY

3.3.2 DESALTER EFFICIENCY [E]

$$E = \frac{\text{SALT IN} - \text{SALT OUT}}{\text{SALT IN}} \times 100\%$$

Day 1

$$E1 = \frac{6.54 - 2.74}{6.54} \times 100 = 58.10\%$$

Day 2

$$E2 = \frac{6.12 - 2.11}{6.12} \times 100 = 65.52\%$$

Day 3

$$E3 = \frac{7.17 - 2.53}{7.17} \times 100 = 64.7\%$$

Day 4

$$E4 = \frac{8.02 - 2.32}{8.02} \times 100 = 71.07\%$$

Day 5

$$E5 = \frac{5.28 - 0.42}{5.28} \times 100 = 92.04\%$$

Day 6

$$E6 = \frac{7.43 - 3.21}{7.43} \times 100 = 56.80\%$$

Although this method can, in some cases, reduce the salt content to approximately 25p.p.m, and H20 to o.o5%, the process requires many days holding time. As there are many occasions when it is not possible to retain the crude for such a long time, the only really satisfactory method of treatment is via a desalter.

2.1.2 CHEMICAL DESALTING

Historically, the first desalting units were chemical desalters. In the chemical desalting process, a demulsifier and wash water are mixed with the crude, the resultant emulsion is heated and allowed to separate by gravity in a vessel sufficiently large to provide up to two (2) hours retention time. Separation is not always efficient and the sizing of a vessel to produce sufficient residence time means that this process is not applicable to larger units. Few chemical desalters remain in service.

2.2.3 ELECTRICAL DESALTING

An important advance in crude oil desalting was made in 1937 with the introduction of eletrical desalting. Today, the vast majority of refineries have electrical desalters. Single stage desalting (using one vessel) is most common, atlhough double desalting is employed by a few refineries. Double desalting is used where very high crude oil salt contents are regularly encountered. In this process two desalters are arranged in series with the wash water being injected into the feed to the second stage and reinjected into the feed to the first stage. .

Single stage electrical desalting is the most popular method, however, and this coverage will therefore concentrate on this process. A typical desalting process will commence with the injection of a desalting chemical into the crude oil the suction side of charge pumps. Wash water is then injected first at about 1-2% of crude flow on the discharge side of the pumps but prior to the first heat exchange. The remainder of the wash water typically 3-4% of crude oil is injected after the exchangers, just up stream of a mixing valve. This valve is adjusted to give the appropriate pressure drop across so that the wash water can contact the salt in the crude.

The crude/water emulsion then enters the desalter at the base where it flows upwards past electodes which promote coalscence of the water droplets. Water settles by gravity and flows out through the effluent line via heat exchanger exchanging heat with in coming wash water. The desalted crude flow through the top of the deralter vessel to the pre heat train furnace and crude column.

2.3.0 PERFORMANCE FACTORS

2.3.1 THE EFFECT OF HEAT

Crude leaving storage tanks is raised to the necessary desalting temperature by passage through heat exchangers.

Heat is required in the desalting operation for a number of reasons.

1. On heating, the viscosity of the crude is reduced, Emulsion breaking is thereby made easier since the dorplets of water can more easily move through a less viscous crude and therefore coalesce and separate more rapidly.
2. Heating increases the differential density between crude and water and thereby speeds the rate of seperation.
3. Heating increases the energy and molecular activity in the emulsion. In the desalter, the droplets of water move rapidly increasing the incidence of collision and colescence.

Heat therefore produces larger and heavier water droplets and more rapid and complete separation of water from oil. The desalting temperature should be sufficient to promote rapid coalescence but not so high to cause vapourisation in the unit, excessive water carry over in the form of soluble salt water in the crude or break down of the electrical insulatoion. The optimum temperature range for most units is 110-130°C.

2.3.2 PROCESS WATER

The wash water is injected into the crude before the first heat exchanger in the train to reduce the salt content of the aqueous phase and prevent fouling due to salt deposits in the heat exchangers and before the desalters prior to the mixing valve to provide sufficient water to contact the dispersed salt and other contaminants. The total wash water range should be 4-8% of the crude flow.

A good quality wash water have a PH range of 5-7.

2.3.3 **MIXING AND THE MIXING VALVE**

The basic function of the mixing valve is to create a crude oil/water emulsion which permits the finely dispersed water to dissolve and dilute impurities. Emulsification is achieved by a controlled ..... pressure drop, which ranges between 1-2kg/cm^2.

2.3.4 **ELECTRICAL FIELD**

This is a field created between the gap of two special electrodes positioned at a certain level.

The desalter in most cases is a cylinderical veseel horizontally placed, with a length of about 15m and diameter about 3M, Inside in the upper part along the length, two series of special grill form electrodes are mounted. The lower electrodes are commerced to the transformers while the upper electrodes are earthed. The voltage is in the range of 15,000 volts and above because this is the requirement to obtain a substantial eectrical field in the gap between the electrodes. The gap is 152mm.

2.3.5 **RESIDENCE TIME AND INTERFACE LEVEL**

The residence time is the minimum required time to allow a good separation between crude oil and salty water. It is linked with the volume of the desalter and the throughput design of the unit. Any variation of the settling time depends on two variables the first being the flow rate adjustment and the second the changing of operating temperature in the desalter. An increase of the throughput will also reduce settling time.

The interface level controller, controls the effluent draw-off valve in order to maintain a constant interface level. Any uphold variation of such interface level affects the electric field, so for good operations the interface level should be kept at the top of the desalter. The oil/water interface level should be kept at 395mm below the vessel centre line.

2.3.6 **TEMPERATURE AND ITS RELATION WITH PRESSURE**

The temperature limit depends on the design of the system and the economics of it. Temperature goes along with pressure but its limit is that vapouration is to be avoided as desalting would become inefficient. Normally the equipment design pressure ranges between 8-12kg/cm^2 and operating temperature between 100-130°C with an efficiency of about 95%.

2.3.7 DEMULSIFIERS

This is the final major control variable in the desalting process as it makes the difference between an inefficient and efficient desalting operation. The demusifier assist in "breaking down" the crude oil/water emulsions by reducing the surface tension of the film of oil surrounding the droplets of water. thus, freed, the water settles to the bottom of the desalters.

The demulsifier employed in CDU-1 of KRPC is DS-936 which is a solution of oxyalkylated phenol formaldehyde resins and oxyalkylated polyethylene polyamine in aromatic hydrocarbon and alcohol solvents. DS-936 does not contain any nitrogen or any heavy metal components.

Typical physical properties

Specific gravity, $15/_4{}^0$C,	1,00
Flash point, T.C.	above 66°C
Pour point	below - 20°C
Viscosity, 37.8oC, Sus	250
Solubility	Oilsoluble, water insoluble

2.4 TYPES OF ELECTRICAL DESALTERS

Spherical and horizontal eletrical desalters are the popular at field and refinery desalting plants.

A spherical desalter has a volume of 600m^3 and a diameter of 10.5m. Its capacity is 300-500m^3/h. The desalter provided with the three pairs of electrodes. The centre of each electrode accomodates a distribution head from which the petroleum enters the inter electrode space horizontally. A special connection of the transformer primary windings makes it possible to obtain a voltage from 22 to 44KV in an inter electrode space. Spherical electrical desalters occupy a lot of space, and a large amount of steel is needed for their fabrication.

Horizontal electrical desalters are more economical and efficient. Merits of the horizontal elecltrical desalters are the larger path of petroleum, and an increased residence time in the units

3.2 **SALT CONTENT OF CRUDE AND VARIATIONS AROUND THE WORLD**

		SALT CONTENT	WATER CONTENT
CRUDE	**NAME**	**Kg/1000M³**	**% VOL.**
Midel East			
Iran	Iranian light	14	traces
	Iranian Heavy	14	traces
Iraq	Iraq (Basra)	<3	0.1
	Iraq mideterranean Ain/Zalan/Butman		
	Iraq Mideterranean /Jambur Bai Hassan	37	traces
	Iraq mediterranean/Kurkuk	<6	<0.1
	Kuwait Export	8	<0.1
	Qatar Export		
Kuwait	Arabian Light	11	traces
Qatar	Arabian heavy	2.9	0.02
Saudi Arabia	(Safaniya)	11	0.05
		11	0.05
	Brega		
<u>Africa</u>	El Borma		
Libiya	50/50 MIXED	0	0
Tunisia	UQCC	2.6	1
Nigeria	AND EXCRAVOS	21.8	0.2
<u>Europe</u>	Tujamaza		
Russia	Rajusano	53	0.04
Italy		42	0.1
<u>South America</u>	Bachaquero		
Venezuela		85	1.9

TABLE 2: SALT CONTENT OF CRUDES

SOURCE: KRPC LIBRARY.

