Sudan University of Science and Technology

College of Graduate Studies

Increasing the Heat Transfer Efficiency of Heating System by the Adjusting Flow Rate of Thermanol/ Crude Oil (Petrodar Pipeline Case Study)

رفع كفاءة انتقال الحراره لمنظومة التسخين من خلال ضبط معدل تدفق زيت التسخين للنفط الخام)دراسه حاله لخط انابيب بترودار(

A Thesis Submitted in partial Fulfillment for the Degree of (M.Sc. in Petroleum Engineering (Transporting &Refining

By

Ismail Ahmed Ismail Ahmed

Supervisor:

Abdlla Dr.Abdlla Mokhtar Mohammed

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بسم الله الرحمن الرحيم

الاستهلال

قال تعالي:

(فَفَهَّمْنَاهَا سُلَيْمَانَ ۚ وَكُلًّا آتَيْنَا حُكْمًا وَعِلْمًا ۚ وَسَخَّرْنَا مَعَ دَاوُودَ الْجِبَالَ يُسَبِّحْنَ وَالطَّيْرَ ۚ وَكُنَّا فَاعِلِينَ)

سورة الانبياء الآية (79)

Dedication

To:

My Dear Mother

My Dear Father

My Dear Wife

My Children

My Brothers

To All My Friends

Acknowledgement

First, I would like to express all my deepest thanks to Allah for his grate help in completing this thesis.

I would like to express my most sincere thanks to my supervisor:

Dr. Abdllah Mokhtar Mohammed Abdllahfor his patience, guidance and encouragement, and the tremendous amount of effort and help that offered to mean any time.

I would like to express my most profound gratitude to the staff at the Department of Mechanical Engineering, Sudan University for general assistance in different ways and for valuable comments.

I would like to thank the staff and management at the PetrodarCompany.

I would like to thank all my colleagues for their help.

Finally, am forever indebted to my family for their endless patience and encouragement, when it was most required.

Abstract:

The aim of the research is to identify the maximum efficiency of the heating system and investigate the opportunities of operating cost reduction the in Petrodar operation company pipeline crude by adjusting thermal oil flow rate, real data (readings) such as temperature, of flow rate taken, analyzed and put into tables and graphs and calculating system efficiency with corresponding thermail oil by excel program.

The data taken for five months starting from October 2017 until February 2018.The maximum thermal efficiency was 90.73% with lower fuel consumption 5 cubic meters per hour in December 2017, when the thermal oil flow rate (thermanol) was670315kg/ h. The appropriate fuel consumption 5 cubic meter per hours which is gives the highest crude oil temperature about 71.9 ° C.

By using the finding result, we can consider it as a reference operating condition for the heating system.

ملخص الدراسة:

الهدف من هداالبحث تحديد اقصي كفاءة لنظام التسخين والتحقق من فرص خفض تكلفة التشغيللخام خط أنابيب بترودار بضبط سريان الزيت الحراري، وتم اخذ بياناتحقيقية (قراءات) مثل درجة الحرارة والضغوط وكمية التدفيق وتحليلها ووضعها في جداول ورسومات بيانية وحساب الكفاءه المناظره لكل معدل سريان تدفق الزيت الحراري ببرنامج اكسل,اخزت البيانات لخمسه اشهر تبدا من شهر اكتوبر,نوفمبر, ديسمبر,يانابر, فبراير

توصل البحث إلى هذه النتائج: تحدث الكفاءة الحرارية القصوىوهي90.73%. المناظره لا قل استهلاك وقود4 متر مكعب ف الساعهفي ديسمبر 2017م عندما كان معدل تدفق الزيت الحراري (ثيرمانول) 571190 كيلوجرام في الساعة واستهلاك الوقود الملائم 5 أمتار مكعبة في الساعة والزي اعطي أعلى درجة حرارة للنفط الخام حوالي 71.9 درجة مئوية، باستخدام النتائج المتحصله يمكننا أن نعتبرها مرجعية للتشغيل.

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CHAPTER I

CHAPTER I

1.1 Introduction

Heating of heavy crude oil in pipeline is very important to avoid gel or any other problem especially in winter season at night time while the ambient temperature is lower than its pour point temperature which is **36°C**.

A heating system (heat exchanger) is a medium that transfers heat energy from a high temperature fluid to another low temperature fluid. Thermal exchange is one of the most important applications in many fields, such as food processing engineering, especially in the manufacture of materials that are highly sensitive to high temperatures, as well as difficult to heat or raise their temperature by direct methods and other materials. (Beck, 1998)

heating system (Heat exchangers) are used in many engineering processes, including cooling, evaporation, condensation and other thermal processes.

Heat exchangers are widely used in the chemical, petroleumand power generation industries. The shape of the heat exchanger is determined by the use of a specific temperature limit, the fluid flow (fluid or gas), the amount of heat to be transported and the pressure loss allowed for both hot and cold fluid, and in the working life.

The performance of the heat exchanger is affected beyond which the flow of the mass in which the specific heat and temperatures of entry and exit of fluid hot and cold. and thermal conductivity of a substance tube rate.

this study will cover the heating system in Petrodar operatingcompany(PDOC) which consist of heaters, heat exchanger pipe, pumps, heating medium Therminol SP fluid is designed for use in non-pressurized/low- pressure, indirect heating systems. It delivers efficient, dependable, uniform process heat with no need for high pressures. The high boiling point of Therminol SP helps reduce the volatility and fluid leakage problems associated with other fluidsTherminol SP has been shown to be significantly less sensitive than mineral oils to the negative consequences (sludging, fouling) of thermal oxidation Therminol SP is noncorrosive to metals commonly used in the construction of heat transfer systems.

While Therminol SP has a relatively high flash point, it is not classified as a fire-resistant heat transfer fluid Delivers excellent cost performance over the fluid life when compared to common mineral oil-based heat transfer fluids, even when operating temperatures reach a maximum extended use temperature of 315°C (600°F) see table (1.1).

