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Recovery of Flare Gas

At the level of the field BEN KAHLA

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Dedication

Five years of hard work and vigil, we conclude it with lines, even if there are too many, they will not tell what we have experienced of joy, sadness, fear ..., Thank God who has evangelized us with his mercy, kindness and Grace.

To the one who got tired of it, and endured the harshness of life for our sake, to the one who told me one day you will not be naughty as long as you are alive to my support, my strength and my dependence, my dear father "**Belkacem**"

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Dedication

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"Saliha"

Nomenclature

HBK	Haoud Berkaoui
E&P	Exploration-production
TRC	Pipeline transport
LQC	Liquefaction and separation
PRC	Refining and Petro chemistry
COM	Marketing
CFPA	Compagnie Française du Pétrole algérienne
GLA	Guellala
BKH	Ben Kahla
DRT	Draa tamra
LPG	Liquefied petroleum gas
BP	Pressure base
UTG	Gas unit
HP	High pressure
MP	Medium pressure
DCS	Distributed control system
RGA	Recovery of the associated gases
CET	Commonwealth of Independent States
CP	Production center
CPI	International project coordination committee
AG	associated gases
BDV	Blow down Valve
PVC	Pressure regulating valves
ESD	emergency shutdown system

LSHH	Very high liquid level
LSLL	Very low liquid level
TSHH	Very high temperature of the heater
TSSL	Very low temperature of the heater

List of tables

Table	Title	page
Chapter IV: Calculation and simulation part		
IV.01	Gas input composition	37
IV.02	Equipment designations	38
IV.03	Gas input feed data coming from the pretreatment process	39
IV.04	Existing compressor performance DATA	39
IV.05	“TO FLARE” Gas DATA as per simulation	39
IV.06	TO GALLELA Shipping gas DATA as per simulation	40
IV.07	Gas input feed data coming from the pretreatment process	40
IV.08	The new compressor with higher capacities DATA as per simulation	40
IV.09	Gas shipping DATA in the 1 st proposed solution as per simulation	41
IV.10	The first new added compressor data as per aspen HYSYS simulation	41
IV.11	The second new added compressor data as per aspen HYSYS simulation	41
IV.12	Gas shipping DATA in the 2 nd proposed solution as per simulation	42
IV.13	Approximate CAPEX and OPEX of the first proposed solution (1 compressor replacing the old one with greater capacities)	42
IV.14	Approximate CAPEX and OPEX of the 2 nd proposed solution (Adding two new compressors and working together)	43

List of Figures

Figure	Title	page
Chapter I: Presentation of the HBK regional directorate		
I.01	the organizational chart of Regional Directorate HBK	04
I.02	geographical situation of Haoud Berkaoui	05
I.03	Separation	08
I.04	Gas boosting unit	09
I.05	Deoiling unit	10
I.06	Water injection unit	12
I.07	Shipping unit	13
I.08	Air instrument / service unit	14
Chapter II: Flare Gas		
II.09	Troch system	21
II.10	Conventional spring valves	26
Chapter III: General information about compressors		
III.11	Dynamic compressors	29
III.12	Positive displacement compressors	30
III.13	The centrifugal compressor in elements separates	31
III.14	Construction of the centrifugal compressor	33
III.15	General structure of the HYSYS	35
Chapter IV: Calculation and simulation part		
IV.16	PFD diagram of the existing compression train	39
IV.17	PFD for the first compressor alternative	40
IV.18	PFD for adding a new compressor with the old one	41

Table of Contents

Nomenclature	I
List of tables	III
List of Figures	IV
Table of Contents	V
General Introduction	01

Title	Page
Chapter I: Presentation of the HBK regional directorate	
Introduction	02
I. Presentation of the study area	02
I.1- Presentation of Sonatrach	02
I.2- Presentation of Haoud Berkaoui region	03
I.3- Geographical situation	05
II. Main fields	06
II.1- Haoud Berkaoui field	06
II.2- Guellala field	06
II.3- Benkahla field	06
III. History of the HBK regional directorate	07
IV. Production of the regional HBK	07
V. Description of the Benkahla production center	08
V.1- Separation unit	08
V.2- Gas boosting unit	09
V.3- Deoiling unit	10
V.4- Water injection unit	11
V.5- Shipping units	13
V.6- Air instrument/service unit	14
Chapter II: Flare Gas	
I. Generality	16
I.1- Definition of torching	16
I.2- Purpose of the torch system	16
I.3- The gases present in the atmosphere come from various sources	16
II. Types of flaring	17

II.1-	Continuous flaring	17
II.2-	Operational flaring	17
II.3-	Shutdown and start-up flaring of production units	17
III. Reasons for flaring		18
IV.	Economic and environmental impact of flaring	18
IV.1-	Impact of flared gases on the economy	18
IV.2-	Impact of flared gases on the environment	19
IV.3-	Pollutants resulting from the combustion reaction in flares	19
IV.4-	Greenhouse effect	20
V. Description of the torch system		21
VI.	Types of flare systems	22
VI.1-	Sonic flare stack	23
VI.2-	Cold flare stack or vents	23
VI.3-	Low flare stack with combustion chamber	23
VI.4-	Conventional flare stack	23
VII.	Operation of the torches	24
VIII.	Operation parameter	25
IX.	Equipment safety system	25
IX.1-	PVC pressure regulating valves	25
IX.2-	BDW (Blow Down Valves) decompression valves	26
IX.3-	The safety valves	26
X.	CP/GLA torch system and its source	27
X.1-	HP high-pressure torch	27
X.2-	Boosting decompression torch	27

Chapter III: General information about compressors

I.	General information about compressors	29
1.1-	Different types of compressors	29
1.1.1-	Dynamic compressors	29
1.1.2-	Positive displacement compressors	30
1.2-	Areas of application and criteria for choosing compressors	30
	Centrifugal compressors	31
1.1-	Definition of centrifugal compressor	31
1.2-	Features of centrifugal compressor	32
1.3-	Design of centrifugal compressor	32

1.4-	Operation of centrifugal compressor	33
1.5-	Field of use of centrifugal compressor	34
III.	Description of the HYSYS simulator	34
III.1-	the basic operating concepts of HYSYS	35
III.2-	General structure of the HYSYS	35
Chapter IV: Calculation and simulation part		
I.	Problematic	37
II.	Process simulation	37
III.	Comparison of compressor performance by aspen HYSYS	39
IV.	Economic study/comparison between the two proposed Alternatives	42
General conclusion		45
Bibliographic references		
Annex		

General

Introduction

General Introduction

Flare gas, a natural byproduct of oil and gas production, is a valuable resource that is often wasted through flaring, or burning, at the wellhead. This practice not only releases harmful greenhouse gases into the atmosphere, contributing to climate change, but also represents a significant loss of energy potential. However, with the advancement of technology and the growing importance of environmental sustainability, the recovery of flare gas has become an increasingly important priority for the oil and gas industry. Flare gas recovery involves the capture and utilization of this previously wasted resource, transforming it into a valuable commodity that can be used to generate electricity, power production operations, or even be sold as a natural gas product. This process not only reduces greenhouse gas emissions and minimizes waste, but also provides a new revenue stream for operators and helps to meet growing global energy demands.

The recovery of flare gas is a crucial step towards reducing the environmental impact of oil and gas operations, and it has become an increasingly important goal for many operators and regulators around the world. In the United States, for example, the Environmental Protection Agency (EPA) has established regulations to reduce flare gas emissions from oil and gas operations, while in Europe; the European Union's methane strategy aims to reduce methane emissions from the oil and gas sector by 50% by 2030. In addition to environmental benefits, flare gas recovery also offers economic advantages. By capturing and utilizing flare gas, operators can generate additional revenue streams, reduce waste, and improve the overall efficiency of their operations. Furthermore, flare gas recovery can help to meet growing global energy demands, while also reducing the need for new, more expensive energy sources. Despite the benefits of flare gas recovery, there are still several challenges that must be addressed. These include the need for significant investment in infrastructure and technology, as well as the requirement for specialized expertise and resources.

Additionally, the variability and unpredictability of flare gas flows can make it difficult to design and operate effective recovery systems. By exploring solutions for flare gas recovery, this document's presentation aims to provide a comprehensive overview of this important topic, and to inspire further innovation and progress in the oil and gas industry's efforts to reduce waste, improve efficiency, and minimize environmental impact.

Chapter I

Presentation of the HBK regional directorate

Introduction:

One of Algeria's most promising natural resource-rich areas, particularly in terms of energy resources, is the south, which is distinguished by an abundance of hydrocarbons, such as natural gas and oil.

HAOUD BREAKOUI is one of Algeria's most important petroleum producing locations. Because of its enormous natural gas and oil reserves, Algeria's economy depends heavily on the HBK.

These petroleum resources are vital source of cash for the nation and make a substantial contribution to its economic growth.

I. Presentation of the study area:**I.1. Presentation of Sonatrach:**

Sonatrach (acronym for "National Company for the Research, Production, Transport, Processing, and Marketing of Hydrocarbons") it is considered one of the largest energy companies in the world and the foremost in the African continent.

Created on December 31, 1963. It is a major player in the oil industry the operational structures of the SONNATRACH are organized around the following activities:

- Exploration-Production (E&P)
- Pipeline transport (TRC)
- Liquefaction and Separation (LQS)
- Refining and Petro chemistry (PRC)
- Marketing (COM)

The national company's work (SONATRACH) aims to strengthen social ties assist needy population, enhance research and scientific activities, contribute to nature conservation, and maximize the long-term value of hydrocarbon resource in Algeria. It is also aims to meet Algeria's current and future needs for fuels and petroleum products.[1]

I.2. Presentation of HAoud BERKAOUi (HBK) region:

The Haoud Berkaoui Regional Directorate is one of the ten main hydrocarbon production areas in the Algerian Sahara and is part of the Production Division of the Exploration-Production (E&P) activity of Sonatrach.

The nine (09) divisions that make up the regional management of HBK each include a certain number of services. Until 1976, when it became independent, Hassi Messaoud supervised the Haoud Berkaoui region. In March 1965, the deposit was discovered by the CFPA (Compagnie Française du PétrolAlgerian) with the fodder (OK 101) located at the top of the building.

This refinery was commissioned in January 1967, with reserves of 136.4 million cm³ of oil. The Haoud Berkaoui region consists of three main fields:

- Haoud Berkaoui "HBK"
- Guellala Field "GLA"
- Field of ben Kahla "BKH"

One of the ten (six) main regions in the Algerian Sahara that produces hydrocarbons is the Haoud-Berkaoui region. Three oil treatment centers, two satellite DRT and GLA NE centers, and a gas treatment unit are currently operational. Every production center receives raw material from various sources, stabilizes it, and stores it in barrels before shipping it to TRC.