The technology of desalting crude ois usually depends on the quantity of salt contained in the crude oil in question. The salt in most cases is present in a dissolved form in the water contained in the crude oil and in some intances in crystalline form, or both, therefore in most cases the salt content is a function of the water content of the crude oil.

For crude oils (exptional cases) with no water content and no salt content such as that from Brega in Libiya. The desalting submit is not required in the crude distillation unit and hence it lowers the cost of processing such crude.

The amount of salt associated with crude oil is far more important than its quantity would indicate, hence any crude that contains salt regardless of the quantity should be desalted using the appropriate technology.

Electrical method of desalting crude oil, is the most modern method employed in most refineries because of its high officiency, only few chemical desalters remain in service today. Single stage electrical desalting (using one vessel) is most common, the method is employed for crude oils whose salt content ranges from 1 - 30kg/1000m^3. In few cases where the salt content is on the higher side (31-1000kg/100m3) double desalting is employed, this involves the use of two vessels in series. Although this will increase the desalting cost, the high efficiency of the desalting process componsates the cost.

3.3 DETERMINATION OF DESALTER EFFICIENCY

The desalter efficiency is referred to as the amount of salts removed over the total salt contents expressed in percentage points. The desalter has been designed to remove 95% with a maximum 3ptb (1 pound per thousand barrels = 2.85ppm) residual salt.

3.3.1 ANALYSIS OF CRUDE OIL BEFORE GOING IN TO THE DESALTER AND AFTER PASSING THROUGH THE DESALTER.

TABLE OF RESULTS

DAY		1		2		3		4	
TEST	UNIT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
Specific gravity 15/4oC	kg/l	0.8456	0.8447	0.8476	0.84476	0.8473	0.8445	0.8444	0.8440
Viscosity kinematic AT 100of or 37.8oC	CSt	3.90	3.68	4.10	3.92	3.72	3.51	3.53	3.50
Salt content	PTB	6.54	2.74	6.12	2.11	7.17	2.53	8.02	2.32
Water & sediment.	%Vol	trace	trace	trace	trace	0.3	0.1	0.1	trace

DAY		5		6		7		8	
TEST	UNIT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
Specific gravity 15/4oC	kg/l	0.8452	0.8445	0.8443	0.8440	0.8435	0.8430	0.8473	0.8470
Viscosity kinematic AT 100oF or 37.8oC	CSt	3.55	3.50	3.61	3.58	3.40	3.27	3.80	3.50
Salt content	PTB	5.28	0.42	7.43	3.21	7.81	3.22	5.48	0.53
Water & sediment.	%Vol	0.2	trace	0.1	trace	0.2	0.1	0.6	0.1

DAY		9		10		11		12	
TEST	UNIT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
Specific gravity 15/4oC	kg/l	0.8486	0.8476	0.8473	0.8463	0.8466	0.8446	0.8460	0.8456
Viscosity kinematic AT 100oF or 37.8oC	CSt	3.92	3.79	3.84	3.76	3.65	3.61	3.68	3.61
Salt content	PTB	3.70	2.10	7.35	2.10	10.55	2.11	6.33	2.82
Water & sediment.	%Vol	0.1	trace	0.1	trace	0.1	trace	0.2	trace

DAY		13		14		15		16	
TEST	UNIT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
Specific gravity 15/4oC	kg/l	0.8474	0.8452	0.8456	0.8456	0.8479	0.8466	0.8466	0.8456
Viscosity kinematic AT 100oF or 7.8oC	CSt	3.78	3.69	3.70	3.68	3.84	3.67	3.72	3.61
Salt content	PTB	5.49	4.63	16.0	2.74	10.22	3.64	8.02	3.02
Water & sediment.	%Vol	0.3	0.1	0.2	trace	0.4	0.1	0.6	0.2

DAY		17		18		19		20	
TEST	UNIT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
Specific gravity 15/4oC	kg/l	0.8488	0.8469	0.8456	0.8450	0.8460	0.8454	0.8460	0.8456
Viscosity kinematic AT 100oF or 37.8oC	CSt	4.18	3.91	3.60	3.50	3.99	3.64	3.72	3.68
Salt content	PTB	11.06	3.92	6.52	2.31	8.22	3.41	6.12	2.00
Water & sediment.	%Vol	0.50	0.20	0.1	trace	0.2	trace	0.2	0.1

DAY		21		22		23		24	
TEST	UNIT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
Specific gravity 15/4oC	kg/l	0.8468	0.8460	0.8443	0.8434	0.8456	0.8452	0.8466	0.8463
Viscosity kinematic AT 100oF or 37.8oC	CSt	3.81	3.62	3.68	3.61	3.67	3.62	3.76	3.71
Salt content	PTB	5.28	2.16	6.02	2.01	5.02	2.06	6.30	2.10
Water & sediment.	%Vol	0.2	trace	0.1	trace	0.1	trace	0.1	trace

Day 7

$$E7 = \frac{7.81 - 3.22}{7.81} \times 100 = 58.77\%$$

Day 8

$$E8 = \frac{5.48 - 0.53}{5.48} \times 100 = 90.32\%$$

Day 9

$$E9 = \frac{3.70 - 3.10}{3.70} \times 100 = 43.24\%$$

Day 10

$$E10 = \frac{7.35 - 2.10}{7.35} \times 100 = 71.42\%$$

Day 11

$$E11 = \frac{10.55 - 2.11}{10.55} \times 100 = 80\%$$

Day 12

$$E12 = \frac{6.33 - 2.82}{6.33} \times 100 = 55.45\%$$

Day 13

$$E13 = \frac{5.49 - 4.63}{5.49} \times 100 = 15.66\%$$

Day 14

$$E14 = \frac{16.0 - 2.74}{16.0} \times 100 = 82.88\%$$

Day 15

$$E15 = \frac{10.22 - 3.64}{10.22} \times 100 = 64.38\%$$

Day 16

$$E16 = \frac{8.02 - 3.02}{8.02} \times 100 = 62.34\%$$

Day 17

$$E17 = \frac{11.06 - 3.92}{11.06} \times 100 = 64.56\%$$

Day 18

$$E18 = \frac{6.52 - 2.31}{6.52} \times 100 = 64.57\%$$

Day 19

$$E19 = \frac{8.22 - 3.41}{8.22} \times 100 = 58.51\%$$

Day 20

$$E20 = \frac{6.12 - 2.00}{6.12} \times 100 = 67.32\%$$

Day 21

$$E21 = \frac{5.28 - 2.16}{5.28} \times 100 = 59.09\%$$

Day 22

$$E22 = \frac{6.02 - 2.01}{6.02} \times 100 = 66.61\%$$

Day 23

$$E23 = \frac{5.02 - 2.06}{5.02} \times 100 = 58.96\%$$

Day 24

$$E24 = \frac{6.30 - 2.10}{6.30} \times 100 = 66.67\%$$

Day 25

$$E25 = \frac{7.50 - 2.48}{7.50} \times 100 = 66.93\%$$

Day 26

$$E26 = \frac{9.45 - 2.10}{9.45} \times 100 = 77.78\%$$

Day 27

$$E27 = \frac{10.46 - 3.11}{10.46} \times 100 = 70.17\%$$

Day 28

$$E28 = \frac{11.55 - 2.10}{11.55} \times 100 = 81.81\%$$

Day 29

$$E29 = \frac{11.41 - 2.28}{11.41} \times 100 = 80.01\%$$

Day 30

$$E30 = \frac{10.04 - 4.02}{10.04} \times 100 = 59.96\%$$

Day 31

$$E31 = \frac{4.20 - 2.10}{4.20} \times 100 = 50.00\%$$

Day 32

$$E32 = \frac{4.64 - 1.10}{4.64} \times 100 = 76.29\%$$

3.3.3 AVERAGE EFFICIENCY OVER THE PERIOD

$$E = \frac{\sum_{i=1}^{32} E}{32}$$

$$E = \frac{2101.93}{32}$$

$$E = 65.69\%$$

3.4 PERFORMANCE FACTORS

3.4.1 WASH WATER (PROCESS WATER)

A. QUANTITY

The global flow rate of the process water must be kept in the range of 5-8% in volume over the crude.

Too litle wash water can produce at least two undsirable effects:

1. The resultant salt solution is more concentrated than would be the case with more wash water, hence any water carried over in the desalted crude will carry forward more salt e.g assuming good mixing if a wash water rate of 2% is emloyed and the desalted crude has a salt contant of 10ppm, doubling the wash water rate to 4% will approximately half the salt content of the water droplets and reduce the salt carry over to 5ppm.
2. The smaller volume of water dipersed in roughly the same volume of crude means that the average distance between dispersed droplets is greater than with a higher water additive rate. Inter-droplet contact and coalescence are therefore reduced and dehydration efficiency falls.