Table (1.1): therminol specifications

Appearance	Clear, yellow liquid
Composition	Synthetic hydrocarbon mixture
Maximum bulk temperature	290°C (550°F)
Maximum extended use temperature	315°C (600°F)
Maximum film temperature	335°C (635°F)
Normal boiling point	351°C (664°F)
Pumpability, at 300 mm²/s (cSt)	−8°C (17°F)
Flash point, COC (ASTM D-92)	177°C (350°F
Pour point (ISO 3016)	−54°C (−65°F)
Coefficient of thermal expansion	0.000961/°C (0.000534/°F)

@ 200°C	
Heat of vaporization at maximum use temperature	228 kJ/kg (98.1 Btu/lb)
Average molecular weight	320
Pseudocritical density	258 kg/m3 (16.1 lb/ft3)

this system increases the temperature of crude oil when interring the pumping station to certain point above the pour point temperature36°C to avoid gelling and reducing the viscosity to allow the flow.

MATLAB and excel very useful tool in the analysis and design of computer based electronic systems has become a large presence in the engineering curriculum it is also used industrially in the design and operation process of systems this reacarch used excel for calculating the thermal efficiency.

Transporting heavy crude oil via pipeline usuallychallenging due to its high density and viscosity (1,000 CP) (cent poise) and very low mobility at reservoir temperature. Asphalting deposition, heavy metals, Sulphur and brine or salt content make it difficult to be transported and refined using conventional refinery methods without firstly upgrading them to meet conventional light crude oil properties Also, the presence of brine or salt in the heavy crude stimulates corrosion problems in the pipeline. In some cases, the formation of emulsion such as the oil–water mixture produced from the reservoir poses transportation difficulty. Though the issue of the environment remains a concern, petroleum is still the dominant source of energy worldwide for our transportation fuels. The global demand for energy to meet our daily industrial and transportation needs is ever growing at an average annual growth rate. Pipelines are used to transport about 95 % of the heavy crude oil produced in Canada and Venezuela, respectively. This is because pipelines are the least expensive, environmentally convenient and the most effective means to transport crude oil from the field to the refinery, marine terminal or storage tanks. (Jonathan Fiedler, 1998)(prod technol, 2013)

To transport heavy oils economically, the pressure drop in the pipeline must be lowered to minimize the pump power required to push the oil over a long distance. However,because of their high viscosity at reservoir conditions compared to conventional light crude oils, conventional pipelining is not adequate for transporting heavy crude oil to refinery, marine terminal or storage tanks without reducing their viscosity. The methods used for transporting heavy oil through pipelines are generally grouped into three.

(a) viscosity reduction [e.g. preheating of the heavy crude oil and subsequent heating of the pipeline, blending and dilution with light hydrocarbons or solvent, emulsification through the formation of an oil-in-water emulsion and lowering the oil's pour point by using pour point depressant (PPD) (power point depress net);

(b) drag/friction reduction (e.g. pipeline lubrication through the use of core-annular flow, drag reducing additive);

(c) In situ partial upgrading of the heavy crude to produce a sync rude with improved viscosity, American Petroleum Institute (API) gravity, and minimizedasphaltenes, Sulphur and heavy metal content.

In this study will consider heating method which is commonly used method to reduce the high viscosity of heavy crude oil and improve the flowability is the effect of temperature. Heating (i.e. increasing temperature) the pipeline causes a rapid reduction in viscosity to lower the resistance of the oil to flow. Therefore, heating is an alternative means of enhancing the flow properties of heavy crude oil. This is because the viscosity of the heavy oils is reduced by several orders of magnitude with increasing temperature. This involves preheating the heavy crude oil followed by subsequent heating of the pipeline to improve its flow. However, heating to increase the temperature of the fluid involves a considerable amount of energy and cost as well. Other issues include greater internal corrosion problems, due to the increase in temperature. However, heating the pipeline may possibly induce changes in the rheological properties of the crude oil which may result in instability in flow. Many number of heating stations are required adding to the cost, in addition to heat losses occurring along the pipeline as a result of the low flow of the oil. However, most of the times the pipeline is insulated to maintain an elevated temperature and reduce the heat losses to the surroundings. Additionally, sudden expansion and contraction long the pipeline may induce challenging problems. Consequently, the cost of operating the heating as well as the pumping systems over a long distance from the oil field to the final storage or refinery is on the high side. The method might not be viable for transporting crude oil when it comes to subsea pipelines. Finally, the cooling effect of the surrounding water as well as the earth lowers the efficiency of the technique. (Aaron, 2016)

1.2 Research Problems

1. Heating of heavy crude oil in pipeline is very important to avoid gel especially in winter season at night time while the ambient temperature is very low about 10 C°.
2. This lead to operate the heating system in full load and high fuel consumption (160 barrel /day) without out high efficacy.

3. Use high fuel mean more money have to payed.
4. Researchproblem is efficiency increasing.

1.3Research Objectives:

1.3.1General objective:

To increase heating system efficiency and decrease operation cost.

1.3.2 Specific objectives:

The research aims to:

1. To identify the operation performance, flow rate temperature, pressure that gives high efficiency of heating system with corresponding flow rate of crude oil.
2. To apply this result of operation condition as guideline manual in petrodar operating company central process facility and pump station.

1.4 Research Plan & Methodology:

The process of heat exchanger operation is actually a process of selecting the optimal values of variable transactions such as pressure loss, pumping capacity (flow rate), temperature.

1. Information gathering and analysis
2. Consider considerations for the heat exchanger operation process.
3. Consider operation process using mathematical equations andExcel
4. Explanation of operation process.
5. Compare the finding results with real operation process

design.

6. Discuss theresults.
7. select the best allowable efficiency

CHAPTER II

Literature review and background

CHAPTER II
Heat Exchanger

2. Literature review:

2.1previous studies

According to (Aaron Guche et al.2016),(Aaron, 2016)The problem was overheating to solve the it the engineer decides to install heat exchanger to the systemthey make experiment to allow the hot fluid to flow in the heat exchanger percentage grading 10%,30%,50%,70% and 100% and see the result for the cold fluid and repeat the same procedure to the cold fluid the affection.this cannot give accurate result because it is difficult to identify the real position of the valve opening, but in my study take floe rate of thermal oil from local gage and computer reading from control room this done by adjusting the valve turn.

While (Su Thet Mon Than, 2008) though that The purpose of this paper is how to design the oil cooler (heat exchanger) especially for shell-and-tube heat exchanger which is the majority type of liquid-to-liquid heat exchanger, General design considerations and design procedure are also illustrated in this paper and a flow diagram is provided as an aid of design procedure. The primary aim of this design is to obtain a high heat transfer rate without exceeding the allowable pressure drop.In design calculation, the Mat LAB and AutoCAD software are used ,The comment it wasanalysis design by computer as theory but this research used real data and the experiment is actually existing .