The recovered gas is compressed and sent to Guellala gas treatment plant (UTG/GLA), which also supplies LPG, vented gas and gas lift.[2]

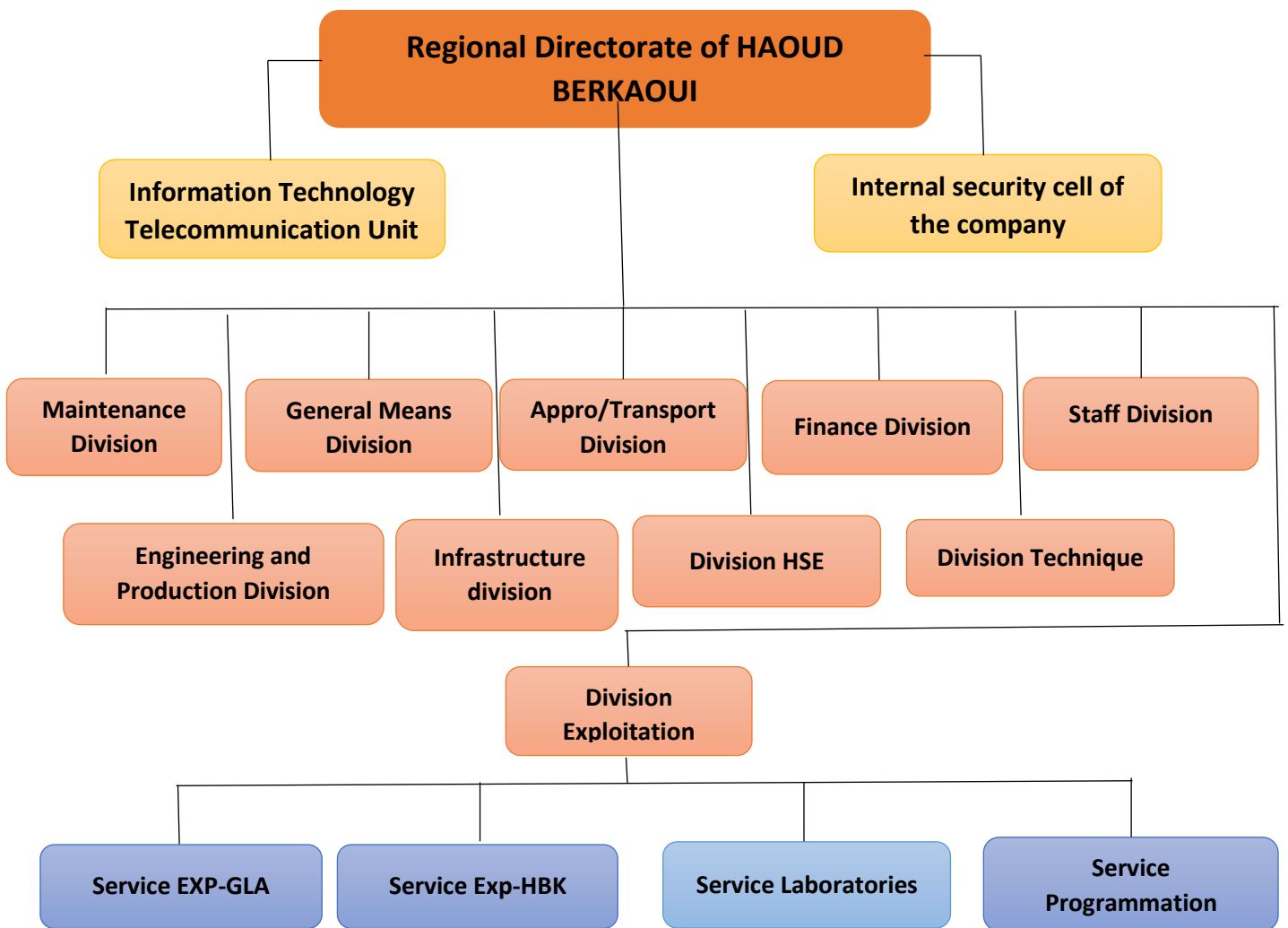


Figure I.01: the organizational chart of Regional Directorate of Haoud Berkaoui[3]

I.3. Geographical situation:

On the RN° 49 so-called tanker road linking Ghardaïa to Hassi Messaoud, and 35km southwest of Ouargla, a crossroads indicates the presence of an oil field; it is the region of HAUD BERKAOUI.

This region is located 142Km from HASSI Messaoud, 770Km south of the Capital (ALGIERS), it is important because of its share of production of the country's hydrocarbons. It extends from the south-east of Ghardaïa to the extreme field of Bukhzana, near the Touggourt[1]



FigureI.02:geographical situation of Haoud Berkaoui

II. main fields:[4]**II.1. Haoud Berkaoui field (HBK):**

This field, which covers an area of 175km^2 , was discovered in 1965 and began to be cultivated in January 1967. The production of the HBK center is composed of:

- An oil separation unit with a capacity of $8000\text{ m}^3/\text{day}$.
- A storage capacity of $13,000\text{ m}^3/\text{day}$.
- A gas pump with a capacity of one million m^3/day .

The gas pressure improvement units (BP), the gas unit (U.T.G) in GUELLELA the gas (HP, MP, BP) is extracted from the lines of the torches already in place.

- Water injection station with a capacity of $6000\text{ m}^3/\text{day}$.
- Oil removal unit of the station.

II.2. GUELLALA Field (GLA):

Discovered in 1969, the GLA field extends over an area of 35 km^2 and consists of:

- Oil separation unit with a capacity of $5000\text{ m}^3/\text{day}$.
- Storage unit of $15000\text{ m}^3/\text{day}$.
- Gas boosting unit of $762,000\text{ m}^3/\text{day}$.

This station is also equipped with a gas treatment unit of approximately $2.4\text{ million m}^3/\text{day}$, its recovery capacity is estimated at $500\text{ tons}/\text{day}$ for LPG and $90\text{ tons}/\text{day}$ for condense.

This treatment unit contains a gas compression station at 75 bars with a capacity of $1.66\text{ million m}^3/\text{day}$ of which $65,000\text{ m}^3/\text{day}$ are compressed at 140 bars for lift gases from wells in the region, the remaining volumes being shipped to HASSI R'MEL to which $429,000\text{ tons}$ of LPG are added.

II.3. BENKAHLA Field (BKH):

Created in 1966, and covers an area of 72 km^2 . It has been put into production in 1967 and it consists of:

- An oil separation unit of $5000\text{ m}^3/\text{day}$.
- Gas station with a capacity of $0.59\text{ million m}^3/\text{day}$.
- The deoiling station is unified.
- Water injection equipment.

The entire oil production of BKH is sent to the HBK production center by the shipping unit.

III. History of the HBK Regional Directorate:

Important changes in the development of the region:

- **January 1965:** Discovery of the HBK field by the OK101 survey, located at the top of the structure.
- **January 1966:** Discovery of the BKH field by the OKP24 survey.
- **January 1967:** An oil-processing center is put into production in HBK.
- **In 1969:** Discovery of the GLA field by the (GLA 02 survey).
- **January 1971:** Commissioning of the BKH center.
- **In 1976:** Creation of the Haoud - Berkaoui Region.
- **January 1976:** Commissioning of the GLA production center.
- **January 2007:** Extension of associated gas recovery project, DCS installation of Production centers HBK, BKH and GLA.
- **January 2008:** Start of the associated gas recovery project (RGA).
- **January 2008:** Commissioning of a technical landfill center (CET) for the Treatment of household waste.
- **January 2012:** Realization of a nitrogen storage unit.
- **2016:** Quagmire treatment.

IV. Production of the Regional direction HBK:

Oil is produced in the HAoud BERKAOUI region thanks to natural depletion that is to say thanks to the internal energy of the deposit, which pushes the crude to the surface under strong pressures. A water injection is carried out in the three sectors HBK, BKH and GLA in order to maintain the pressure. For shallow wells, the

Production is ensured thanks to the gas-lift. So far, it has used 120 wells distributed in all fields, including:

- 23 Producing wells without gas-lift (eruptive).
- 61 production wells equipped with a gas lift.
- 15 wells that produce water.
- 21 wells equipped with water injectors.

V. Description of the BENKAHLA Production Center:

The BENKAHLA Production Center mainly consists the following units:

- Separation unit.
- Gas boosting unit.
- Shipping unit.
- Water injection unit.
- Deoiling unit.
- Instrument air unit.

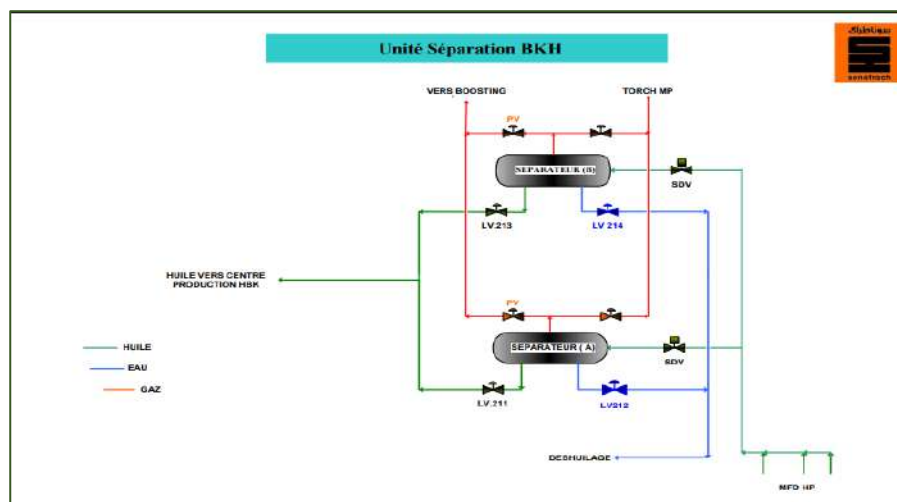
At the entrance of the treatment center, the crude oil from the BENKAHLA field undergoes chemical treatment using a product, which is:

Demulsifier: This product allows for the separation of water suspended within the crude oil.

V.1. Separation unit:

This center processes effluents from the oil-producing wells in the BENKAHLA area. A manifold receives the oil wells and allows the feeding of 02 HP separators (A/B), one in operation and the other on standby, operating at 8 bars with a processing capacity of $150m^3/h$. The gas is sent by pressure control to the compression unit, and the excess gas is sent to the high-pressure torch of the unit.

The water, controlled by a level controller, goes to the deoiling unit, and the oil, controlled by a level controller, is dispatched to the HBK production center via an electric pump.[4]



FigureI.03: Separation [4]

V.2. Gas boosting unit

The station's purpose is to compress the HP gas from the primary separators on-site for shipment to the GUELLALA gas treatment plant. It consists of a single-stage compression section. The HP gas from the separation feeds the centrifugal compressor (K-201) at an absolute pressure of 9 bars and a suction flow rate of **21,000 Nm³/h**. Before entering the compressor, the gas first passes through the suction drum **V-201** to remove any possible liquid fractions. It is then introduced into the compressor to be compressed to a pressure of 29.3 bara.

The compressed gas is then cooled using an air cooler (**E-201**) to a temperature of 60°C and then passes through a drum **V-202** to remove liquid hydrocarbons before being shipped to the Guellala plant. The pipeline that ships the gas to Guellala (30 km long, 12" diameter) is buried and cathodically protected.