Excessive wash water rates are undesirable as:

1. Heat losses from the desalter are increased
2. The residence time of the water in the desalter is reduced which can lead to incomplete water "de-oiling" and poor effluent quality.

B. QUALITY

The quality of wash water can have an effect on desalting efficiency. The water should have as low an ionic content as possible and should not be excessively alkaline, i.e PH<8. For the majority of desalting operations, the optimum conditions will exist when the wash water PH lies within the range of 5-7.

The ideal source of wash water is process condesante, notably pipestill over heads water. Although many refineries use stripped sour water, this practice can impair desalting if the water is produced from F.C.C.U or other cracking operations. The presence of high levels of ammonia in this type of water reduces emulsion breaking efficiency. The ammonia can also transfer to the desalted crude and contaminate over heads water. Where there is a history of fouling or corrosion by ammonium salts in the overheads, this practice should be avoided.

The injection of caustic soda to raise desalter PH levels should also be avoided where naphthenic acids is present, as an impurity in the crude, the addition of caustic soda result in the formation of sodium naphthenic which is an emulsion stabilizer and can therefore cause severe emulsion problems in the desalter.

Bicarbonates and sulphates can be found in some wash water sources and formation water produced with crude. These substances have reduced solubility as temperature increase the potential for inorganic fouling in the effluent exchangers.

3.4.2 MIXING AND THE MIXING VALVE

This valve is specifically designed to effect an itimate mixing of the crude controlling the pressure drop across the valve. Increasing the mixing energy imparted to the crude charge, by increasing pressure drop (DP) causes the formation of smaller water droplets. Excessive mixing causes the production of droplets which are so small as to result poor coalescence. This will cause carry over of water with the desalted crude and, as the droplets contain the salt, the salt content of the crude will also rise.

Mixing must, therefore, be sufficient to ensure that the wash water contact all of the dispersed brine dorplets all of the sand sediment particles and any crystalline salt present in the crude, whilst not being great enough to lead to water carry over.

The relationship between these requirements may be expressed graphically as shown in figure2

The required pressure drop (DP) for optimum mixing will vary according to temperature and crude type but normally lies within the range 0.5-1kg/cm2 (7-15 P.S.I;).

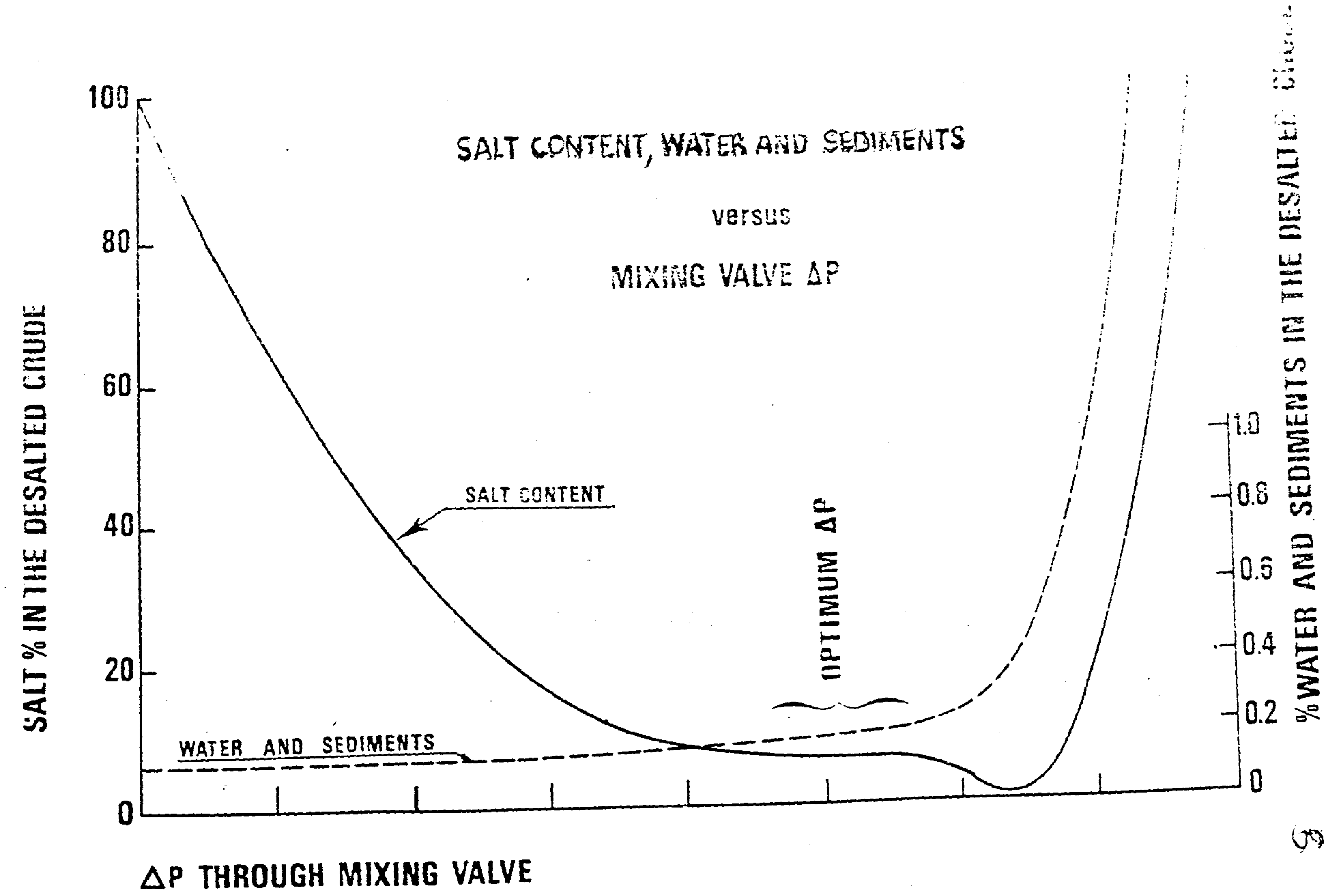

SALT CONTENT, WATER AND SEDIMENTS
versus
MIXING VALVE ΔP
SALT % IN THE DESALTED CRUDE
100
80
60
40
20
0
%WATER AND SEDIMENTS IN THE DESALTED
1.0
0.8
0.6
0.4
0.2
0
SALT CONTENT
WATER AND SEDIMENTS
OPTIMUM ΔP
ΔP THROUGH MIXING VALVE

Figure 5

3.4.3 ELECTRICAL FIELD

The function of the electrical in the desalter is to dehydrate the crude.

When a non-conducive liquid, such as crude oil contains a dispersed conducive liquid, such as brine the conductive droplets will combine, or coalesce, as a result of one of three mechanisms.

a. The water droplets become polarised and align them selves with lines of the electrical field. The positive and negative poles are thus oriented adjacent to each other and the resultant attraction causes them to collide and coalesce.

b. Water droplets are attracted to the vessel's electrodes where they combine with other droplets until they again fall by gravity.

c. The electrical force promotes increased motion of the droplets in the oil which increases the incidence of collisions.

Most desalters employ A.C fields with an applied voltage in the range 800-1600 volts per cm. The desalter voltage may drop if the unit is operated at too high a temperature 125°C, crude oil itself becomes more conductive and electrode efficiency is reduced. Under normal operating conditions the voltage and current readings should remain stable. High current readings are an indication of water carry over. However, each crude or mixture will have its own intrinsic conductivity at any given temperature. Even in a dehydrated state these values may be high·Reference should diagnising an emulsion problem or water carry over.

3.3.4 RESIDENCE TIME AND INTERFACE LEVEL

Crude dehydration and desalting efficiency are affected by various parameters, of which oil residence time is one. If the crude residence time is too short, then dehydration efficiency may be appreciably reduced.

Residence time is affected by two parameters:

a. Crude charge rate, over which there is little control as dictated by production requirements. Elevated charge rates will in effect reduce the residence time in the desalter, whilst reduced through put will increase in residence time.

b. Interface Level

This is controlled by the desalter level controller which regulates the height of the interface between the oil and water phases. When the interface level is reduced the water residence time increased and the oil residence time reduced. Lowering the interface produce the opposite effect. Crude rasidence times can vary from 15-45 minutes.

In addition to dehydrating the crude, the desalter should also produce effluent which is essentially oil-free, too short a residence time for the water phase may result in the production of oily effluent. The optimum desalter level control setting is therefore a conpromise in the face of a crude feed rate which can not be varried to produce optimum dehydration of the desalted whilst maintaining oil free effluent water.