(Fakheri, 2007) provides the solution to the problem of defining thermal efficiency for heat exchanger based on the second law of thermodynamics to each actual heat exchanger ,there is an ideal heat exchanger that is balanced counter flow heat exchanger. the ideal heat exchanger has same UA ,the same aarithmetic mean temperature difference , and the same cold to hot fluid inlet temperature raito.the ideal heat exchangers heat capacity rate are equal to the minimum heat capacity rate of the actual heat exchanger the heat exchanger transfer the maximum amount of heat equal to the product of UA and arithmetic mean temperature difference and generates the minimum amount of entropy, making it the most efficient and last irreversible heat exchanger .This study is theoretical and mathematical calculation while this research has real data and fact .

Accoring to (Lab)Flow Simulation can be used to study the fluid flow and heat transfer for a wide variety of engineering equipment.this example the other use Flow Simulation to determine the efficiency of a counter flow heat exchanger and to observe the temperature and flow patterns inside of it. With Flow Simulation the determination of heat exchanger efficiency is straightforward and by investigating the flow and temperature patterns. The goal of the project is to calculate the efficiency of the counterflow heat exchanger. Also, determine the average temperature of the heat exchanger central tube's wall. author make this example by commuter program same like (Su Thet Mon Than, 2008) in procedures if he support his finding by experiment the result will become more accurate .

While (tutorial, 2011)this project you will evaluate performance of three different types of heat exchangers (tubular, plate, and shell & tube). All these heat exchangers can be operated in both parallel- and counter-flow configurations. The heat exchange is performed between hot and cold water.Investigate effects of the control parameters and the heat exchanger configuration on the rate of the heat transfer, q, and the overall heat transfer coefficient, U.Check validity of the theoretical models

More over it is a theoreticalexercise not real data and hecompare between three type of heat exchanger.

According to (prod technol, 2013)In this study, different technologies are reviewed and the advantages and disadvantages of each technology are highlighted with the view that the review will provide direction for improvement and development of novel technologies for bitumen and heavy oil transportation via pipelines.

Means of aiding heavy crude oil and bitumen transportation via pipelineViscosity reduction (Dilution/blending, Heating, Emulsification Pour point reduction), Friction reduction (Drag reducing additives, Core-annular flow), In situ upgrading. In this review paper, the technologies used to enhance the transportation of heavy crude oil and bitumen through pipelines was explored. Each of the three categories of methods employed to reduce viscosity and pressure drop to aid pipeline transportation of heavy crude oil has been presented along with their advantages and disadvantages. while the auother spoke about the three categories of methods employed to reduce viscosity and pressure drop to aid pipeline transportation of heavy crude oil has been presented along with their advantages and disadvantages only if he conceder the efficiency the reacher will become more usefull.

2.2. Background

Transfer of heat from one fluid to another is an important operation for most of the chemical and petroleum industries. The most common application of heat transfer is in designing of heat transfer equipment for exchanging heat from one fluid to another fluid. Such devices for efficient transfer of heat are generally called Heat Exchanger. Heat exchangers are normally classified depending on the heat transfer process occurring in them.

A heat exchanger can be defined as any device that transfers heat from one fluid to another or from or to a fluid and the environment. Whereas in direct contact heat exchangers, there is no intervening surface between fluids, in indirect contact heat exchangers, the customary definition pertains to a device that is employed in the transfer of heat between two fluids or between a surface and a fluid. [3]

2.3Theory and Application:

Two fluids, of different starting temperatures, flow through the heat exchanger. One flows through the tubes (the tube side) and the other flows outside the tubes but inside the shell (the shell side). Heat is transferred from one fluid to the other through the tube walls, either from tube side to shell side or vice versa. The fluids can be either liquids or gases on either the shell or the tube side. In order to transfer heat efficiently, a large heat transfer area should be used, leading to the use of many tubes. In this way, waste heat can be put to use. This is an efficient way to conserve energy.

Heat exchangers with only one phase (liquid or gas) on each side can be called one-phase or single-phase heat exchangers. Two-phase heat exchangers can be used to heat a liquid to boil it into a gas (vapor), sometimes called boilers, or cool a vapor to condense it into a liquid (called condensers), with the phase change usually occurring on the shell side. Boilers in steam engine locomotives are typically large, usually cylindrically-shaped shell-and-tube heat exchangers. In large power plants with steam-driven turbines, shell-and-tube surface condensers are used to condense the exhaust steam exiting the turbine into condensate water which is recycled back to be turned into steam in the steam generator.

2.4Shell and tube heat exchanger design:

There can be many variations on the shell and tube design. Typically, the ends of each tube are connected to plenums (sometimes called water boxes) through holes in tube sheets. The tubes may be straight or bent in the shape of a U, called U-tubes. (Beck D. D., 1996).

In nuclear power plants called pressurized water reactors, large heat exchangers called steam generators are two-phase, shell-and-tube heat exchangers which typically have U-tubes. They are used to boil water recycled from a surface condenser into steam to drive the turbine to produce power. Most shell-and-tube heat exchangers are either 1, 2, or 4 pass designs on the tube side. This refers to the number of times the fluid in the tubes passes through the fluid in the shell. In a single pass heat exchanger, the fluid goes in one end of each tube and out the other.

There are often baffles directing flow through the shell side so the fluid does not take a short cut through the shell side leaving ineffective low flow volumes.

Counter current heat exchangers are most efficient because they allow the highest log mean temperature difference between the hot and cold streams. Many companies however do not use single pass heat exchangers because they can break easily in addition to being more expensive to build. Often multiple heat exchangers can be used to simulate the counter current flow of a single large exchanger

2.5Selection of tube material:

To be able to transfer heat well, the tube material should have good thermal conductivity. Because heat is transferred from a hot to a cold side through the tubes, there is a temperature difference through the width of the tubes. Because of the tendency of the tube material to thermally expand differently at various temperatures, thermal stresses occur during operation. This is in addition to any stress from high pressures from the fluids themselves. The tube material also should be compatible with both the shell and tube side fluids for long periods under the operating conditions (temperatures, pressures, pH, etc.) to minimize deterioration such as corrosion. All of these requirements call for careful selection of strong, thermally-conductive, corrosion-resistant, high quality tube materials, typically metals. Poor choice of tube material could result in a leak through a tube between the shell and tube sides causing fluid cross-contamination and possibly loss of pressure.