The compression station is connected to the Guellala gas treatment plant, allowing Guellala to monitor continuous operating parameters and to perform emergency shutdowns in extreme cases.[5]

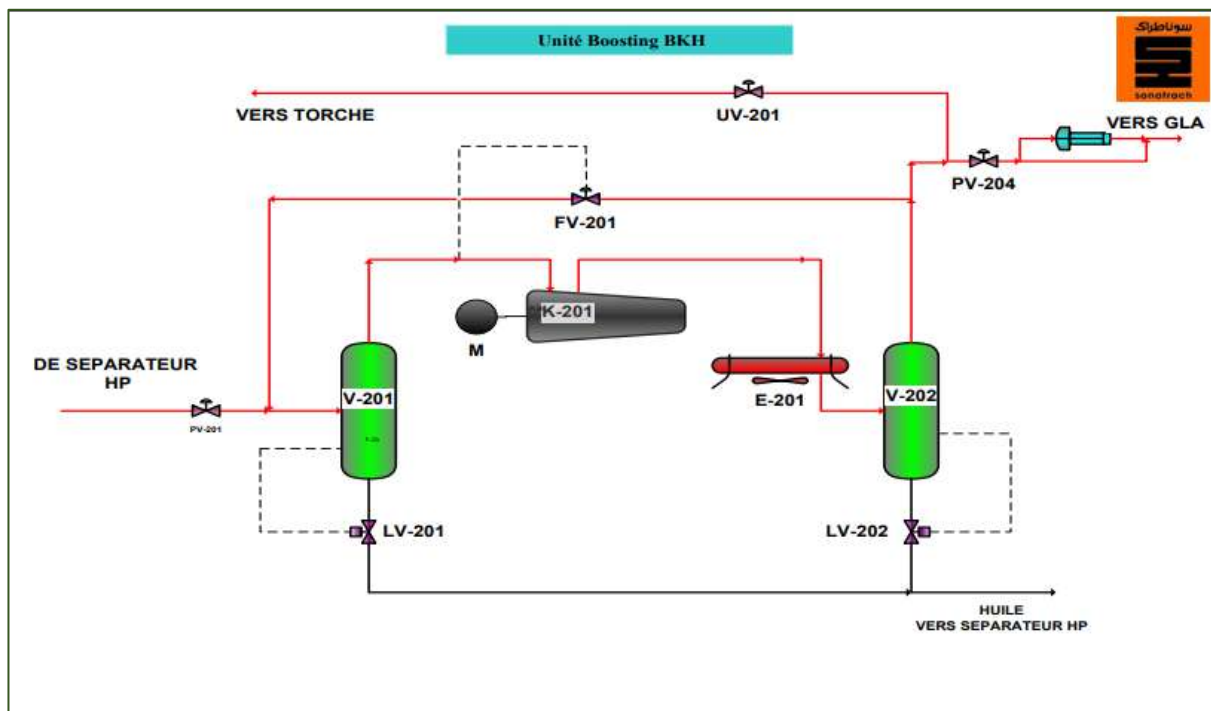


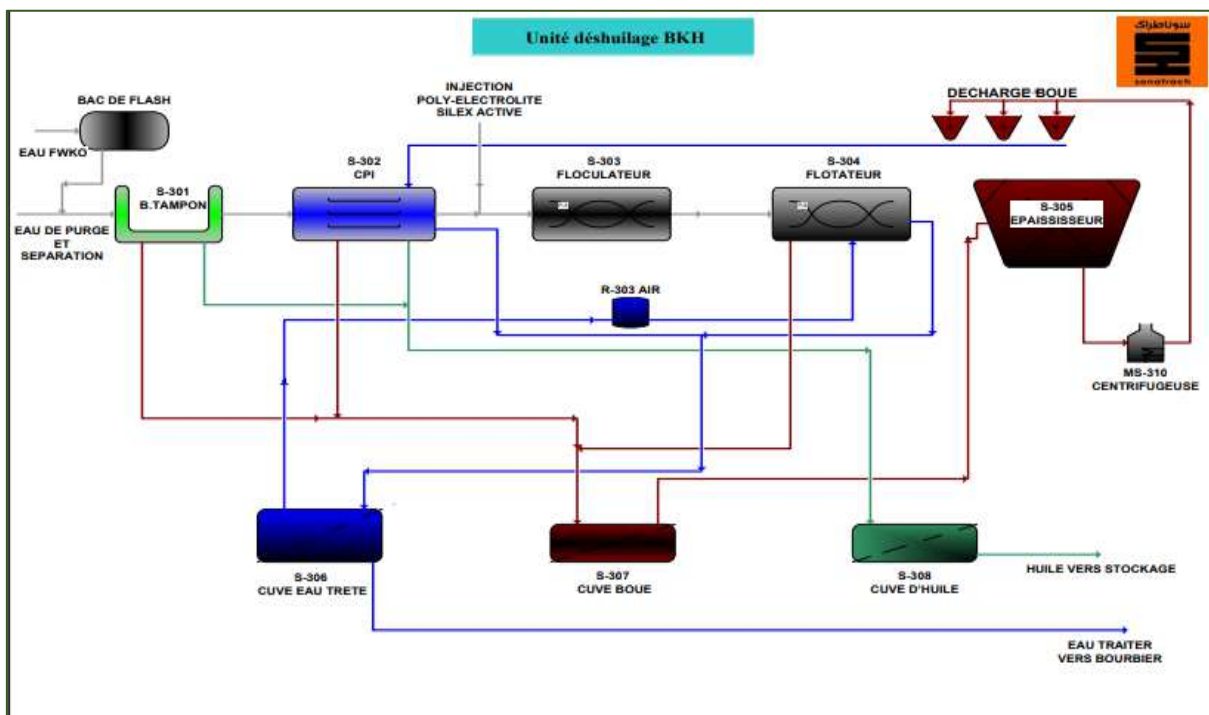
Figure I.04: Gas boosting unit [4]

V.3. Deoiling unit

The water from the various separators at the BKH station arrives at the buffer tank where it will be temporarily stored for the deoiling operation. The water from the buffer tank flows to **CPI (MS-302)** and fills it at a rate of **30m³/h**. The Disc Oil Separators **MS-306** and **MS-307** perform the initial oil recovery, which will be conveyed to the oil storage tank.

The water exiting MS 302 enters the flocculation tank S-303 where two dosing products are injected: the coagulant (polyelectrolyte) and the flocculants (active silica). The flocculated water then enters the floatation unit MS -304

The oil recovery is carried out using a scraper bridge MS-304. The collected water flows to the treated water tank S-307 and is directed towards the sludge pit.[6]



FigureI.05: Deoiling unit [4]

V.4. Water injection unit

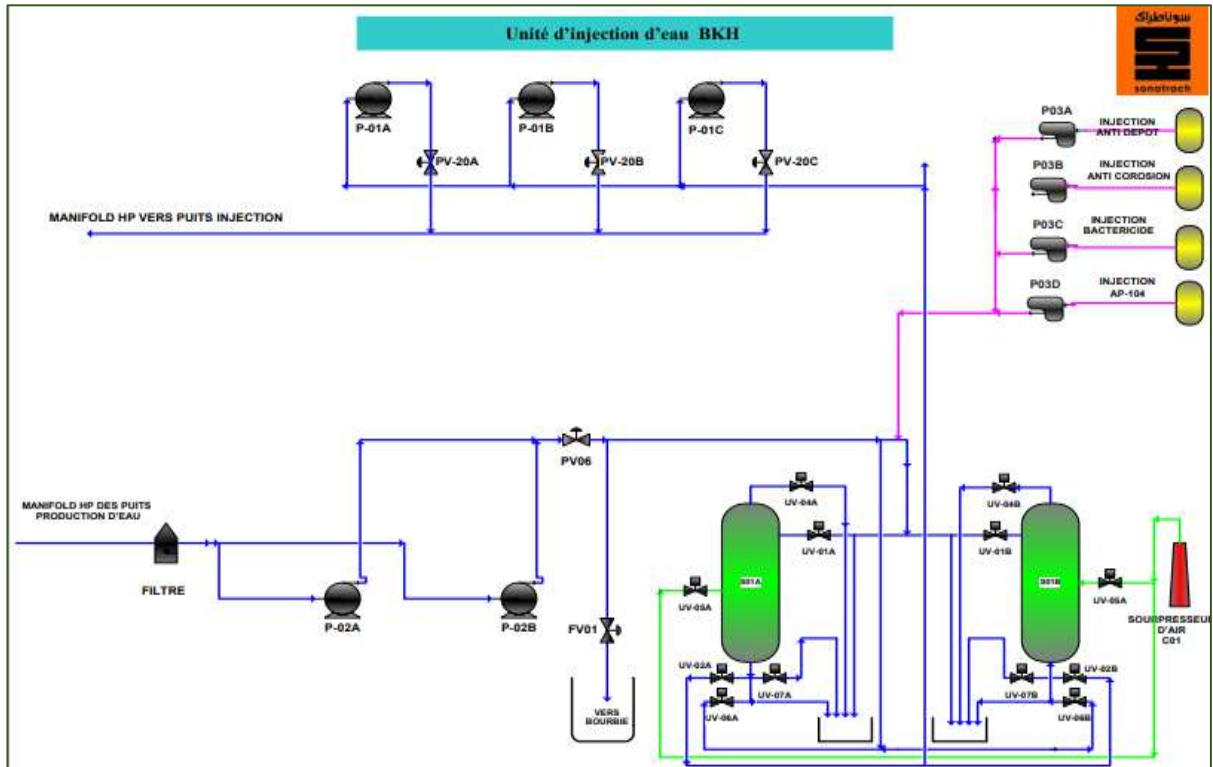
This center also includes a station for maintaining pressure in the BENKHLA field. At the entrance of the station, there are two medium-pressure booster pumps (**P02 A and B**) (one in operation and the other on standby). They are used to provide sufficient pressure for the suction of high-pressure injection pumps after the water be filtered. A regulation valve (FV01), which, under the action of a control and regulation system, ensures a minimum flow rate at the pumps' discharge protects the two medium-pressure pumps.

Furthermore, a regulation valve (PV 06) located at the discharge of these same pumps protects the installations towards filtration by limiting the network pressure. The water then passes through a filtration station, consisting of two dual-layer filters (S01A/B) installed in parallel, which eliminate particles larger than 01 micron. Upstream of this filtration station, the injection of polyelectrolyte facilitates the flocculation of suspended matter in the water before filtration. Downstream of this station, the filtered water receives various additive products such as anti-deposit, bactericide, and corrosion inhibitor based on analyses.

Three high-pressure ensures the pressurization of the filtered water injection pumps (P 01 A/B and C) operating in parallel.

A regulation valve (PV 20A/B and C) located at the discharge of each of these high-pressure pump's limits and regulates the water flow rates and pressure at the station's discharge. The high-pressure water is then directed to a manifold located at the station for distribution to the water injection wellheads.

The filtration station consists of two filters S01 A/B that operate normally in parallel and treat the entire maximum flow rate of the station set at 250m³/h. An automatic timer triggers the filter washing sequence periodically. This washing is performed alternately to avoid stopping operations. At the start of the sequence, the injection flow rate at the station's discharge is reduced to 125m³/h by adjusting the regulation valves PV20 A/B and C located at the discharge of the high-pressure pumps P01A/B and C. [6]

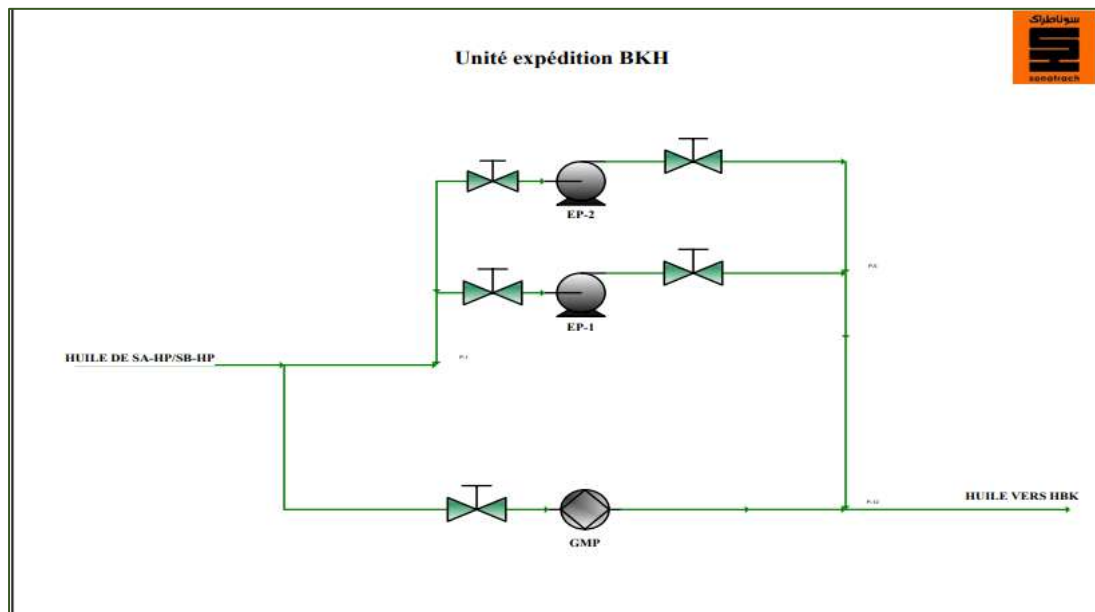


FigureI.06: Water injection unit [4]