The most reliable guide to levels in the desalter can be obtained from an examination of samples from trycocks fitted to the desalter drum. Most unit have five of these sampling lines, the lowest of which is normally at 2 foot (61 cm) or 2 feet 6 inches (76 cm) level. The remainder of the tryrock are spaced at 6 inch (15 cm) intervals.

It is normal practice to operate the desalter with the two lowest trycocks showing clean water. Whilst the desalter is producing good quality effluent, the interface level should not be raised to produce more than two clean water trycocks as the crude residence time and dehydration efficiency will be unnecessarily reduced.

3.4.5 **PRESSURE**

The operating pressure must be sufficiently high to avoid vapourization within the desalter. If the operating pressure is so low as to permit the water to vapourize then,

a. Water would leave the desalter as a vapour, present in the crude.

b. The act of the water vapouring will cause the desalter contents to roll in the vessel. This can cause water to contact and short out, the electrodes and also promotes oil carry under with the effluent water.

The normal design pressure is between 8-12 kg/cm^2.

3.4.6 TEMPERATURE

Crude leaving storage tanks is raised to necessary desalting temperature by passage through heat exchnagers.

Heat is required in the desalting operation for a number of reasons:

1. On heating, the viscosity of the crude is reduced. Emulsion breaking is thereby made easier since the droplets of water can more easily move through a less viscous crude and therefore coalesce and separate more rapidly.

2. Heating increase the differential density between crude and water and thereby speeds up the rate of separation.

3. Heating increases the energy and molecular activity in the emulsion. In the desalter, the droplets of water move more rapidly increasing the incidence of collision and colascence.

Heat therefore produces larger and heavier water droplets and more rapid and complete separation of water from oil. The desalting temperature should be sufficient to promote rapid coalescence but not so high to cause vapourisation in the unit, excesive water carry over in the form of soluble salt in the crude or break down of the electrical insulation. The optimum temperature range for most units is 110-130°C.

3.4.7 DESALTING CHEMICAL (DEMULSIFIER)

The final major control variable in the desalting process is the desalting chemical (also known as demlulsifier or emulsion breaker). The use of an effective chemical is of great importance as it can make the difference between an inefficient and an efficient desalting operation. When crude oil enters the refinery, the brine it contains is usually present in form of a very stable emulsion. The emulsion stabilising substances, whether they be solids, or soluble emulsifiers such as naturally occuring soaps, are concentrated at the interface between the brine dorplets forming a tenacious film which impedes coalscence and settling.

The desalting chemical works at the crude/oil interface disrupting this film and allowing the water droplets to coalesce more easily. For this reason it is important that the chemical is injected on the suction side of the crude charge pump where the water droplet concentration is low. The chemical migrates to the crude/water droplet interface giving a high effective dosage rate even though the overall dosage may be less than 5 p.p.m. If the chemical was injected after the wash water, the water droplet concentration will be greater and the effective dosage rate much lower.

Additionally, when injecting the chemical at the crude charge pump suction, not only is a high effective dosage applied, but the residence time of the chemical before wash water injection is increased. This allows the chemical to set against the naturally present emulsion stabilisers and also eases the entry of the wash water into the dispersed brine droplets.

The desalting chemical should be multifunctional. In addition to the important function of crude dehydration, it should be so formulated to assist in the removal of filterable solids from rhe crude and produce oil free effluent from the desalter. This distinguishes desalting chemicals from oil-field demulsifiers whose sole function is to dewater crude oil.

3.4.8 CAUSTIC SODA (NaOH)

The greater part of crudes contains free acids, therefore caustic soda must be added in the right proportion in order to neutralise them. Since the quantity of acid varies from crude to crude and even in the different tanks containing the same crude, the amount of soda required for the control of the PH will be variable. The crude oils processed in CDU-1 contain about 0.5% wt. of napthenic acids which attack equipment.

The recomendation is that the PH of the water coming out of the desalter be checked once a week and the injection of caustic soda be regulated so as to keep the PH of the discharged water in the range of 7-8.5. Sometimes the soda is not required at all; in any case a maximum consumption of about 3.0kg per 100 cum of crude is expected.

3.4.9 CRUDE FEED QUALITY

The type and quality of the crude charge can also affect desalting efficiency. Normally light (low density) crudes are relatively easy to desalt. Higher density crudes are normally more difficult to desalt as:

a. The differential density between the crude and water is small.

b. Heavier crudes tend to contain more naturally occuring emulsifiers than do lighter crudes.

c. Heavier crudes often contain more sulphur and hence, more iron sulphide. Where iron sulphide is present it is insoluble in both oil and water and tends to accumulate at the oil/water interface making it a very effective emulsion stabiliser.

3.5 DESALTER TROUBLE SHOOTING

A. PROBLEM

High chlorides content in over heads accumulator water.

INTERPRETATION

i. Poor desalter performance

ii. Insufficient NaOH added to desalted crude oil

ACTION

i. Examine mixing index

ii. Determine whether B.S & W. in desalted crude is in the form of unresolved emulsion or clear water carry over.

B. PROBLEM

Low mixing index

INTERPRETATION

i. Low index valve pressure drop (DP)

ii. Wash water introduced too far forward in the system

iii. Inssuficient wash water.

ACTION

i. Increase mix valve pressure drop (DP)

ii. Feed more wash water further back in the system i.e before the preheat exchangers.

iii. Increase the wash water rate.

C. **PROBLEM**

Water carry over (free water) but good mixing index.

INTERPRETATION

i. High desalter water level

ii. Low crude oil residence time in desalter

iii. Too little emulsion breaker

iv. Low % wash water

ACTION

i. Lower desalter water level

ii. Increase emulsion breaker dosage

iii. Increase % wash water to provide better coalescing.

D. **PROBLEM**

Good mixing index but emulsion carry over

INTERPRETATION

i. Tool little emulsion breaker

ii. High mix valve pressure drop (DP)

ACTION

i. Increase emulsion breaker dosage

ii. Reduce mix valve pressure drop (DP)

CHAPTER FOUR

EQUIPMENT DESIGN

INTRODUCTION

The equipment design is on a crude oil desalter whose function as earlier spelt out in the preceeding chapters is to get rid of salts, sediments and other impurities from the crude oil. Its functiom also involves the removal of water from crude oil (dehydraltion).

AIMS AND OBJECTIVES

The aim is to design a crude oil desalter that will give high efficiency in the desalting process within crude distilation unit one of kaduna refinery and Petrochemical company and other crude distilation units as applicable.

DESIGN CONDITIONS

PETROLEUM HEATING TEMPERATURE $^{\circ}C$	130 - 140
Pressure in electrical desalter, kg/cm^2	8 - 12
Voltage in interlecrode space, Kv	17
Production capacity, m^3/h	400
Plant efficienty, %	95

PROCESS CONDITIONS

Operating temperature, $^{\circ}C$	100 - 130
Operating pressure, kg/cm^2	80 - 10
Caustic soda (NaoH), PPM	10
Demulsifies, PPM	5
Utility conditon:	
Metrological condition:	32
Temperature of Air, $^{\circ}C$	32
Relative humidity of Air, %	75

4.2 CALCULATION OF MATERIAL BALANCE AROUND THE DESALTER

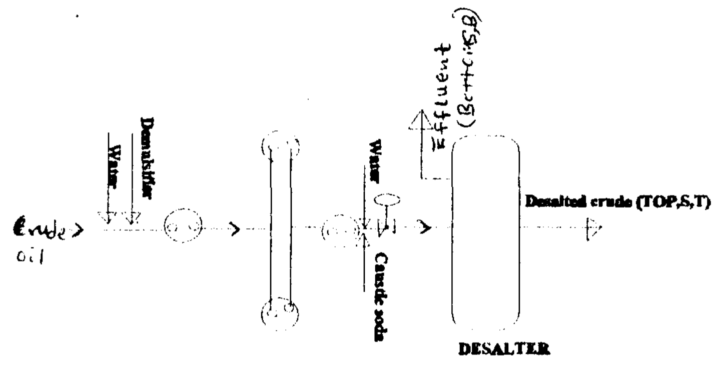


FIGURE 1

Basis: 1

hour

The plant is desiigned to process 60,000 BPSD OF CRUDE OIL.