2.6 Types of Heat Exchangers

Classified divided exchangers based on many considerations, including what is classified according to the mode of communication, such as the number of fluids used in the exchange, including by way of construction and the surface of the exchange, such as the heat exchange mechanism, and generally there are four heat exchangers Classified as entry into the fluid hot and cold during which method on:-

1/Heat exchanger with a single fluid and constant temperature.

2/Heat exchanger parallel.

3/Heat exchanger with reverse flow.

4/The heat exchanger with a flow perpendicular.

2.6.1 Double Pipe Heat Exchanger

The most famous and oldest species ever called (Double pipe) where walking the first fluid inside the tube and the second inside the space between the first tube and the second (tube within a tube) and the movement of fluids may be in the same direction (concurrent) or in the opposite direction (counter current).

2.6.2 Scalloped Heat Exchanger

It is the most commonly used in industries where large capacity to heat or cool large quantities of fluid. Where it consists of a large shell within which a large group of pipes matrix in parallel, there may be more than a group of tubes passing the fluid inside the shell on it more than once pass paths are called single pass or 1-1 exchanger the coincidence contains two passage ways called 1-2 exchanger.

A few times we might have more of a coincidence (shell) is the best known type of component from coincidences and four lanes 2-4 exchanger tubes.And increase the aisles are usually used to give a greater opportunity to meet between fluids and therefore a greater amount of heat transfer and species in the months exchanger psoriasis is 1-2 and 2-4 and are widely used in the industry.

2.6.3 Shell and tube Heat Exchanger:

It is one of the most used exchanges in the field of chemical and petroleumindustries and other types of industrial fields and for the following reasons:

1. The overall shape of the swap gives it a large surface area of relatively small size.
2. The general shape is easy to use in many different applications.
3. It is possible to use many kinds of minerals in the production of such kind of exchanges.
4. Easy to perform inspection, maintenance and cleaning.
5. Easy design and manufacturing procedures.

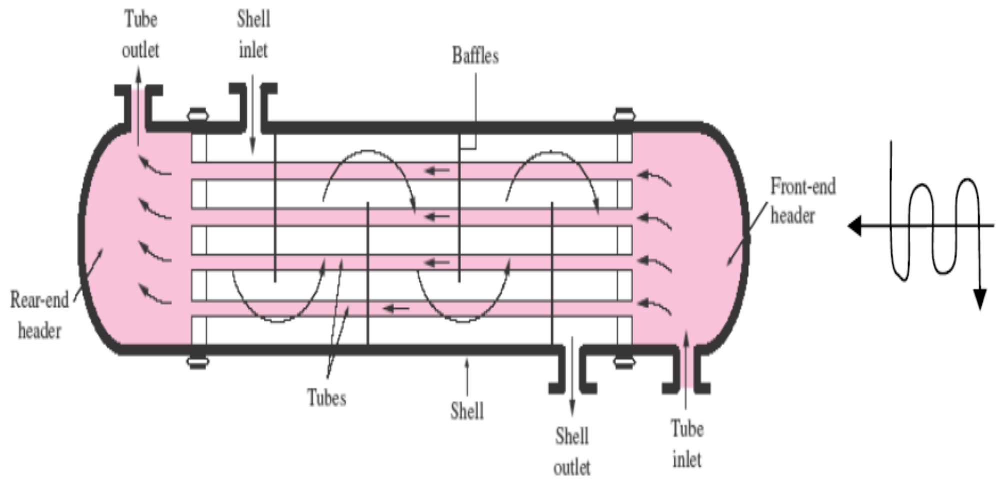

Figure (2.1) shows pass of shell and 1 pass of tube heat exchanger

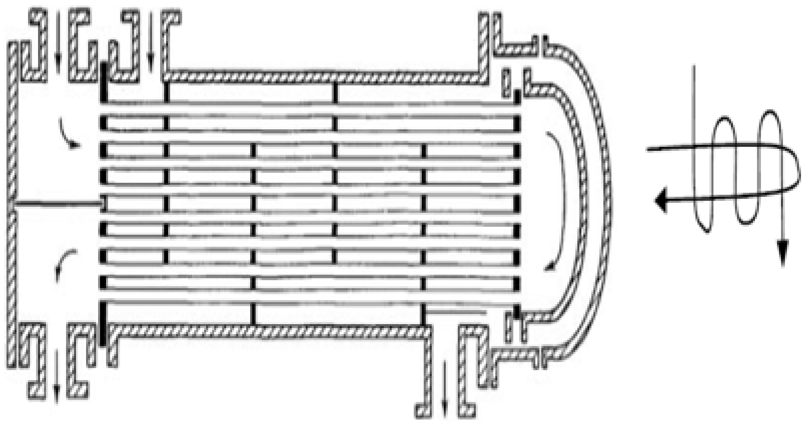

Figure (2.2) shows 1 pass of shell and 2 pass of tube heat exchanger.

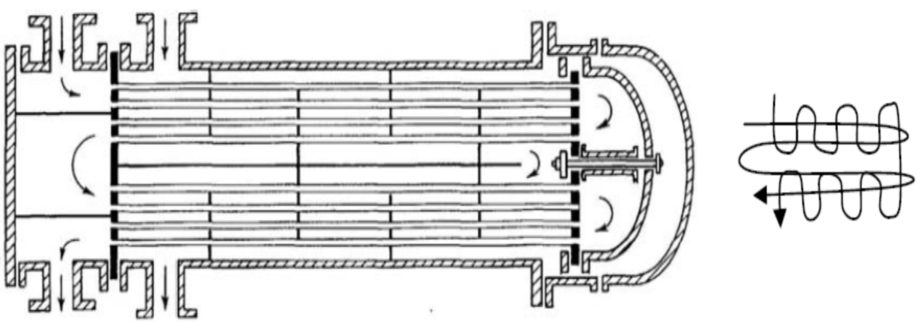

Figure (2.3) shows 2 pass of shell and 4 pass of tube heat exchanger.