V.5.Shipping unit

The oil is dispatched through an 8" manifold to the HBK production center. The pumping system consists of:

- Two electric pump units (EP-1/2)
- One motor pump unit (Emergency Backup) [5]

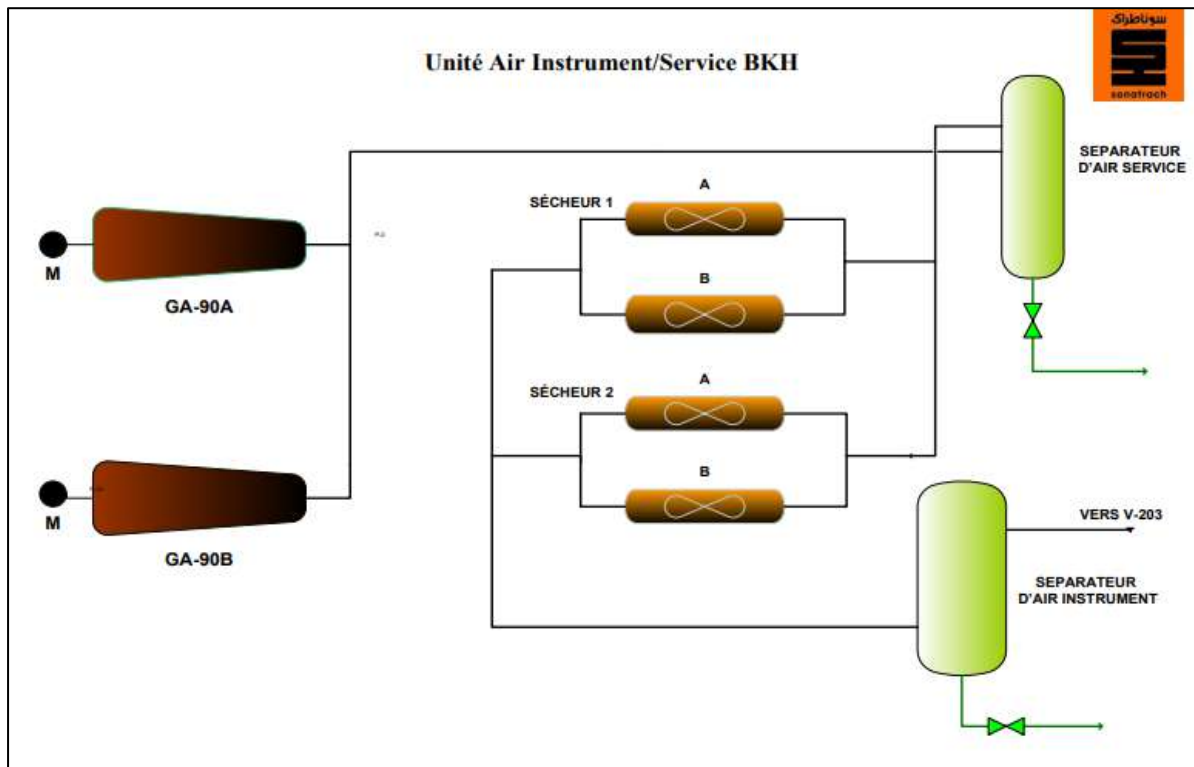


FigureI.07: Shipping unit [4]

V.6. Air Instrument/Service Unit

Air supplied by two reciprocating compressors operating at **8.5 bars** (one in operation and the other on standby). It passes through the service air separator tank, then through the moisture separator tank (air dryer), and is then sent to the instrument air tank.

- Instrument air used to operate pneumatic valves.
- Service air used for cleaning and blowing of equipment, tanks, and vessels.[5]



FigureI.08 : Air Instrument/Service Unit[4]

Chapter II

Flare Gas

I. Generality

I.1. Definition of torching

Flaring, also known as "gas flaring," is the process of burning off gas emissions at various stages of oil and natural gas operations using flares.

The flare safely eliminates steam currents from the facilities by burning them under controlled conditions to avoid any risk to adjacent equipment or personnel, while also complying with environmental regulations to combat pollution and meet public relations requirements.[7]

I.2. purpose of the torch system

To preserve the environment, health, and safety of individuals both inside and outside the site, it is essential to minimize the emissions of toxic, flammable, or explosive substances into the atmosphere. With this goal in mind, flaring systems aim to collect all gas waste:

- When gas compression facilities are temporarily unavailable and to maintain oil production, it is necessary to use gas/oil separators.
- Following an emergency interruption followed by a depression of the facilities.
- Resulting from the intentional decompression of a device.
- Equipment that is kept under gas sweep comes from the gas cap.
- Prevention of intentional decompression of equipment following the opening of one or more safety valves.
- Ensuring equipment safety against hazards.

I.3. the gases present in the atmosphere come from various sources:

Generally, residual gas quantities are burned in the flare in case of odor, health, or safety issues, and if not, they are released into the atmosphere.[8]

The emissions caused by venting and flaring vary depending on various factors:

- The volume of process activity.
- Operating methods.
- On-site utilization possibilities.
- Economic access to markets.
- Local regulations.

II. Types of flaring

Flares and venting circuits exist at all levels of the oil and gas industry and are used to evacuate several types of waste gas: intermittent, continuous and start-up (or shut-down) [9]

II.1. Continuous flaring

Continuous applications may include:

- Evacuation of associated gas and/or steam from pans in oil production facilities, where gas conservation is uneconomic or until its economic benefit has been assessed
- Casing gases in heavy oil wells, process residues or by-product streams that have little or no value, or are uneconomic to recover (e.g., vent gas from glycol dehydrators, sour gas from gas sweetening units and sometimes stabiliser overheads)
- Vent gases from gas-operated devices in which natural gas is used as a supply source (e.g., appliance control loops, chemical injection pumps or samplers).[4]

II.2. Operational flaring

In addition, in the event of a technical problem at an oil installation, it is necessary, for safety reasons, to empty and burn off the gas present in the equipment.

Operational flaring occurs intermittently and the volume burned corresponds to the volume of gas present in the installation at the time of the event. Examples include:

- Evacuation of residual volumes resulting from emergency decompression episodes
- Depressurisation operations initiated or controlled by the plant operator (for example, depressurisation of process installations for inspection or maintenance, or depressurisation of piping for welding purposes);
- Plant or system problems. [10]

II.3. Shutdown and start-up flaring of production units

Finally, flaring is used on a continuous but temporary basis during the start-up of a new installation, or during the programmed shutdown of units; this is shutdown flaring. There is also untimely flaring due to the electrical tripping of installation.

III. Reasons for flaring

When there is no outlet for the gas, flaring is still the safest and most common way of disposing of it. Gas flaring can be justified by:

- Gas associated with oil production in small quantities and of low energy value
Compared with the oil produced, it accounts for most of the gas flared worldwide.
- Substantial investment: insufficient gas recovery and sometimes technical difficulties lead to decisions to flare gas.
- Use of gas for sale to industrial consumers or resellers requires investment in additional, specific treatment infrastructure, transport in compressed (compressors, pipelines) or liquefied form.
- Operation and maintenance of oil installations: Oil production frequently generates often generates associated gas (AG) in addition to liquid oil production, often in small quantities (by mass) compared to the oil a field is often very far away from its production area the gas produced would require heavy investment to be exported, investment to be exported. As it cannot be transported by the same physical by the same physical means as oil, it is generally of no economic interest, which economic interest, which is why it is burnt. It should be noted that natural gas is systematically less valuable than oil. What's more, since gas is around 1000 times less dense than oil, it needs to be compressed or liquefied in order to be transported over long distances, which involves even greater investment.

IV. economic and environmental impact of flaring

Flaring is a waste of non-renewable energy, presents an environmental problem environmental (air pollution, noise, odours, radiation from the flare, greenhouse gas emissions and local air pollution) and that can cause damage in the long or short damage.

The quantity and quality of flared gases are closely linked to a number of factors the type and age of the process infrastructure (i.e., the installations), the characteristics processed or handled, the volume of process activity, and the local regulatory environment.[11]

IV.1. Impact of flared gas on the economy

Flared gases represent a huge loss of money as these gases are burnt off in the atmosphere without being able to be processed and subsequently resold to generate profits.

IV.2. Impact of flared gases on the environment

Atmospheric pollution refers to the presence of contaminants in the air that can lead to considerable discomfort, health issues, and property damage.

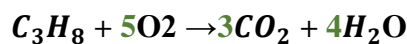
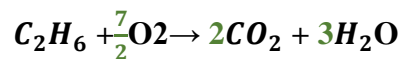
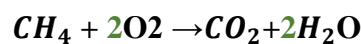
These pollutants may consist of gases, vapors, liquid or solid particles, and even radiation. Furthermore, atmospheric pollution encompasses both chemical and physical alterations to the natural environment, resulting in adverse effects on human health.

IV.3. Pollutants resulting from the combustion reaction in flares

These pollutants can be produced during complete or incomplete combustion.

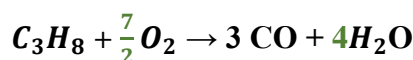
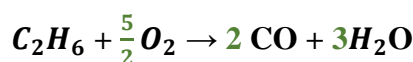
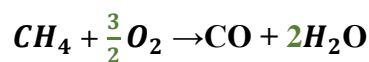
A- Complete combustion:

In theory, the complete combustion of pure hydrocarbons produces only water and carbon dioxide according to the following reactions:



B- Incomplete combustion:

This is the case of flaring during shutdowns and start-ups or during tripping, the gas load will be high, so combustion is incomplete, giving rise to monoxide. The gas load will be high, so combustion is incomplete, giving carbon monoxide (CO) and water vapour (H_2O) as products, and if the gas also contains CO_2 , H_2S or other impurities, this leads to all sorts of harmful compounds.



The effects of incomplete combustion affect both human populations and agriculture (acid rain, heavy metals).

Flaring has an impact on global warming due to emissions of combustion products, which contribute to the increase in greenhouse gas concentrations.

IV.4. Greenhouse effect

The greenhouse effect is a natural phenomenon that contributes to global warming. This process enables the Earth to retain solar heat in the atmosphere and thus maintain a temperature acceptable temperature to support life.

It is present all around the Earth and forms a layer made up of different gases known as greenhouse gases, such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

It's called the "**greenhouse effect**" because the way it works is similar to what happens in a greenhouse, which is used for heating used to grow certain plants: the transparent walls of a greenhouse let in the sun's rays, but they don't let in the heat. The transparent walls of a greenhouse allow the sun's rays to pass through, but the glass slows down the outflow of heat.

When the sun's rays reach the earth:

- Some of it (30%) is reflected directly back into space by the Earth's white or light surfaces (clouds, ice, sandy deserts, etc.).
- The other part (70%) is absorbed by the ground, the oceans and the atmosphere, which allows certain ultraviolet rays to pass through (the most dangerous UV rays are absorbed by ozone), but above all infrared rays, which contain the most heat.

It is this energy that the ground will re-emit in the form of infrared rays. This is where greenhouse gases come into play: they prevent these rays from being lost into space, thereby helping to warm the planet, like the glass in a greenhouse.