$1M^3/h = 150BPSD$

$\therefore$ 60,000 bpsd = $400m^3/h$

The volumetic flowwrate = $400m^3/h$

From one day data below:

TEST	UNIT	IN	OUT
Specific gravity 15/4°C	kg per litre	0.8488	0.8469
Viscosity kinematic 100°F or 37.8°C	Cst	4.18	3.91
Salt content	PTB	11.06	3.92
Basic sediment & water	%vol	0.50	0.20

REQUIREMENTS:

Process water: 8% of crude flow

Caustic soda (NaoH): 10ppm of crude flow

Demulsifier: 5 ppm of crude flow

REACTION:

NaoH + Hcl → Nacl + H_2O

NaoH + RcooH→ RcooNa + H_2O

BASIC SEDIMENT AND WATER (B.S & W):

B.S&W. In = 0.50% vol.

B.S&W. out = 0.20% vol.

PROCESS WATER REQUIREMENT

8% crude flow

$= \frac{8}{100} \times 339520$

= 27161.6kg/h

CHEMICAL REQUIREMENT

Caustic soda (NaOH):

10ppm of crude flow

convert from ppm to kg

1 PTB = 2.85 ppm

∴ 10 ppm .....3.509 PTB

1000 barrels of crude oil requires 3.509lb soda

$400m^3$ = 2500 barrels

2500 Barrels of crude oil requires 8.77 lb soda

∴ 8.77 lb NaOH is required for every $400m^3$ crude oil per hour.

express the amount in kilogram:

8.77 lb = 3.98kg

Express the amount in percentage (%):

$\frac{3.98}{339520} \times 100$ 0.0117%

Demulsifier:

5 ppm of crude flow

Convert from ppm to kg:

5ppm → 1.754 PTB

1000 barrels of crude oil requires 1.75lb demulsifier

∴ 4.385 demulsifier is required for 400m^3 crude oil per hour

Express the amount in kg:

$$\frac{1.99}{339520} \times 100 = 0.000586\%$$

inlet composition (f)

MATERIAL	PERCENTAGE (%)
Crude oil	91.4945
Salt content	0.003696
B.S.&.W.	0.50
Process water	8.0
Caustic soda	0.000117
Demulsifier	0.000586
TOTAL	100.00

OUTLET COMPOSITION (TOPs,T)

The water and salts formed as a result of the reactions are taken care of by the B.S& W. and salt content analysis done on the crude at the outlet.

MATERIAL	PERCENTAGE (%)
Crude oil	99.7986
B.S.&.W.	0.1999
Salt content	0.001429
Total	100.00

OUTLET COMPOSITION (BOTTOMS, B)

To obtain the outlet (bottoms) composition 100% of the demulsifier is assumed to be at the bottom (effluent), since the demulsifier is a tie substance

MATERIAL	PERCENTAGE (%)
Crude oil	0.0961
B.S.&.W.	99.8595
Salt content	0.03731
Demulsifier	0.0070
TOTAL	100.00

Overall material balance:

Overall material balance:

$F = T + B$ (1)

$339520 = T + B$ (2)

Component balance on crude oil:

$0.914945F = 0.997986T + 0.000961B$ (3)

From equation (2)

$B = 339520 - T$ (4)

Substitute equation (4) in to equation (3)

$0.914945 (339520) = 0.99796T \; 0.000961 (339520 - T)$

$310642.1264 = 0.997986T + 326.27872 - 0.000961T$

$310642.1264 - 326.27872 = 0.997986T + 0.997986T - 0.000861T$

$310315.8477 = 0.997025T$

$$T = \frac{310315.8477}{0.997025}$$

$T = 311241.792 kg/h$

To obtain B, substitute the value of T into equation (2)

$339520 = 311241.792 + B$

$B = 339520 - 311241.792$

$B = 28278.208 kg/h$

Check

From equation (1)

$339520 = 31241.792 + 28278.208$

$339520 = 339520$

INLET - OUTLET

TABLE OF COMPOSITION OF INLET AND OUTLET STREAMS

Material	F			T			B		
	Amount + m^3/h	Amount kg/h	%composition	AMMT M^3/h	AMMT kg/h	% composition	AMMT M^3/h	AMMT kg/h	% composition
Crude oil	365.978	310642.28	19.4945	365.9415	310615.1	99.7986	0.0320	27.18	0.0961
Salt content	.0148	12.55	0.003696	0.0052	4.447	0.001429	0.12427	10.553	0.03731
B.S. & W	2.00	1697.6	0.50	0.73299	622.48	0.1999	33.26	28238.25	99.8595
Process water	32.00	27161.6	8.00	-	-	--	-	-	-
Caustic soda	.00648	3.98	0.00117	-	-	-	-	-	-
Demulsifier	.0023	1.99	0.00586	-	-	-	0.00233	1.99	0.0070
TOTAL	400	339520	100.00	366.68	311241.79	100.00	33.31	28278.208	100.00

4.4 CALCULATION OF HEAT BALANCE AROUND THE DESALTER

The heat balance is based on quantity of heat required, outlet heats, and heat loss to the surrounding.

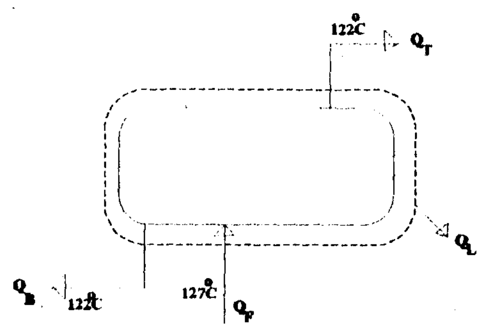


FIGURE (2)

Overall Heat Balance

$Q_F = Q_T + Q_B + Q_L$ ----------(1)

Where

Q_F = heat content of the feed mixture at the inlet

Q_T = heat content of the outlet mixture (tops)

Q_B = heat content of the outlet mixture (bottoms)

Q_L = heat loss to the environment

$Q = MC_pT$

Heat content of the feed mixture at the inlet, Qf

Specific heat capacities of individual components that make up the inlet feed mixture at 127°C.

Crude oil, Cp_1 = 0.4799KJ/kgK

Salt content, Cp_2 = 0.07206KJ/kgK

B.S & W, CP_3, = 4.265 KJ/kgk

Process water, CP_4, = 4.265 KJ/kgk

Caustic Soda, CP_5, 4.121 KJ/kgk

Demulsifier, CP_6, = 1.6736 KJ/kgk

The mean specific heat capacity of mixtures is given by:

$$C_{pmf} = \frac{m_1 c_{p1} + m_2 + m_3 cp_3 + m_4 cp_4 + m_5 cp_5 + m_6 cp_6}{m_1 + m_2 + m_3 + m_4 + m_5 + m_6}$$

Subtitude the values of specific heat capacities and the masses in to equation (2)

$$\frac{10642.28 x 0.4799 + 12.55 x 0.07206 + 1697.6 x 4.265 + 27161.6 x 4.265 + 3.98 x 4.121 + 1.99 x 1.6736}{310642.28 + 12.55 + 1697.6 + 27161.6 + 3.98 + 1.99}$$

$$= \frac{272182.3362}{339520}$$

C pmf =0.8017 KJ/KGK

Heat content of the feed mixture:

Qf = MCpmft

Qf = 339520 x 0.8017 x (127 + 2.73) ok

Qf= 108,877,273.6 kJ/h

∴ the heat content of the feed mixture is equal to 108,877,275.6 KJ/h

Heat content of the outlet mixture (tops), Q

Specific heat capacities of individual components that make up the outlet mixture (tops) at 122°C.

Crude oil, Cp1 = 0.4611KJ/KgK

Salt content, Cp2 = 0.0719KJ/KgK

B.S.&W, Cp3 = 4.254KJ/KgK

The mean specific heat capacity of the mixture is given by:

$$Cpmt = \frac{M_1Cp_1 + M_2Cp_2 + M3Cp_3}{M_1 + M_2 + M_3} \quad (3)$$

Subtitude the value of the specific heat capacities and the masses in to equation (3)

$$C_{pmT} = \frac{310615.1x0.4611+4.447x0.0719+622.48x4.254}{310615.1+4.447+622.48}$$

$$CpmT = \frac{145872.9723}{311242.027} = 0.4687KJ/KgK$$

Heat content of the outlet mixture (tops):

QT = MCpmTT

= 311241.027 x 0.4687 x (122 + 273) oK

= 145879.027 x 395

QT = 57,622,215.67 KJ/h

∴ the heat content of the outlet mixture (tops) is equal to 57,622.2MJ/h

Heat content of the outlet mixture (bottoms), Q5

Specific heat capacity of individual components that make up the outlet mixture (bottoms) at 122oC.