Shell and tube heat exchangers represent the most widely used vehicle for the transfer of heat in industrial process applications. They are frequently selected for such duties as:

- Process liquid or gas cooling.
- Process or refrigerant vapor or steam condensing.
- Process liquid, steam or refrigerant evaporation.
- Process heat removal and preheating of feed water.
- Thermal energy conservation efforts, heat recovery.
- Compressor, turbine and engine cooling, oil and jacket water.
- Hydraulic and lube oil cooling.
- Many other industrial applications.

Shell and tube heat exchangers have the ability to transfer large amounts of heat in relatively low cost, serviceable designs. They can provide large amounts of effective tube surface while minimizing the requirements of floor space, liquid volume and weight. Shell and tube exchangers are available in a wide range of sizes. They have been used in industry for over 150 years, so the thermal technologies and manufacturing methods are well defined and applied by modern competitive manufacturers. Tube surfaces from standard to exotic metals with plain or enhanced surface characteristics are widely available. They can help provide the least costly mechanical design for the flows, liquids and temperatures involved.

2.6.3.1 The advantages of shell and tube exchangers

1. The configuration gives surface in a small volume.
2. Good mechanical lay out and a good shape for pressure operation.

3. Use well – established fabrication techniques.
4. Can be constructed from a wide range.
5. Easily cleaned.
6. Well – established design procedures.

For all above mentioned advantage select the shell and tube exchangers, this heat exchanger is characterized by other exchangers:

1. Easy and quick cleaning.
2. Give a large surface area in a small size.
3. Technical, uncomplicated and easy to manufacture.
4. Multiple manufacturing materials are available.

2.6.3.2 Tube arrangements

The tubes in exchangers are usually arranged in triangular, square, or rotated square pattern. I choose a triangular pitch because it gives higher heat transfer rates.

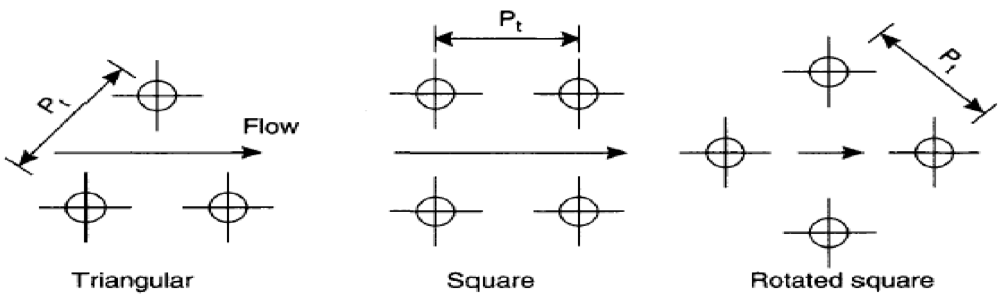

Figure 2.4 Tube patterns.

2.6.3.3 Tube side passes

Fluid in the tube is usually directed to flow and forth in number of passes through gropes passes of tubes arranged parallel to increase the length of flow path, the number of passes is selected to give the required tube –side design velocity.

2.6.3.4 Shell types (passes)

The single shell pass type is the most commonly used, tow shell passes are actually used where the shell and tube side temperature differences will be unfavorable in a single pass, thought the same flow arrangement can be obtained by using tow more exchangers shell in series .

2.6.3.5 Baffles

Baffles are used in the shell to direct the fluid stream across the tubes to increase the fluid velocity and so improve the rate of transfer.

The magnitude of the individual coefficients will depend on the nature of the heat transfer process (conduction, convection, condensation, boiling or radiation), on the physical properties of the fluids, on the fluid flow rates, and on the physical arrangement of the heat-transfer surface.

As the physical layout of the exchanger cannot be determined until the area is known the design of an exchange is of necessity a trial and error procedure.

The steps in a typical design procedure are given below:

1. Define the duty: heat transfer rate, fluid flow rates temperature.
2. Collect together the fluid physical properties required: density, viscosity, temperature and conductivity.
3. Select the type of exchanger to be used.
4. Select trial value for the overall coefficient of heat transfer (U).
5. Calculate the mean temperature difference Δ Tm.
6. Calculate the area required from the equation:$Q = UA\Delta T_m$
7. Select the exchanger layout.
8. Calculate the individual heat transfer coefficients.
9. Calculate the overall heat transfer coefficient and compare it with the trial value. If the calculated value differs significantly from the estimated value, substitute the calculated for the estimated value and return to step 6.

10. Calculate the exchanger pressure drop.

2.6.4 Plate Heat Exchanger

It is called a plate exchanger, which consists of a set of very close panels so that the hot liquid is in a corridor followed by the cold in the other corridor.

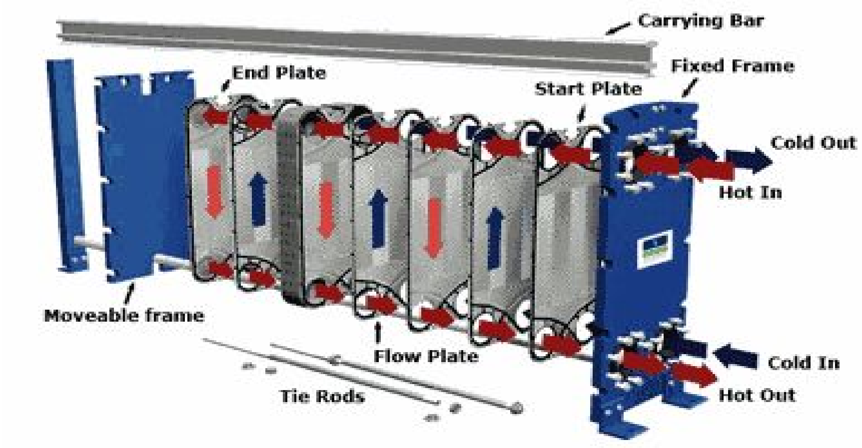

Figure (2.5) shows the plate heat exchanger.