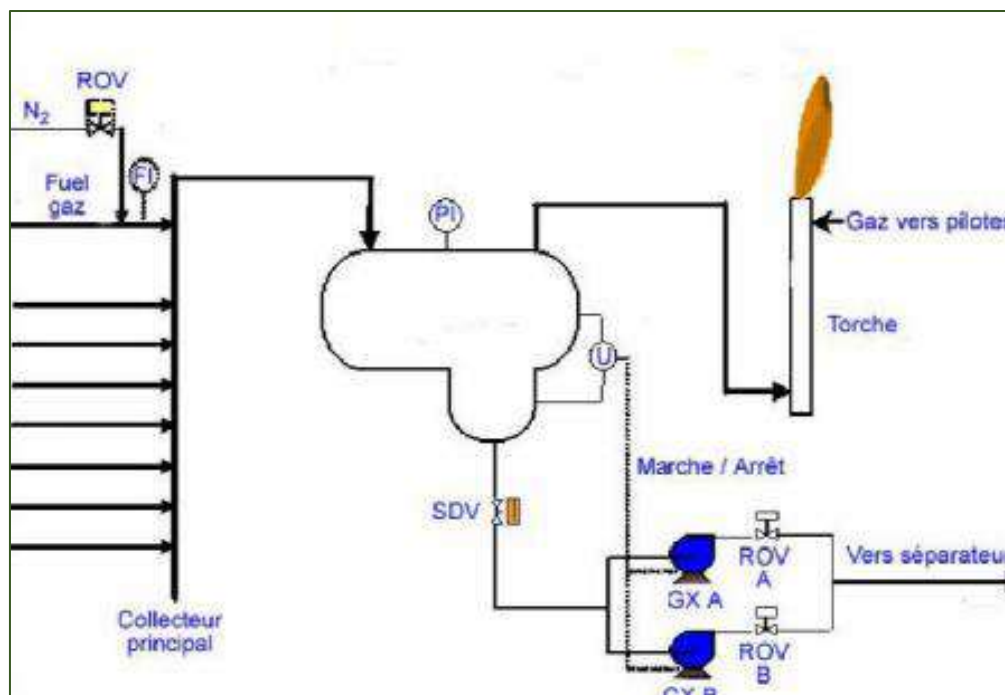
The danger referred to as the greenhouse effect is global warming. What is dangerous is not the phenomenon itself, which is perfectly natural and essential to our existence, but its modification by man.[10]

V. Description of the torch system

The flare stack is the large metal chimney used to burn excess gas at various stages of oil production, above which there is a powerful flame.

The flare system is therefore an essential device in a hydrocarbon processing facility, as it ensures the protection of equipment against excessive pressures that could cause them to explode. The purpose of this system is to:

- The gas and condensates are separated in vessels, and then the gas is sent to the flare to be burned.
- To maintain the equipment within the limits of their operating pressure in the event of depressurization or valve opening, it is essential to safely collect all gas discharges from the process. [7]



FigureII.09: torch system [4]

The torch system is composed of several sections:

- A collection network which consists of a set of lines connecting the protection members (valves, on-off valves or nothing) to the torch balloon;
- A set of depressurization devices (safety valves, rupture discs pressure relief valves BDV "Blow Down Valve", automatic pressure control valves)

- A main collection network and secondary collectors: A separator tank for the different phases (water, liquid and gaseous hydrocarbons), located at the foot of the torch in order to prevent the accumulation of liquid at the foot of the torch barrel which could obstruct the passage of the gas, to minimize the risk of liquid combustion at the nose of the torch, and to recover the recoverable fractions entrained towards the torch;
- A torch barrel, at the top of which a torch nose is placed, it is the last element of the system, it is used to burn the gas without liquid;
- In the case of a lit torch, a pilot gas network is installed to supply permanently the pilots placed near the torch nose, and an ignition system for these pilots;
- A sealing device to prevent air from entering the system. There are two types of systems: Hydraulic guards and gas guards. [4]

VI. Types of flare systems

The quantity and type of flare systems depend on several factors, such as the process scheme, the characteristics of the products involved, and safety criteria (radiation and dispersion). In addition to these main factors, other criteria include:[4]

- ✓ Varying pressure levels that could lead to excessive backpressure in the collectors: it is necessary to avoid collecting high-pressure products in a system that can also receive low-pressure products simultaneously.
- ✓ Nature of the products involved: mixing wet or out-of-spec dry products with cold products should be avoided to prevent hydrate formation that could block the flare system.
- ✓ Corrosiveness of different gases.

Typically, the type of flare stack indicates the type of flare. Various types include:

1. Sonic flare stack
2. Cold flare stack or vents
3. Low flare stack with combustion chamber
4. Conventional flare stack

VI.1. Sonic flare stack:

The gas velocity is at least Mach 1, characterized by a low emissivity coefficient, which improves combustion and gives a clear flame.

The backpressure for the nominal flow rate can reach from 4 to 10 bar (normally: 4 to 5 bar) when properly calculated; because of this back pressure, the upstream equipment can be of a smaller size due to the volume of gas. [12]

VI.2. Cold flare stack or vents

The gas velocity is at least Mach 1, characterized by a low emissivity coefficient, which improves combustion and gives a clear flame.

The backpressure for the nominal flow rate can reach from four to 10 bar (normally: 4 to 5 bar) when properly calculated; because of this back pressure, the upstream equipment can be of a smaller size due to the volume of gas. [12]

VI.3. Low flare stack with combustion chamber

This type of torch consists of a chimney in which a forced draft burner is installed, these torches are installed on the ground when environmental regulations do not allow having a visible flame or when there is no room to install another type of torch. [4]

VI.4. Conventional flare stack

The conventional drum is always installed vertically and the gas velocity is limited to Mach 0.5 / 0.6 for discontinuous flow rates (emergency stop) and Mach 0.3 for a flow rate continuous. [4]

The drum must be able to operate in all atmospheric conditions and must have a reliable ignition system. A specially designed flame-retaining ring installed in the torch tube ensures the stabilization of the flame; this equipment stabilizes the flame front by creating vortices that avoid blowing the flame.

There are several types of conventional barrels:

- ✓ Conventional forced draft drums for high flow rates, equipped with an air fan;
- ✓ Conventional drums with water or steam injection to reduce radiation and smoke emissions.

VII. Operation of the torches

The torch function is a safety function: the torch system protects the equipment against pressure surges that may cause them to explode. By elsewhere, the torch system makes it possible to recover the "fatal" gases and to release them into the atmosphere.

Each flask, column or capacity operating under hydrocarbon pressure is connected to the torch network by means of one or more valves and/or various pressure regulating valves PCV and decompression valves BDV.

Under normal conditions of the installation, the quantity of gas sent to the torch is minimal and represents only the incondensable fraction of the hydrocarbons treated with a fraction of the fuel gas to ensure a regular flow.

An injection of scavenging gas or purging gas is carried out continuously to maintain a safe flow rate to the torch by keeping the flame of the burners lit and thus preventing the air from returning.

In the event of a malfunction of a part of the installation; mainly an overpressure in a capacity, the pressure regulating valve opens to send more gas to the torch

If the overpressure is too fast and/or uncontrolled, the safety valves of the equipment open to protect the capacity.

In the event of a more serious incident or an emergency shutdown of the installation, the safety system triggers the opening of the decompression valves (BDV).

To permanently ensure the proper functioning of the torch system, a certain number of control and safety organs are installed, in particular:

- A gas network for sweeping the torch collectors;
- A pilot gas network that maintains a flame at the torch nose in the case of permanently lit torches.
- Two or more drivers depending on the diameter of the installation;
- A remote ignition system for the pilots;
- A nitrogen network connectable to the torch collectors for the inserting of the system
- when making it available for work or in the case of cold torches;
- Surveillance cameras to control the presence and condition of the flame [4]

VIII. Operating parameter

The torch system is the first process system that must be started before the installations are put into oil (or gas).[4]

- ✓ The operating parameters that must be monitored during normal operation are:
- ✓ The sufficient flow rate of the scavenging gas;
- ✓ The gas flow and the air flow sent to the pilots;
- ✓ The pressure of the torch balloon;
- ✓ The level of the torch tank connected to the start and stop of the recovery pumps;
- ✓ The temperature of the liquid in the torch flask if it is equipped with a pin of reheating;
- ✓ The proper functioning of the pumps for taking up the bottom of the torch flask if it is equipped with them. A weekly test is carried out on the emergency pump. These pumps operate on all or nothing between an LSH (starts the selected pump) and an LSL (stops the pump):
- ✓ The torch balloon is equipped with a certain number of safety members, which are connected to the general system for triggering the installation:
- ✓ Very high liquid level LSHH;
- ✓ Very low LSL liquid level (inhibits the start-up of the recovery pumps)
- ✓ Very high temperature of the TSHH heater;
- ✓ Very low temperature of the TSLH heater [4]

IX. Equipment safety system

IX.1. PCV pressure regulating valves:

These process control valves, operated by an electronic, pneumatic, or hydraulic system, allow the continuous or intermittent passage of excess fluid to the torch, primarily during transitional phases such as startup or programmed shutdown.

The Blow down Valves (BDV) are on-off valves that connect process equipment to torch headers. They are remotely activated by the operator or automatically triggered by the Emergency Shutdown System (ESD).[12]

IX.2. BDV (Blow Down Valve) decompression Valves:

These are valves with either full or zero opening, which establish the connection between the process equipment and the torch headers. Their activation can be performed remotely by the operator or automatically via the Emergency Shutdown System (ESD).[4]

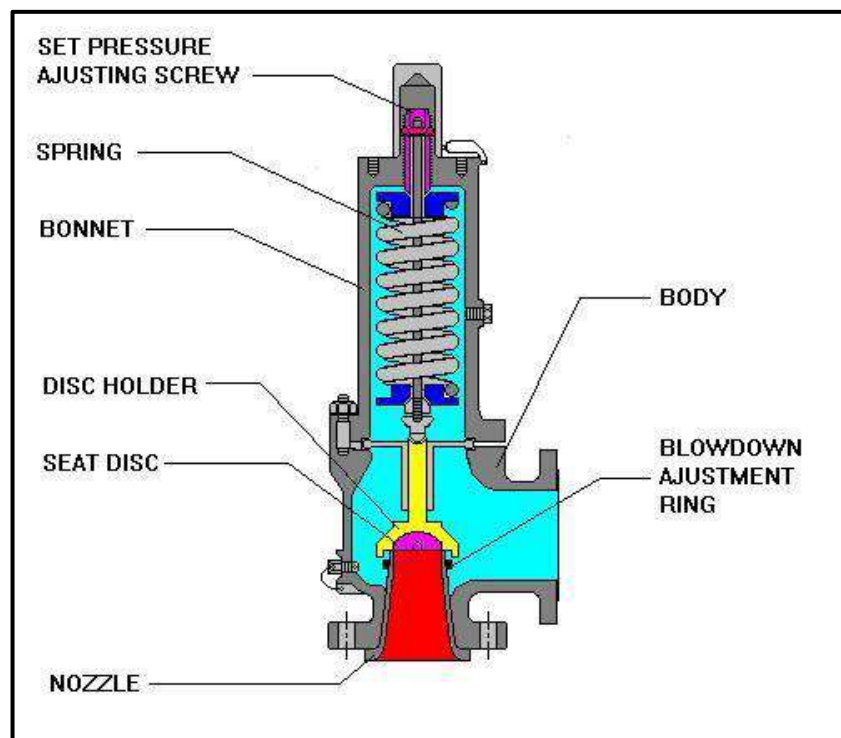
IX.3. The safety valves:

A safety valve is a safety device designed to protect vessels against overpressure or under pressure. Its operation should be exceptional, and its normal position remains closed.

Industrial vessels are characterized by a maximum operating pressure that must not be exceeded, which is the pressure used as the basis for calculating the material resistance of the vessel.[13]

Several types of valves are distinguished:

- ✓ Conventional spring valves
- ✓ Screw plug valves
- ✓ Thermal expansion valves
- ✓ Regulating valves



FigureII.10: Conventional Spring valves [4]

X. CP/BKH torch system and its sources

The torch system of CP/BKH consists of two torches, including one high-pressure torch, and another dedicated to boost decompression.