Crude oil, Cp_2 = 0.0719 KJ/KgK

Salt content, Cp_2 = 0.0719 KJ/KgK

B.S &W, Cp_3 = 4.254 KJ?KgK

Demulsifer, Cp_4 = 1.4644 KJ/KgK

The mean specific heat capacity of the mixture is given by:

$$C_{pmB} = \frac{M_1C_{p1}+M_2C_{p2}+M_3+M_4C_{p4}}{M_1+M_2+M_3+M_4}$$

Subtitude the values of the specific heat capacities and the masses in to equation (4)

$$C_{pmB} = \frac{27.18x0.4611+10.553x0.0719+28238.25x425+1.99x1.4644}{27.18+10.553+282338.25+1.99}$$

$$Cp_{mB} = \frac{120,41.7211}{28277.973}$$

Cp_{mB} = 4.2486KJ/KgK

Heat content of the outlet mixture (bottoms):

$QB = M\ Cp_{mB}\ T$

$QB = 28278.208 \times 4.2486 \times (122 + 273)$ oK

$QB = 47,456,374.22$ KJ/h

∴ the heat content of the outlet mixture (bottoms) is equal to 47,456.37MJ/h

To determine the heat loss, Ql

Subtitude the values of QF, QT & QB into equation (1).

$Q_F = Q_T + Q_B + Q_L$

$108877273.6 = 57622215.67 + 47456374.22 + QL$

$108877273.6 = 10507889.9 + QL$

$QL = 108877273.6 - 105078589.9$

$QL = 3,798,683.71$ KJ/h

∴ the heat loss is equal to 3,798.68MJ/h

Check:

$Q_F = Q_T + Q_B + Q_L$

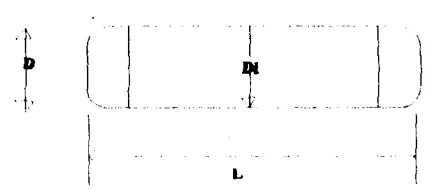
$108877273.6 = 57622215.67 + 47456374.22 + 379\ 863.71$

$108877273.6 = 108877273.6.$

∴ INLET = OUTLET

4.5 SI ZING

The basic dimensions necessary to provide for good desalting are the desalter diameter, desalter length, and desalter volume. For all models of electric desalters used in crude distillatinn units the optimum internal diameter, rated pressure, and rated temperature are fixed at 3400mm, 1.8MPa, and 160°C respectively.



Vessel wall Thickness Required

The minimum thickness required is given by

$$e = \frac{Pi \times Di}{2f - Pi}$$

$$e = \frac{1.8 \times 3.4}{2 \times 150 - 1.8}$$

e = 0.0205m

e = 20.5mm

A corrosion allowance of 2mm is assumed

$\therefore$ e = (20.52 + 2) = 22.5mm

say 23mm

The mean diameter = (Di + e)

= 3400 +23

= 3423mm

External diameter, D = 2e + Di

D = 2 x 23 + 3400

D = 3446mm

Length of Desalter Determination

The desalter under design is of the model 2ər - 160 which have one inlet for the feed stock and a fixed optimum volume of 160m^3. Thus, since the length has a horizontal hemisherical shape, the length is determined by the sum of the volume of a cylinder and that of a sphere.

$V = \pi r^2 L + 4/3\pi r^3$

2r = D

r = D/2

r = 3446/2

= 1.723mm

$160 = \pi \times (1.723)^2 \times L + 4/3 \times \pi \times (1.723)^3$

$160 = 9.419L + 21.415$

$9.419L = 160 - 21.415$

$9.419L = 160 - 21.415$

$9.419L = 138.58/9.419$

$L = 14.7m$

Determination of Optimum Pipe Diameters

For stainless pipe, the optimum pipe diameter, d, optimum $= 260G^{0.52}\rho^{-0.37}$ where

G = flow-rate (kg/s)

ρ = Density (kg/m^3)

Feed inlet Optimum Pipe diameter

Inlet flow-rate G, = 339520 kg/h

= 94.3kg/s

Density, ρ = 848.8kg/m3

d, optimum $= 260G^{0.52}\rho^{-0.37}$

$= 260 \times (94.3)^{0.52} (84.88)^{-0.37}$

d, optimum = 228.1mm

Use 230mm Pipe

viscosity of the feedstock, $\mu = 0.0418 \times 10^{-3}$ NS/M^2

$$Re = \frac{4G}{\pi u d} = \frac{4 \times 94.3}{\pi \times 0.418 \times 10^{-3} \times 230 \times 10^{-3}}$$

$Re = 1.24 \times 10^7$

Re > 4000, so flow is turbulent

Optimum outlet pipe diamter (TOPs)

Outlet flow-rate (TOPs), G = 311241.79kg/h

= 86.46kg/s

Density, ρ = 846.9kg/m^3

d, optimum = 260 $G^{0.52}$ $\rho^{-3.7}$

d, optimum = 260 X $(86.46)^{0.52}$ $(846.9)^{-0.37}$

d, optimum = 218.18mm

Use 220mm Pipe

Viscosity of the outlet mixture, μ = 0.039 X 10^{-3} NS/M^2

$$Re = \frac{4G}{\pi u d}$$

$$Re = \frac{4 \times 86.46}{\pi \times 0.039 \times 10^{-3} \times 220 \times 10^{-3}}$$

Re = 1.28 X 10^7

Re > 4000, so flow is turbulent

Optimum outlet Pipe diameter (Bottoms)Outlet flow-rate (Bottoms),

G = 28278.208kg/h.

= 7.86kg/s

Density, ρ = 1000kg/M^3

d, optimum = 260 $G^{0.52}$ $\rho^{-0.37}$

d, optimum = 58.96mm

Use 60mm pipe

Visosity of the outlet mixture, μ = 1.1 X 10^{-3} NS/M^2

$$Re = \frac{4G}{\pi u d}$$

$$Re = \frac{4 \times 7.86}{\pi \times 1.1 \times 10^{-3} \times 60 \times 10^{-3}}$$

Re = 1.51 X 10^5

Re > 4000, so flow is turbulent

Overall Specifications

Model	23r-160
Volume, M^3	160

Capacity, M^3/h	400
Internal diamter, mm	3400
Wall thickness, mm	23
External diameter, mm	3446
Length, mm	14700
Rated pressure, Mpa	1.8
Rated temperature, °C	160

4.6 COST ANALYSIS

The cost analysis is based on equipment costing, raw materials costing and utilities costing. The cost escalation (inflation) is considered for costing done.

Purchased Equipment cost

The purchased equipment cost is given by:

$$Ce = CS^n$$

Where

Ce = Purchased equipment cost

C = Cost constant

S = Characteristic size parameter in M^3

n = Index for the type of equipment

$Ce = 1500 \times (160)^{0.60}$

Ce = E 31518.33

Ce = ₦3,782200.038

Cost escalation (inflation):

$$\text{Present cost} = \text{Past cost} \times \frac{\text{present cost index}}{\text{past cost index}}$$

$$\text{Present cost} = 3782200 \times \frac{(78)}{56}$$

Present cost = ₦5268064.286

Say ₦5,268,100.00

Estimation of fixed capital cost

This is given by

$C_f = F_l C_e$

Where

CF = fixed capital cost

Ce = the total delivered cost of all major equipment items, but here only the desalter is considered.

FL = Lang factor, which is 4.7 for predominantly fluid processing plants.

Cf = 4.7 X 5268100

₦24,760,070.00

Purchase cost = (bare cost) X material factor X pressure factors

For stainless steel the following data are available| material factor = 2.0

Pressure factors = 10 X 1.1 bar

bare cost 14.7 X 1000 = E14700

= ₦1,764,000.00

:Purhase cost = 1764000 X 2.0 X 10 X 1.1

= ₦38,808,000

Raw material costing

The crude oil costing is based on the current price of S13 per barrel. 400M^3 per hour of crude oil is processed, which is equivalent to 2500 barrels.

Crude oil cost = 2500 X 13 = S32,500/h

= ₦2,370,000/h

= S 780,000/day

= ₦65,520,000/day

Estimated cost for period of four months

One month = 65520000 X 30

= ₦1,965,600,000.00

Four months = 4 X 1965600000

= ₦7,862,400,000.00

Caustic Soda cost

Cost in E/Unit tonne = 350

3.98kg/h is required = 0.00398 tonne

Cost = 0.00398 X 350

= E1.393/h = ₦167.16/h

Escalation (inflation) cost"

Present Cost = 167.16 X (78)
56

= ₦232.8/h

One day = 232.8 X 24

= ₦5,587.92

One month = ₦167,637.6

Four months = ₦670,550.4

Demlsifier Cost

Cost in E/unit kg = 0.55

1.99kg/h is required

: Cost = 1.99 X 0.55 = E1.0945/h

= ₦131.34/h

Escalation cost (inflation)

Present cost = 131.34 X (78)
56

One day cost = 183 X 24

= ₦4,392.00

One month cost = 4392 X 30

= ₦131,760.00

Four months cost = 4 X 131760

=₦527,040.00

Total raw material cost for four months = cost of crude oil + cost of caustic soda + cost of Demulsifier

= 7862400000 + 670550.4 + 527040.00

= ₦7,863,597,590

Cost of utilities

The utilities is use are mainly process water, electricity, and fuel oil for furnace use.