2.6.5 Cases of fluid flow in heat exchangers

There are two cases to the direction of fluid flow in heat exchangers:

2.6.5.1 Parallel Flow

The direction of fluid flow in this case is similar.That is the fluids moves in the same direction. As in Figure:

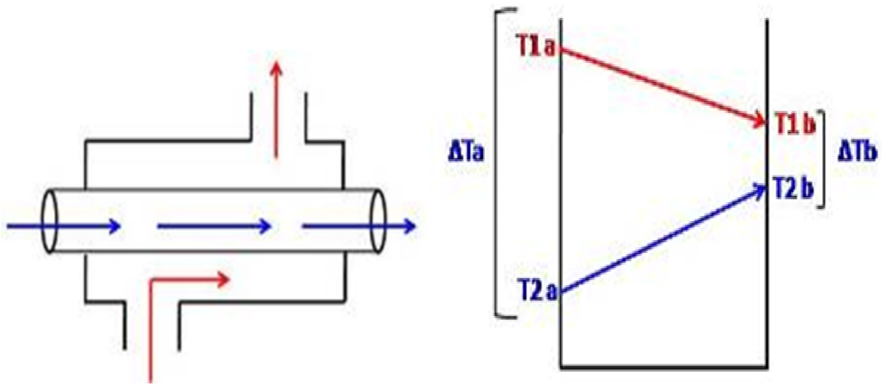

Figure (2.6) shows the parallel flow.

2.6.5.2 Counter Flow

The direction of the fluid flow is reversed. That is the fluid goes in opposite directions and as in the figure:

The direction of flow fluids contrasted that any fluids go in opposite directions as in the figure:

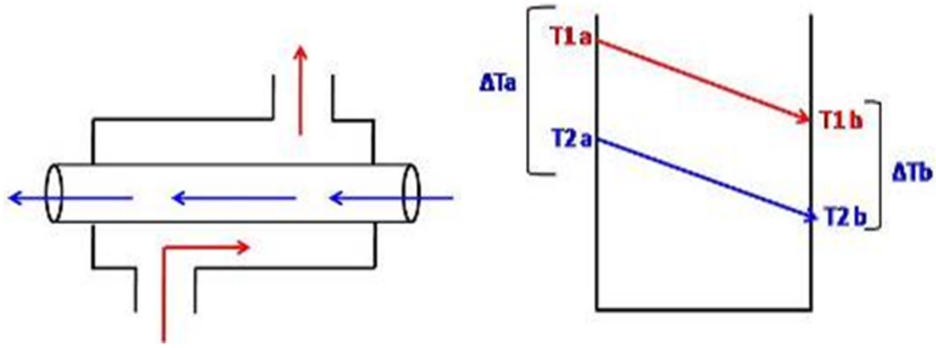

Figure (2.7) shows the counter flow.

The X-Axis horizontal axis in the two figures above represents the length of the exchanger. The notes are in counter flow temperature bands are proven almost along the heat exchanger .While in parallel flow it is noted that the difference is very large in the entry of the exchanger and decreases along its length.

Practical applications have shown that the counter flow is more efficient than the parallel flow.

The heat exchanger is used usually for the following purposes:

Liquid or gas heating.

Cooling liquid or gas.

Steam intensifies.

Steaming liquid.

2.6.5.3 Cross Flow

Usually it used for gases (often to cool), where you pass on the interceptor pipe set containing a liquid (to be heated), which is mixed where the fluid passes into the pipe group and all heats.

For gas may be mixed or may separates its parts, insulating panels and is called Mixed Among the most famous applications use of exhaust gases from certain industries in the water and heating and also be used in air-conditioners are widely.

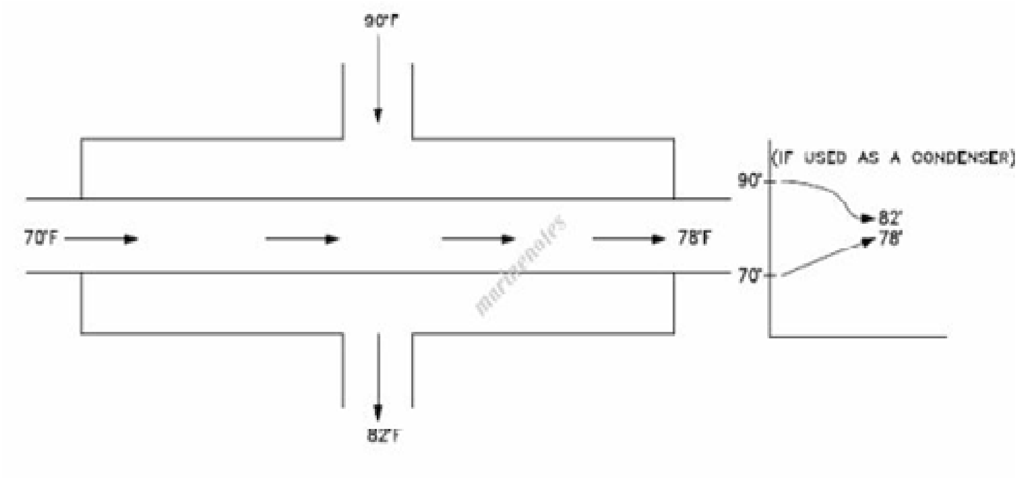

Figure (2.8) shows the cross flow.

2.6.6 Classification of heat exchangers according to the nature of the work

1. Heaters: the exchangers that are used to heat the hot liquid fluid.
2. Coolers: Heat exchangers used to cool the fluids by another liquid, usually water is used for this purpose is called the cooling water in the case of the use of air called the air chillers.
3. Condensate: Heat exchanger which is used to intensify the steam and its main objective is to remove or latent heat of vaporization and absorption of water is used for this purpose usually.
4. Evaporators: Commonly used to concentrate lotions by evaporation of water (aqueous lotions of these).
5. Boilers: Heat exchangers typically used to heat distillation towers to separate derivatives or retail towers (to separate gases from liquids). Water vapor is widely used in the

petroleum industry.

2.6.7 Types of heat exchangers based on its design

2.6.7.1 Fixed-head exchangers

In these heat exchangers the pipe plate is fixed to the shell at each end of the heat exchanger.

2.5.7.2 Floating Head Exchangers

In this type of heat exchanger install one of the two tube liners from one end14 and leave loose from the other end. In order to allow the expansion of the pipe package as a result of thermal expansion, especially if the thermal differences between the large fluid

This type is used very widely in the oil industry and is easy to clean when doing maintenance work.

2.6.7.3 U-Type Exchangers

In this type of heat exchanger, the pipe is U-shaped and the pipe is installed on one sheet of pipe .In this type the pipes are extended freely and are usually used in boilers, especially those that are heated by steam and used for temperatures and high pressures, but it is difficult to clean them by normal means compared to other types.