X.1. HP high-pressure torch:

The HP manifold is designed to protect the separation unit against overpressures related to high-pressure gases. Its design allows it to fully contain the flow of high-pressure gas dedicated to the BOOSTING unit.[4]

X.2. Boosting decompression torch:

The boosting decompression manifold is designed to ensure the protection of the separation unit against overpressures related to boosting decompression gases. Its design allows it to fully contain the flow of boosting decompression gas allocated to the BOOSTING.[4]

Chapter III

General information about compressors

I. General information about Compressors

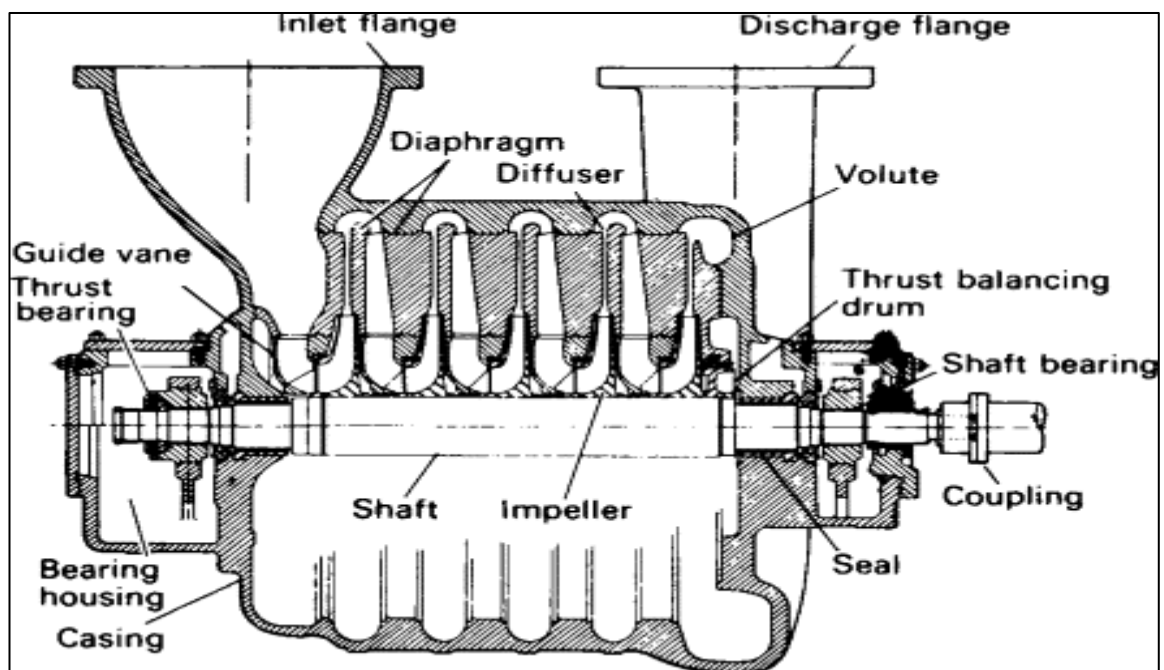
Compressors are devices that convert the mechanical energy provided by a driving machine into pressure energy by increasing the pressure of a gas fluid. Their main use is to move a gas from one point to another, farther away, using this pressure energy. [14]

I.1. Different types of Compressors

Volumetric and dynamic compressors are the two primary types that are most frequently found in the oil industry. [3]

I.1.1. Dynamic Compressors

These devices perform the compression of the gases by exploiting a centrifugal force generated by the rotation of the wheels equipped with blades. The gas is sucked into the impeller, acquires a high speed, and then this kinetic energy is converted into pressure through the impeller and the diffuser.



FigureIII.11: Dynamic Compressors [12]

Depending on how they are used and what kind of machine they are, some compressors go by special names such as ventilators, soufflantes, suppresseurs, and vacuum pumps. [3]

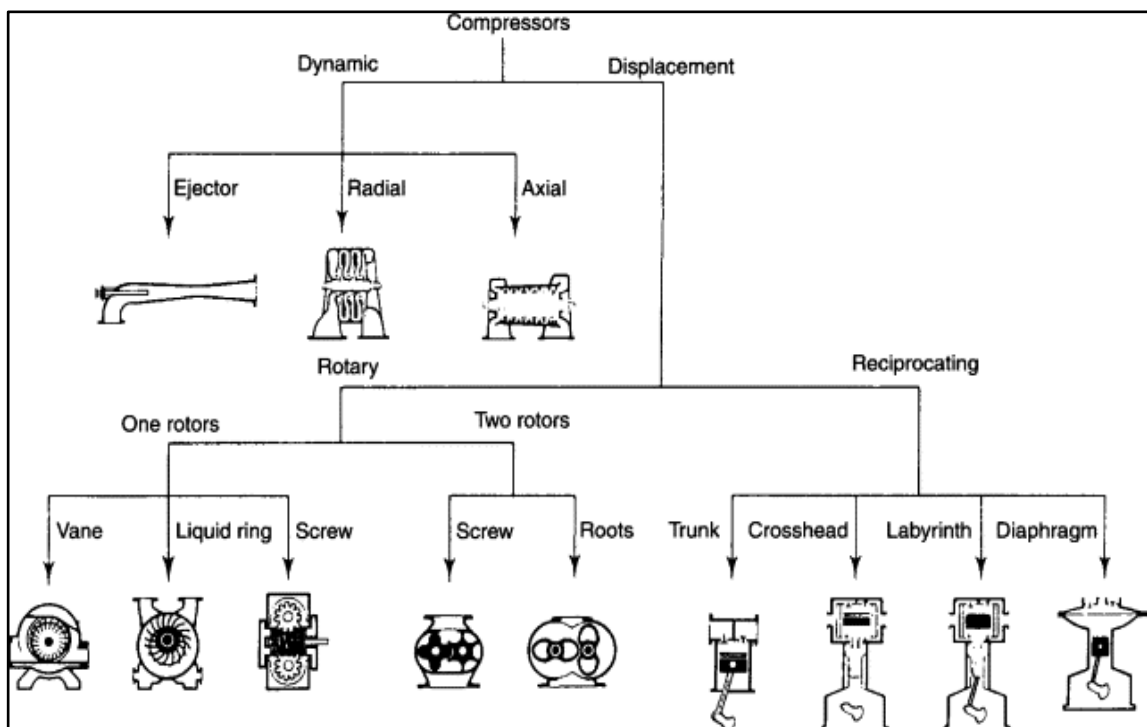
- A Pompe à vide is a device that transfers a gas from a very low-pressure zone to the atmospheric pressure zone or from a lower pressure zone to the atmospheric pressure zone;

- a soufflé is a device whose pressure gain ranges from 0.1 to 2 bars;
- a ventilator is a device whose pressure gain does not exceed 0.1 bar.

I.1.2. Positive Displacement Compressors:

These devices increase static pressure by supplying successive quantities of gas in a closed chamber and providing a moveable element for refoulement. Within this family of machines, one can distinguish: [3]

- For reciprocating piston, diaphragm positive displacement compressors.
- For rotary vane, lobe, screw, liquid ring positive displacement compressors.



FigureIII.12: Positive Displacement Compressors

I.2. Areas of application and criteria for choosing compressors

The uses for compressors are incredibly varied. The limits that are stated are first and foremost economic in nature before becoming technical.

The maximum refoulement pressure is known as the pressure, and the desired debit volume is represented by the debit. This list below provides some examples of how to use these machines: [15]

Les unités de raffinage (reformage catalytique) pour le recyclage des gaz riche en hydrogène sous haute pression ;

- Les unités de fractionnement des gaz pour amener ces derniers à la pression de travail Pour liquéfier un gaz (GPL) ;

- Les centrales frigorifiques, telles que, celles utilisées pour le déparaffinage des huiles et le désalphaltage au propane ;
- Le transport du gaz naturel par pipe-line ;
- La réinjection du gaz dans les puits

II. Centrifugal Compressors

II.1. Definition of centrifugal compressor

The centrifuge compressor is a type of turbomachine where gas is mostly ejected in a radial direction. The fluid-supplying aubes of a centrifuge provide the energy required to raise the pressure. These lobes create an aubage and divide the lateral surface of the roue into sectors that function as drainage channels.

The loyal roues at the tree supply this latter with energy. Les roux utilisent une partie of cette énergie pour augmenter la pression, tandis que les diffuseurs et le stator utilisent l'autre partie.[3]

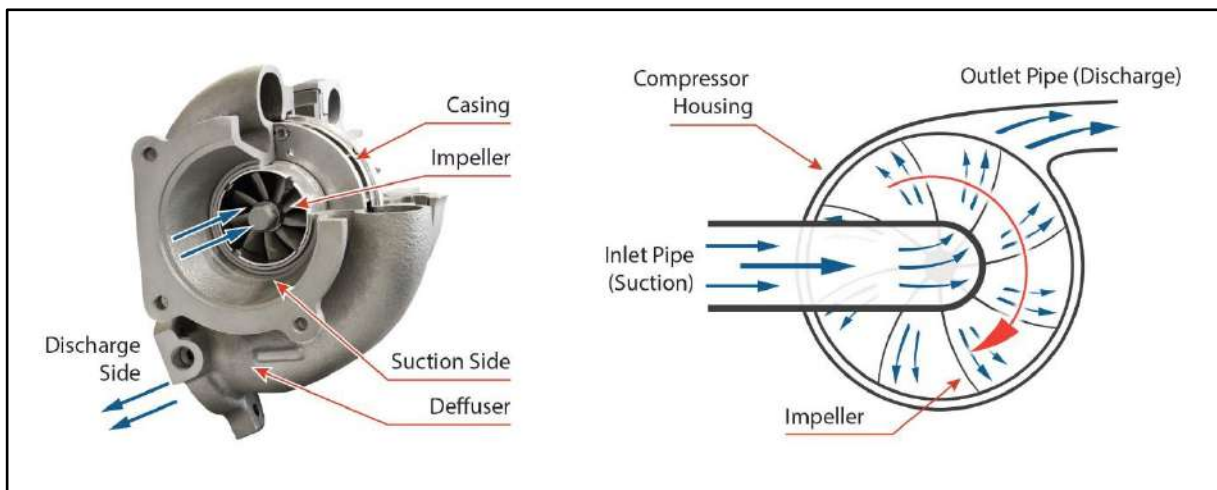


Figure III.13: The centrifugal compressor in elements separates

II.2. Features of centrifugal compressor:

- The flow penetrates axially into a three-dimensional impeller through an inlet duct. The impeller can be preceded by a row of blades of entrance guidance.
- The impeller, through its blades, transmits the speed and pressure to the gas that flows in the radial direction.
- The increase in pressure occurs due to the centrifugal action of the impeller and the divergent passages of the diffuser and / or the volute downstream.
- A diffuser with fins or without fins with a volute is provided to convert the kinetic energy at the output of the impeller into static pressure at the output of the compressor.

- Centrifugal compressors are used to produce large pressure ratios.
- A single-stage centrifugal compressor can have a typical pressure ratio of about. Some test compressors are designed for a pressure ratio.
- Centrifugal compressors are suitable for applications with low specific speed, high pressure per stage and low mass flow.
- Depending on the application, the centrifugal compressors can be of the single-stage or multi-stage type.[3]

II.3. Design of a Centrifugal Compressor

From the outside, this equipment seems to be a large closed unit equipped with two external flanges: one connected to the suction piping and the other to the discharge piping.

Inside this unit, there is a mobile active component responsible for compressing the gas from the suction pressure to the discharge pressure. We will detail how it works in the rest of our presentation.