Process water cost

Process water cost = 60p/t

E1= 100P

27161.6kg/h process water is required

27161.6kg/h = 27.16 tonnes

Cost = 60 X 27.16t

= 1629.696P

= E16.297/h

= ₦1,955.6/h

Escalation cost (inflation)

$$\text{Present cost} = 1955.6 \times \frac{(78)}{56}$$

= ₦2,723.9/h

One day cost = ₦65,374.09

One month cost = ₦1,961,222.7

Four months cost = ₦7,844,891.00

Fuel oil cost

The fuel oil cost was estimated based on the total quantity of heat, Q required to achieve the desalting (i.e 108877.27MJ/h)

fuel oil cost = 1.2P/MJ

E1 = 100P

Fuel oil cost = 108877.27 X 1.2

= 130652.7P

= E1,306.52/h

= ₦156,783.27/h

Escalation cost (inflation)

Present cost = 156783.27 X $\frac{(78)}{56}$

= ₦218376.7/h

One day cost = ₦5,241,040.873

One month cost = ₦157,231,226.2

Four months cost = ₦628,924.904.8

<u>Cost of Electricity</u>

Electricity cost = 1.2P/MJ

E1 = 100P

Electricity cost = 1848.4 X 1.2

= 1248.48P

= E1.248

= ₦148.8/h

Escalation cost = (inflation)

Present cost = 148.8 X $\frac{(78)}{56}$

= ₦208.67/h

One day cost = ₦5,008.19

One month cost = ₦150,245.65

Four months cost = ₦600,982.60

Total utilities cost over the four month period = process water cost + fuel oil cost + cost of electricity

= 7,844,891 + 628,924,904.8 + 600, 982.60

= ₦637,370,778.40

4.7 SAFETY AND HAZARDS

The attendants of electrical desalting plants have to deal with equipment in which a high voltage of electric current is maintained. ~~This creates an increased hazard is maintained~~. This creates an increased hazard of these plants. The top platform on the electrical desalters accomodating the transfomers and reactive coils is provided with screen guards. The stair case providing access on to the electrical desalter has a blocking device that switches off the main power supply circuit when the stair case doors are opened. Each of these units outfitted with a device for switching off the voltage when the petroleum level in the desalter drops.

The equipment installed on the top plant form and inside an electrical desalter may be repaired only after the power supply circuit has been switched off and the premises housing the desalters (if they are installed in a building) have been thoroughly ventilated.

If fire breaks out on the electrical equipment, the current must be swtched off immediately.

CHAPTER FIVE

5.0 DISCUSSION OF RESULTS

The main purpose of this study work is to evaluate the performance of a crude oil desalter in order to come up with best ways out in ensuring high efficiency of the desalter inview of the the importance of the desalting process.

From the efficiency of the desalter determined over a period of one month, the lowest efficiency of 15.66% was recorded in day 13 while the highest efficiency of 90.32% was recorded in day 8. The average effieciency over the one month period was 65.69%. The design efficiency was 95%, thus the average efficiency of 65.69% over the period is for below the design efficiency.

The low efficiency often encountered is attributed to anomalies in the performance factors whih include: Process water (both interms of quantity and quality), mixing and mixing valve pressure, electrical field, residence time and interface level, temperature and its relation with pressure, desalting chemical and caustic soda.

Under the equipment design, a crude oil electrical desalter model 23r-160 with one inlet for the feed and two outlets for the desalted crude and effluent was designed. From the material balance carried out based on one day data the mass flow-rate (inlet) was 339520kg/h and volumetric flow-rate of400m3/h.Also the flow-rate of process water (27161.61hg/h), caustic soda (3.98kg/h), and demulsifier (1.99kg/h) required were determined. The outlet flow-rates, tops was found to be 311241.79kg/h (366.68m^3/h) and that of bottoms is 2827. 208kg/h (33.31M^3/h). The total quantity of heat required to achieve the separation was determined to be 108877.2736 MJ/h. The outlet heat quantity (tops) is 57622.2 MJ/h, and the outlet heat quantity (bottoms) is 47456.37MJ/h. The heat loss is 3798.68MJ/h.

The equipment sizing was done with the minimum vessel wall thickness as 23mm, external diameter as 3446mm, desalter length as 14700mm, and optimum pipe diameters as follows: 230mm pipe (inlet), 220mm pipe (outlet, tops) and 60mm (outlet, bottoms). The length of desalter found to be 14700mm is lower than the deslater length of 15,200mm of the case study.

The cost analysis carried out was based on the main equipment cost (desalter), raw materials required, and the utilities required. The main equipment cost was found to be ₦5,268,100.00. The total raw material cost over a projected four month period is ₦7,863,597,590.00. The total utilities cost estimate over four month period is ₦637,370,778.40.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

From all results arrived at, its clear that the only way out to achieving high efficiency in the desalting process is to ensure that all the performance factors are in order.

Summing up from the findings, a good desalting process will result in convenience and also economic apart from operational gains in the following ways: increase in the capacity of the distillation plants; decrease in the maintenance cost; decrease in corrosion; decrease in the consumption of chemical substances; Improvement of the feeds directed towards the secondary plants (catalytic) following the elimination from the feed materials of the salts of heavy metals (vamadium, nickel, iron, lead, etc) and of the chlorides that can be harmful to catalysts; and increase in the capacity of the crude tanks and the elimination of the sludge deposited on their bottom.

6.2 RECOMMENDATION

From the observation made so far in this work, it is necessary to make the following recommendations:

1. To ensure high desalter efficiency all performance factors must be in order.
2. For very high desalter efficiency, double desalting process in which two desalters are used in series is advocated.
3. The desalter must operate completely under liquid atmosphere.
4. The desalter must be well insulated to reduce the heat loss to the surrounding.