It is used to clean modern mechanical means such as the use of high pressure water or fine brushes and flexible hoses. This type is commonly used in the oil industry.

Figure (2.9) shows the U-type heat exchanger.

2.6.7.4 Double Pipe heat Exchanger

It is an external tube and another internal tube shorter and pass the material through the outer tube and other material to be cooled or heated through the internal tube and the advantage of cheaper prices.

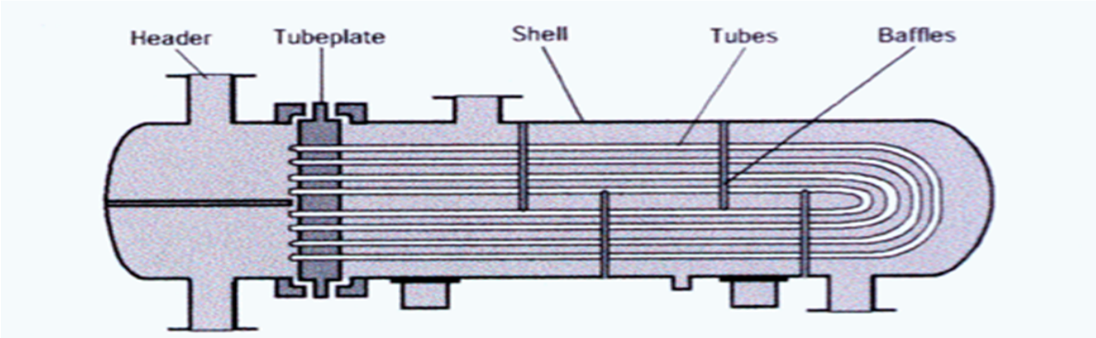

Figure (2.10) shows the double pipeheat exchanger.

CHAPTER III

CASE STUDY

CHAPTER III

Case Study

3.1 Preface:

Petrodar Operating Company (**PDOC**) is an international business company, incorporated under the laws of the British Virgin Islands on 31 October 2001. The concession area was blocks 3 & 7, which were situated between longitudes 31 & 34 East and latitudes 8 & 10 North. The total concession area was about 72,000 km^2. (company, 2018).

A consortium of international exploration and production oil companies has been established to explore and exploit oil in the concession area. The consortium entered into an Exploration and Production Sharing Agreement (**EPSA**) with the Government of the Sudan in November 2000. The consortium also entered into a Crude Oil Pipeline Agreement (**COPA**) for the downstream operations in 2006. On 8 May 2011, PDOC concluded the Crude Oil Transportation Agreement (**COTA**) with the Government of the Sudan (company, 2018).

3.1.1 Shareholders:

PDOC was the designated operator to manage and run the oil operations in the above stated concession area on behalf of the shareholders, who are:

- China National Petroleum Corporation (**CNPC International-DAR**), a Chinese national company, incorporated in the British Virgin Islands and has a registered branch in the Sudan. It owns 41% of the shares of Petrodar.
- Petronas Carigali Nile **(PETRONAS)**, a national Malaysian oil company, incorporated in Malaysia and holds 40% of the

shares of Petrodar.

- Sudapet Co. Ltd (**SUDAPET)**, a company owned by the Government of Sudan and holds 8% of the shares of Petrodar.
- SINOPEC International Petroleum Exploration and Production Corporation **(SINOPEC)**, a private company, incorporated in China and holds 6% of the shares of Petrodar.
- Tri-Ocean Exploration and Production (**TRI-OCEAN**), a private company, incorporated in Cayman Islands and owns 5% of the shares of Petrodar.

3.1.2 AL-Jabalain CPF

AL-Jabalain Central Processing Facility (**CPF**) was designed initially with (9) trains to process and treat a 210,000 bbl/d crude oil in phase-I then it has been upgraded and expanded with (8) new processing trains added to the facilities in phase-II to process and handle a 300,000 bbl/d crude oil with 10 % water cut maximum at feed inlet.

Al-Jabalayn CPF comprises the following process system

1. Crude Oil Receiving System
2. Crude Oil Processing System
3. Crude Oil Storage/ Exporting system
4. Utility System

AL-Jabalain CPF process system receives partially-treated crude with maximum 10% water cut from the Palouge FPF through PS#1 via a 24”
pipeline, 250 km long.

3.1.3 PDOC Business Change

The remarkable business change in Sudan’s oil and gas sector was driven by South Sudan separation / secession on 9^{th} July, 2011.

However, during and after this development, PDOC has effectively and efficiently managed the challenges and has continued the business with best momentum and blossomed records of outstanding achievements and success stories.

By the dawn of March 2015, PDOC has continued giving more care and devoting additional effort and opportunity to embark on Processing and Transportation activities.

This change in business landscape was tailored by signing a Memorandum of Understanding (MOU - 24th June 2014) between the government of Sudan and PDOC share holders. Thus, the current PDOC Focus is mainly on Oil Processing and Transportation activities beside the other established corporate and governance strategies and initiatives.

3.1.4 PDOC Pipeline Operations

The processing and transportation of PDOC Dar Blend crude oil are major elements of PDOC Mission. This is undertaken through PDOC giant pipeline together with its pumping stations, processing facilities at AL-Jabalain Central Processing Facility (CPF) and Bashayer-2 Marine Terminal crude exporting facilities at Portsudan.

3.1.5 Pipeline

PDOC Export Pipeline is one of three major cross-country pipelines transporting crude in the Republic of the Sudan.

The main pipeline transports export-quality treated crude from the Field Processing Facilities (FPF) located at Palogue to the Marine Terminal (MT) at Port Sudan. The (FPF) at Palogue supplies partially -treated crude with a maximum of 10% water-cut. The pipeline segment between (FPF) at Palogue and (CPF) at Al Jabalain is technically referred to as the Field Pipeline (approximately 237 km) as the crude transported is of properties and specifications different from the export-quality crude.

The crude oil pipeline transportation system consists of three major components, namely:

1. The Nominal Pipe Size (NPS) 32-inch diameter pipeline 1370 km in length with associated sectionalizing block valves, scraper launching and receiving facilities and take-off valves for future take-off stations.
2. The pipeline pumping facilities of which six pumping stations were built for the first phase with design capacity of 300,000 bpd. Each pumping station includes three centrifugal pumps with two working and one in stand-by position; two screw pumps used for low-flow "yo-yo" operations and for initial start; heaters; dual fuel engines; tankage, fuel storage, and other utilities.
3. Marine Terminal which exports transported crude with a capacity of 2,000,000 barrels per day.