A centrifugal compressor essentially comprises:

- An intake duct, in connection with the suction flange of the compressor;
- Installation of the inlet guide vanes;
- A rotor with one or more wheels, its bearings, its seals;
- Choose a broadcaster;
- Create an exit volute;
- Return channels in the case of multi-wheel compressors ensuring the flow of the gas from the outlet of the diffuser of the previous stage to the inlet of the distributor of the next wheel.

The assembly comprising the inlet guide vanes, the impeller and the diffuser forms a compression stage. Each unit is equipped with a wheel where the gas acquires kinetic energy, which is converted into pressure in the diffuser at its outlet. The gas, now under pressure, is conveyed to the suction of the second impeller through a profiled channel. Sometimes, fixed fins are present to prevent vortices and minimize pressure losses between the stages.[15]

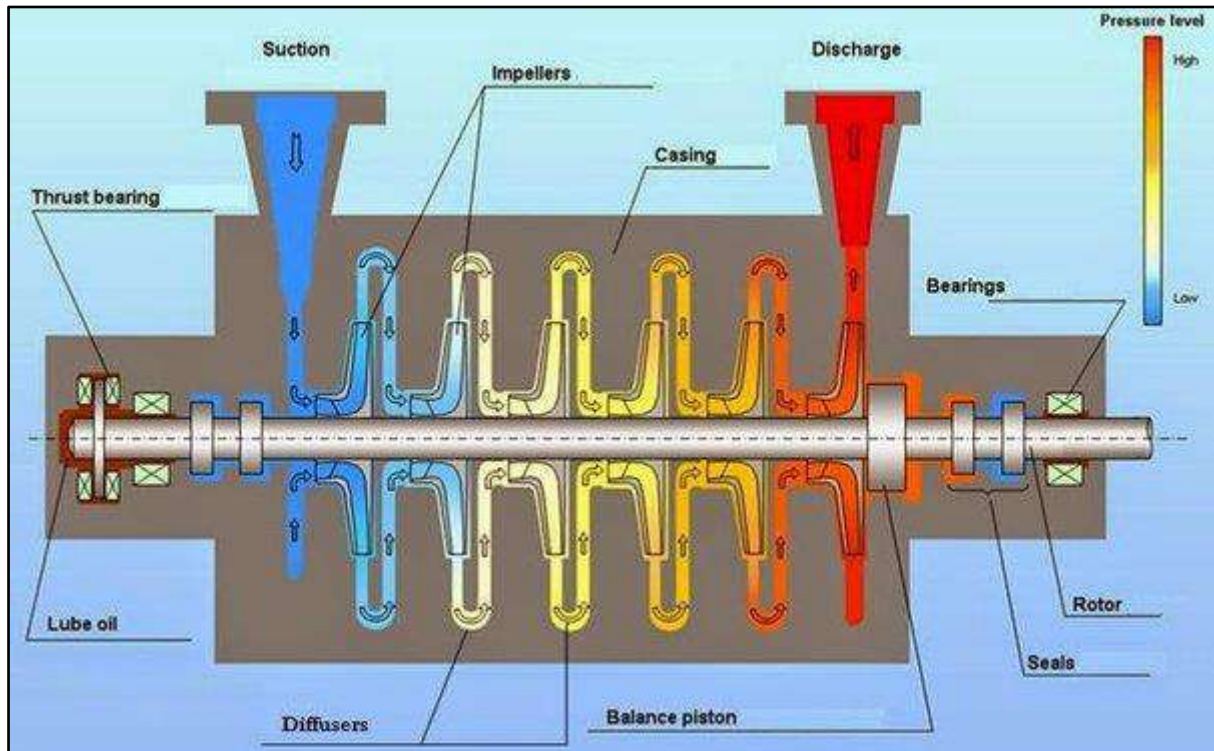


Figure III.14: Construction of the centrifugal compressor [12]

II.4. Operation of centrifugal compressor

- The impeller is the compressor rotation wheel constituted of fins, which rotates at high speed.
- When the impeller is rotating, it sucks the fluid towards the center and pushes it to the sides with the help of centrifugal force.
- If the fluid enters the implusor at a low speed and exits with a high speed, this, which means that the implusor transfers their rotational energy to the fluid. However, a high speed doesn't mean a lot of pressure.
- To reach the desired pressure, the fluid passes through the diffuser. The diffuser consists essentially of fixed vanes, which are tangent
- The passages between the fixed blades diverge to convert the fluid velocity into pressure by slowing down the speed. Most of the kinetic energy, leaving the impeller is converted into pressure energy.
- The volute collects the fluid with a low speed and high pressure from around the diffuser and directs it to the compressor outlet (discharge).

II.5. Field of use of centrifugal compressor

The applications of compressors are very diverse, we give some examples:

- In gas pipelines (to move natural gas from the deposit to the consumer).
- ideal for underground storage of natural gas or carbon dioxide,
- Used in oil refineries and on natural gas processing sites, petrochemical and chemical.
- Work on air separation sites (to manufacture gas products).
- Used in refrigeration or air conditioning appliances.
- Used in devices supplying compressed air.
- Used in gas turbines and auxiliary power units.
- used in pressurization systems on board aircraft (with the aim of maintaining a safe and comfortable pressure to people)
- Used in turbochargers and turbochargers in (which serve to increase the power of gasoline or diesel engines).
- Used on oilfield exploitation sites, to inject gases into the subsoil in order to increase the extraction rate, or to facilitate the recovery of oil by injection into the well (gas lift).

III. Description of the HYSYS simulator

For this work, we chose the HYSYS simulation software. Developed by the Canadian company HYPROTECH, HYSYS specializes in the simulation of chemical engineering processes. This software is designed to handle a wide range of issues, from design to process optimization. It allows for the identification of optimal designs and the modeling of existing units to ensure equipment performance. Thus, it is possible to evaluate and improve the performance of existing processes.

The simulator can be used to:

- Adjust operating parameters in the case of changes in feed composition;
- Determine the performance of the tested equipment.[16]

III.1- The basic operating concepts of HYSYS

- ✓ **Fluid package:** It defines the chemical components found in the process and the thermodynamic models used to calculate the properties of mixtures.
- ✓ **Process Flow Diagram:** This diagram visualizes the streams and unit operations, represented by symbols in the flowsheet, as well as the connectivity between streams, unit operations, and stream property tables.
- ✓ **Workbook:** It provides access to information on streams and unit operations in a tabular data format.
- ✓ **Desktop:** This is the main space in HYSYS for viewing windows during the design process.
- ✓ **Property view:** It contains information describing an object (operation or stream).
- ✓ **Simulation Case (simulation file):** This includes the collection of fluid packages, flowsheets, and flowsheet elements that make up the model. [17]

III.2- General structure of the HYSYS

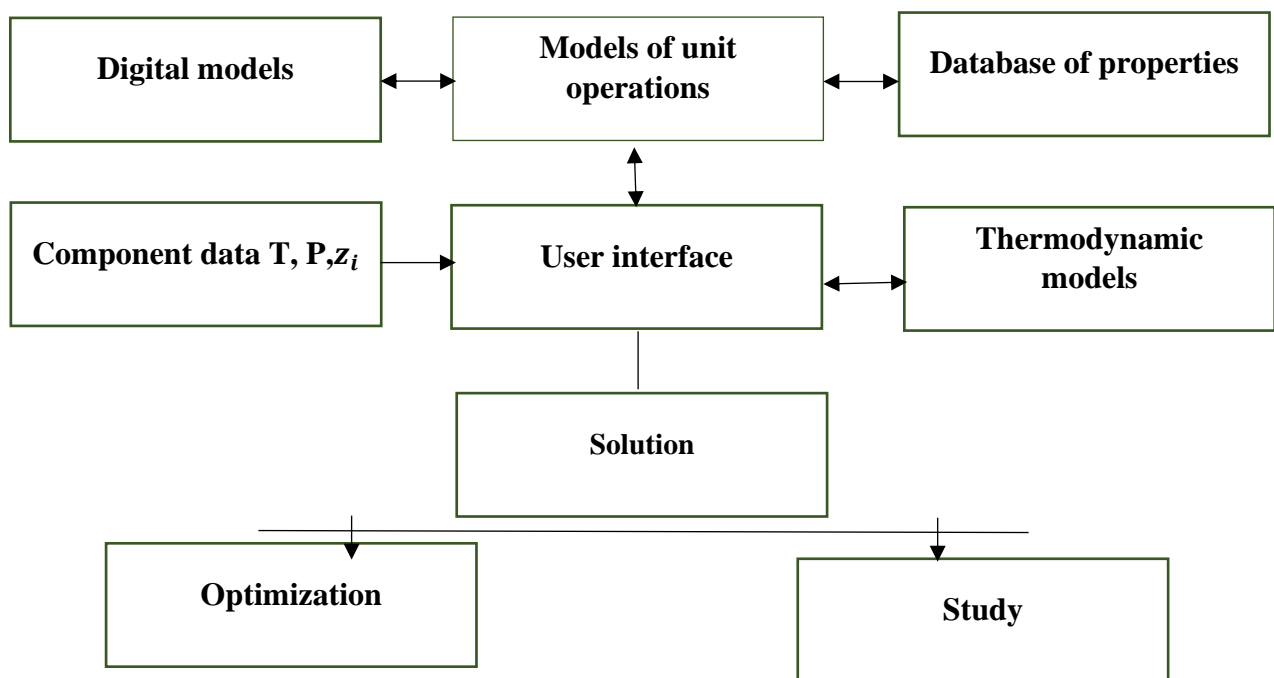


Figure III.15: General structure of the HYSYS

The range offered by AspenTech includes software for modeling all types of processes, design, exchanger evaluation, energy and systems analysis, economic assessment, and process development [18]

Chapter IV

Calculation and simulation part

I. Problematic

Sonatrach recently unveiled a significant gas discovery in the Desert, affirming the region's substantial production potential. As part of the processing plan, the gas will undergo compression in a unit before being transported via a 12-inch pipeline to the GAL final destination for further treatment. However, a key challenge has arisen: only 75% of the incoming gas can be compressed, leading to the flaring of the remaining percentage due to the limitations of the existing compressor.

To address this issue, two primary options have been proposed. The first option involves selecting a compressor capable of handling the entire gas volume, while the second option explores the use of multiple compressors. Aspen HYSYS has been employed to evaluate and select the most suitable option. Through economic analysis, the optimal solution will be identified.