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APPENDIXES

CDU-1 PROCESS FLOWSHEET

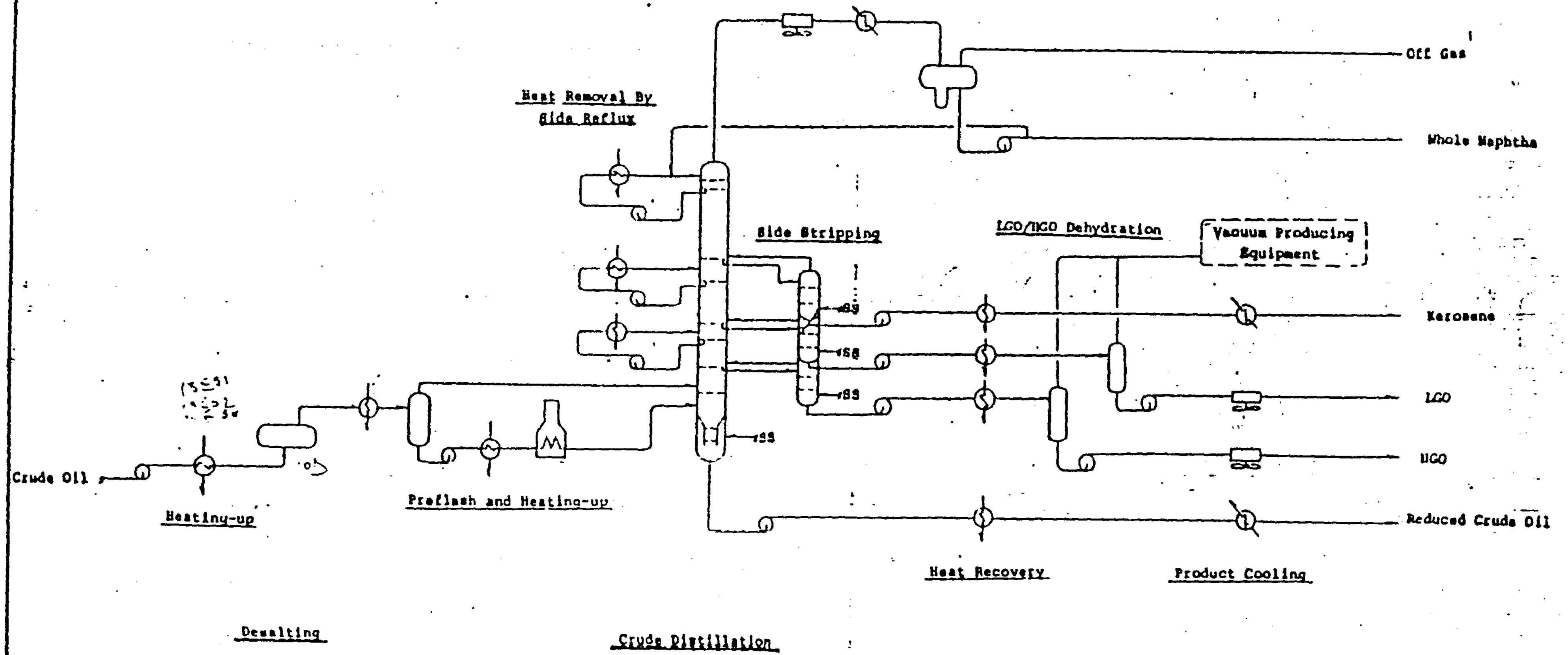
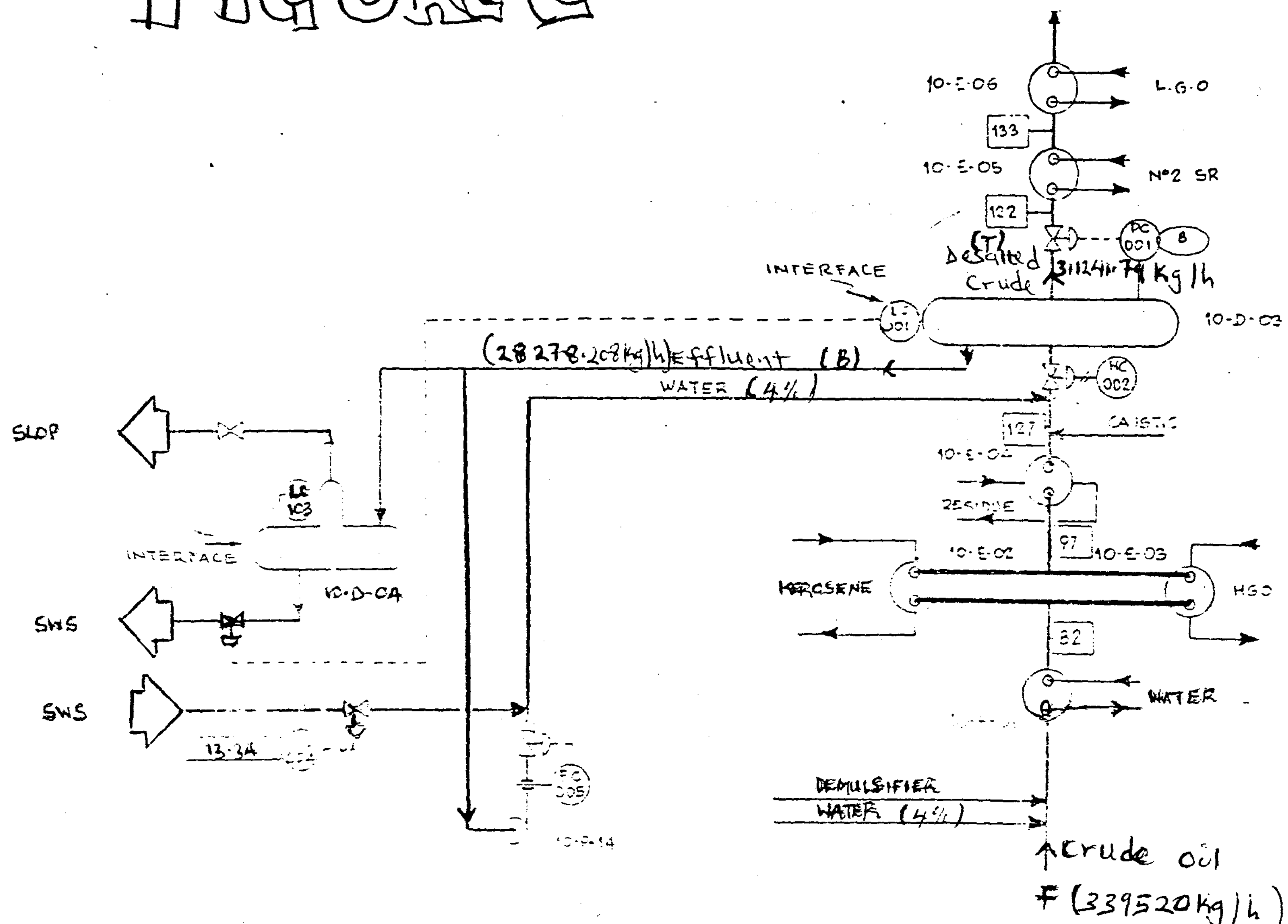


FIGURE 3

FIGURE C



- CONTROL OF CRUDE WASHING (DESALTER)

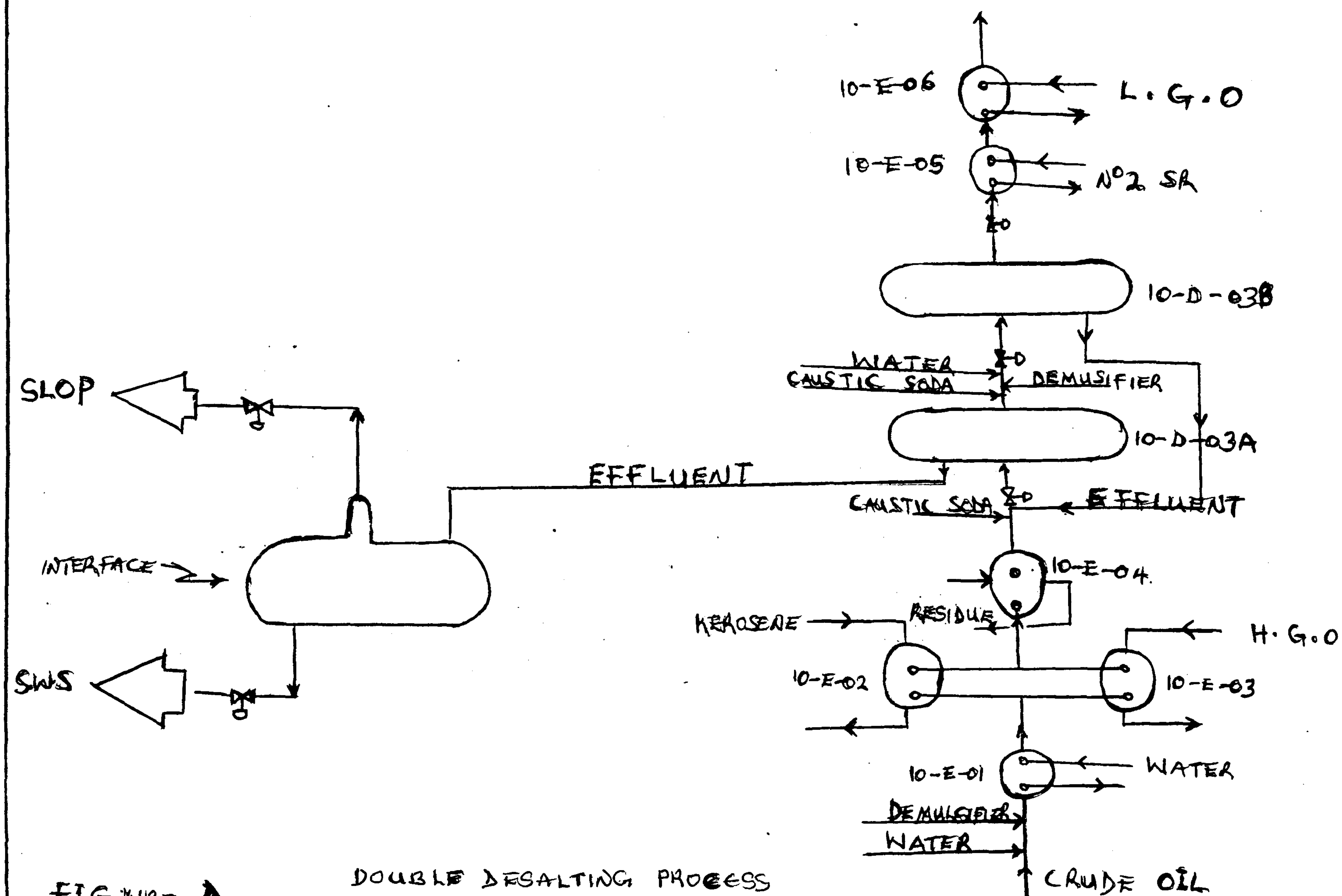


FIGURE 4 DOUBLE DESALTING PROCESS