II. Process simulation

For this simulation using HYSYS, some approaches are undertaken:

- define the chemical components that will be used in the process

The composition of the gas used as inlet is described in table:

Table IV.01: Gas input composition

Component	Molar %
H ₂ O	0.3825
N ₂	3.0284
CO ₂	0.6774
C ₁	63.3866
C ₂	18.3097
C ₃	9.4936
IC ₄	0.8766
NC ₄	2.4904
IC ₅	0.3387
NC ₅	0.5379
NC ₆	0.3387
NC ₇	0.1395
NC ₈	0.0000

The operating conditions of the gas are given below:

- gas temperature: **30°C**
- gas pressure: **11.00 Bar**
- gas flow rate: **19.70 MMSCFD**

The designations of different equipment involved in the simulation are arranged in table

Table IV.02: Equipment designations

Designation (HYSYS)	Equipment
V-201, V-100, V-101	Separators
VLV-101, VLV-100	Expansion valves
K-201.K-100, K-101	Compressors
E-201, E-100, E-101	Air coolers
TEE-100, MIX-100	Mixer
CGP-100, CGP-101	Pipe segment

III. Comparison of compressor performance by Aspen HYSYS

For the comparative study of compressor performance, we have developed three PFD schemes in the HYSYS simulator:

- The existing compression train (see Figure IV.14)

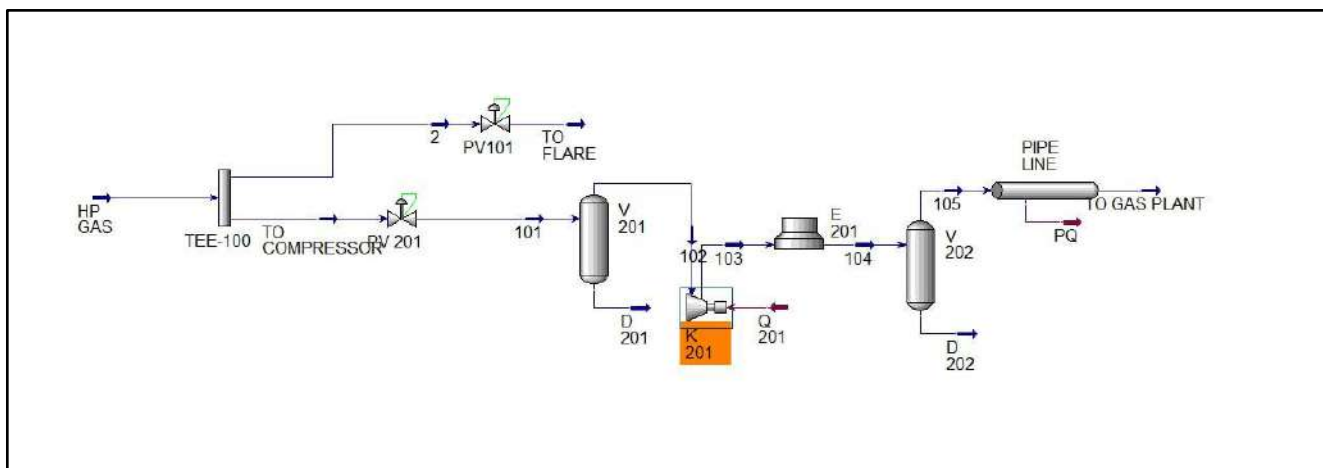


Figure IV.16: PFD diagram of the existing compression train

This represent a presentation of what is running and operating now in the shipping plant. We have done a simulation to determine the current compressor performance and use them as basis in our technical and economic studies.

Table IV.03: Gas Input feed data coming from the pretreatment process

101		
Temperature	29.93	°C
Pressure	10.91	Bar
Molar Flow	14.77	MMSCFD

Table IV.04: Existing compressor performance DATA

K-201		
Feed intake Pressure	10.91	Bar
Discharge Pressure	29.80	Bar
Molar Flow	14.77	MMSCFD
Energy	2.566e+006	kJ/h
Volume flow	47.27	m ³ /h

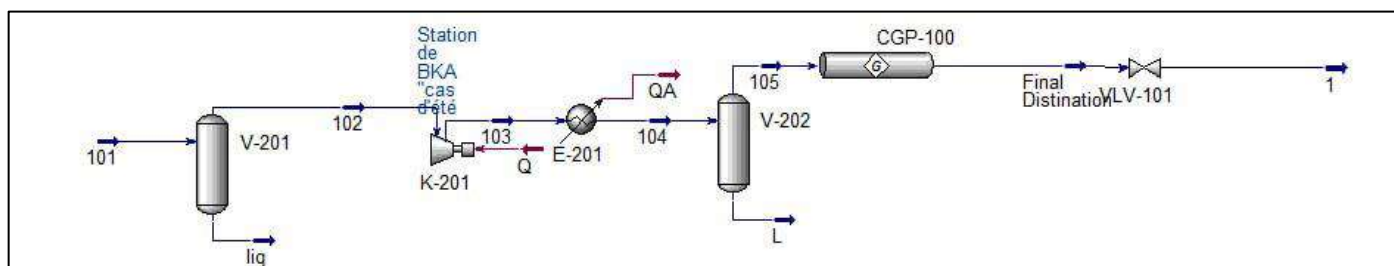
Table IV.05: ‘TO FLARE’ Gas DATA as per simulation

To Flare		
Feed Pressure	11.01	Bar
Product Pressure	11.01	Bar
Molar Flow	4.925	MMSCFD
Volume flow	15.76	m ³ /h

Table IV.06: TO GALLELA shipping gas DATA as per simulation

Final destination		
Temperature	31.82	°C
Pressure	27.66	Bar
Molar Flow	14.77	MMSCFD

- The first PFD for design a new compressor with a higher capacity (see Figure IV.14)

**Figure IV.17: PFD for the 1st compressor alternative**

The First Alternative is shown in the following PFD. It represents the total replacement of the existing compressor by a new one with higher capacities (pressures & flow rate) in order to handle more than 75% of the produced gases and ship it to its final destination (GALLELA treatment plant)

Another compressor should be available (standby) in case any functional problem happens to the main one

Table IV.07: Gas Input feed data coming from the pretreatment process

101		
Temperature	30.00	°C
Pressure	11.00	Bar
Molar Flow	19.70	MMSCFD

Table IV.08: The new compressor with higher capacities DATA as per simulation

K-201		
Feed Pressure	11.00	Bar
Product Pressure	29.80	Bar
Molar Flow	19.70	MMSCFD
Energy	3.392e+006	kJ/h
Volume flow	63.02	m ³ /h

Table IV.09: Gas shipping DATA in the 1st proposed solution as per simulation

Final destination		
Temperature	45.35	°C
Pressure	26.49	Bar
Molar Flow	19.70	MMSCFD

- The second PFD adding two new compressors

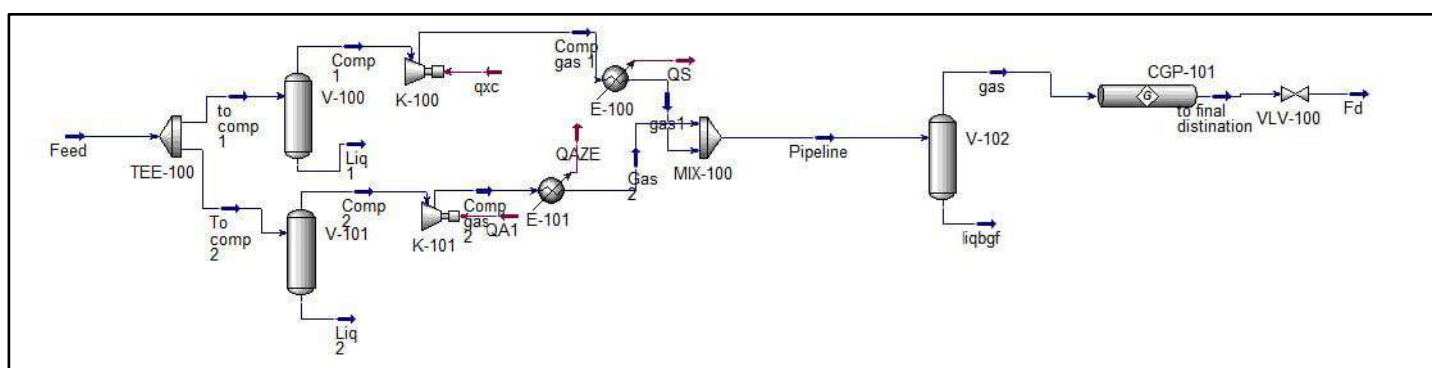


Figure IV.18: PFD for design a new compressor

This alternative consists of adding a double compressor with given the same capacities to work simultaneously in order to reduce the flared gas amount and increase the volume of gas being shipped to gallela (GLA).

Two compressors should be available (standby) in case any functional problem happens to the main one

Table IV.10: The first new added compressor data as per aspen HYSYS simulation

K-101		
Feed Pressure	11.00	Bar
Product Pressure	29.80	Bar
Molar Flow	9.850	MMSCFD
Energy	1.696e+006	kJ/h
Volume flow	31.51	m ³ /h

Table IV.11: The second new added compressor data as per aspen HYSYS simulation

K-100		
Feed Pressure	11.00	Bar
Product Pressure	29.80	Bar
Molar Flow	9.850	MMSCFD
Energy	1.696e+006	kJ/h
Volume flow	31.51	m ³ /h

Table IV.12: Gas shipping DATA in the 2nd proposed solution as per simulation

Final destination		
Temperature	45.18	°C
Pressure	26.74	Bar
Molar Flow	19.70	MMSCFD

The results of the three simulations showed that the performance of the compressor in the second PFD and the third PFD is better compared to the first PFD. The details of these results is provided in that chapter

IV. Economic study/comparison between the two proposed Alternatives

To understand which solution will be the most suitable in term of cost, we need to compare them base on two parameters:

CAPEX = capital expenditure = equipment purchased cost + equipment installation costs

OPEX = operating expenditure = equipment running cost per year.

The plant that has the lowest CAPEX + OPEX may be the more adequate to be installed. This is from an economic side.

However, final choice could be picked base on technical evaluation like operating conditions, plant conditions, Environmental conditions...

ASPEN HYSYS allowed us to compare the CAPEX and OPEX of two alternatives as per the equipment existing.

Table IV.13: Approximate CAPEX and OPEX of the first proposed solution (1 compressor replacing the old one with greater capacities)

Name	Equipment cost [USD]	Installed cost [USD]	Utility cost [USD/HR]
V-201	19000	94800	0
k-201	1117300	1282700	86,7225
E-201	15600	77000	1,52244
V-202	19600	91300	0
CGP-100	0	0	0
VLV-100	0	0	0
Capital total		4553460	819236

Table IV.14: Approximate CAPEX and OPEX of the 2nd proposed solution (Adding two new compressors similar and working together).

Name	Equipment cost [USD]	Installed cost [USD]	Utility cost [USD/HR]
TEE-100	0	0	0
V-100	16000	90700	0
V-101	16000	90700	0
V-102	20100	91900	0
E-100	11600	63400	0,76584
E-101	11600	63400	0,76584
K-100	995600	1142400	40,4705
K-101	995600	1142400	40,4705
MIX-100	0	0	0
CGP-101	0	0	0
VLV-100	0	0	0
Capital total	6627200		768636

All the previous results are Preliminary studies for reducing flaring gas in BKH, this work to be implemented, in deep study from both economic and technical sides should be done under SONATRACH Standards.

General

conclusion

general conclusion

The purpose of our work is reducing flaring gas in BKH that was mainly because of the compressor used, it's characteristics and performance not able to deliver whole gas amount to GAL.

Looking for Another compressor with high performance is a must to decrease flaring gas thus protecting environment and saving energy source.

Two different designs have been done by the use of Aspen hysys.in the first design, one compressor used with volume of 63.02m³/h which can deliver 100% of gas means 0 flaring gas. while tow compressors have been used in the 2nd design each one can handle 50% of the whole amount.

In conclusion, the use of one highly efficient compressor would require a larger size and significant capital investment, however using double compressor consuming more energy compared to one efficient compressor.

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Annex

Abstract

The group SONATRACH has committed to improving its environmental protection performance.

However, BKH still suffers from the combustion of 25% of gas per day, approximately 259,915 m³/day, due to the incapacity of compressor K 201 to send all the gas to GAL. Therefore, Aspen HYSYS was used as a simulation program, and two designs were carried out to find the appropriate compressors to obtain more than 75% of the gas, which means reducing the amount of gas burned

Key words: simulation, HYSY, Flared gas, Ben Kahla, compressor

Résumé

Le groupe SONATRACH s'est engagé à améliorer sa performance en matière de protection de l'environnement

Cependant, BKH souffre encore de la combustion de 25 % du gaz par jour, soit environ 259 915 m³/jour, en raison de l'incapacité du compresseur K 201 à envoyer tout le gaz à GAL. Par conséquent, Aspen HYSYS a été utilisé comme programme de simulation, et deux conceptions ont été réalisées afin de trouver les compresseurs appropriés pour obtenir plus de 75 % du gaz, ce qui signifie réduire la quantité de gaz brûlé.

MOTS CLÈS : simulation, HYSYS, Gas torché, Ben Kahla, compressor