3.1.6 Pipeline Quick Reference Facts

- Construction began on October 8th, 2004 and was completed on December 24th, 2005.
- PDOC Pipeline System was designed and constructed to move oil from the south east of Sudan to the marine terminal at Port Sudan, North East of Sudan.
- Length: 1370 km.
- Diameter: 32 inches.
- Crosses mountain ranges, 2 major rivers and many streams and valleys.
- First oil moved through the pipeline on July 25, 2006.
- First tanker to carry crude oil from MT: August 30, 2006.
- Design life: designed for an operating life of 25 years.

- Line pipe is Carbon Steel, API 5L X65 & 70.
- Pipeline external coating: Three layer Poly Propylene (3LPP), consisting of 500 micron epoxy coating, primer and 2.5 mm Polypropylene, providing excellent protection against mechanical and impact damage.
- Cathodic Protection (CP) is the secondary means of combating external corrosion of the pipeline. The (CP) was designed to use the impressed current system and several factors were considered for its sizing namely, soil resistivity, required current density, coating breakdown factor and anode bed type.

4. 8Pumping Stations

Pumping Stations with Main Line Pumps, Hot Oil Heaters, Fuel Storage Tank and Control Building.

3.1.7 Bashayer (2) Marine Terminal

PDOC exports the Dar Blend Crude through its own Marine Terminal (**MT**) Bashayer (2) which was inaugurated by H.E. the President of the Republic of the Sudan on 11 July 2007.

The (MT) includes the following facilities:

1. Six (6) storage tanks with a capacity of 500,000 barrels each (total storage capacity is 3 million barrels).
2. Onshore Facilities: Heat Exchangers, Metering Skid, Boosters, Shipping Pumps and Heaters.
3. Offshore Facilities: Sub-sea Line, Pipeline End Manifold (**PLEM**), Single Point Mooring (**SPM**) and Jetty.
4. Water Treatment Unit.
5. Power Station.
6. Fire Fighting and Foam System.

3.1.8 Pipeline Special Achievements

- PDOC pipeline was subjected to a prolonged shutdown (about 15 months) as directed and effected by the Government of South Sudan in February 2012.
- PDOC under the direct supervision and follow up of the Ministry of Petroleum & Gas has successfully managed to preserve the pipeline, prevent crude gelling and secure pipeline integrity.
- Downstream facilities have also been preserved whereby corrosion and rust have been successfully prevented by applying advanced gravitational dewatering methodologies.
- Pump stations, the Marine Terminal and offshore system have successfully been preserved.
- Resumption of oil transportation has been conducted safely and successfully by PDOC.
- The above stated shutdown / resumption operations have professionally been carried out by a staff 98 % of whom are highly skilled Sudanese nationals.

3.2 Data collection and Calculation

A convenient measure of heat exchanger performance is its "efficiency" in transferring a given amount of heat from one fluid at higher temperature to another fluid at lower temperature. The efficiency can be determined if the temperatures at all flow openings are known Heat exchanger efficiency is defined as follows:

………………….………. equation (1)

$Q_{th}=(M_{th} * CP_{th}) * (Tth_{in} - Tth_{out})$……………..…. equation (2)

$Q_{cr}=(M_{cr} * CP_{cr}) * (Tcr_{out} - Tcr_{in})$……………..…. equation (3)

Where =

theminol Heat quaintly Q_{th} =

Q_{cr}= Crude oil heat quantity

M_{th}= Mass of therminol

M_{cr}= Mass of crude oil

CP_{th} = therminol Heat capacity

CP_{cr} = Crude oil heat capacity

Tth_{in}= in let temrature of theminol=centigrade

Tth_{out}=out let temrature of theminol=centigrade

Tcr_{out}= out let temperature of crude = centigrade

= in let temperature of crude = centigradeTcr_{in}

Actual heat transfer maximum possible heat transfeThe actualheat transfer can be calculated as either the energy lost by the hot fluid or the energy gained by the cold fluid. The maximum possible heat transfer is attained if one of the fluids was to undergo a temperature change equal to the maximum temperature difference present in the exchanger, which is the difference in the inlet temperatures of the hot and cold fluids.

Example for calculation of high effciceny.

571130 Kg/H =M_{th}

670300 Kg/H=M_{cr}

2.85 KJ/Kg.KCP_{th}=

2.13 KJ/Kg.K(Daily report, 2017)= CP_{cr}

132°**C**=Tth_{in}

103°**C**=Tth_{out}

71.9°**C**=Tcr_{out}

41.9°**C**=Tcr_{out}

2) to calculate heat transfer by theminol) Use Eq

Q_{th}=(M_{th} * CP_{th}) * (Tth_{in} - Tth_{out})…………..…. equation (2)

Kj/ K 47203849.5 =(103-132)*2.85* 571130=Q_{th}

3) to calculate heat transfer by curde oil) Use Eq

$Q_{cr}=(M_{cr} * CP_{cr}) * (Tcr_{out} - Tcr_{in})$……………..…. equation (3)

Q_{cr}=670300*2.13*(71.9-41.9)=42832170 Kj/ Kg

1) to calculate efficiency) Use Eq

…………………..………. equation (1)

ε = 47203849.5/42832170*100= efficiency=90.73%

CHAPTER IV
RESULTS AND DISCUSSION

CHAPTER IV

Results and Discussion

4.1 Results calculation

Table (4.1) show October data of crude oil and theminol

			thetmi					crude					
M th	CP th	T out	T in	delt T	Q th	M cr	CP cr	T in	T out	dekt T	Q cr	Thermal E	fuel cons
551230	2.85	101	130	29	45559160	670298	2.13	43.2	68.3	25.1	35836142	78.65848	5
549240	2.85	96	125	29	45394686	670292	2.13	43.7	64.2	20.5	29268300	64.47517	5
556205	2.85	98	133	35	55481449	670297	2.13	34.8	65.5	30.7	43831391	79.00189	5
553220	2.85	106	141	35	55183695	670300	2.13	44.1	70.2	26.1	37263988	67.52717	7
562175	2.85	102	132	30	48065963	670305	2.13	44.1	68.7	24.6	35122641	73.07175	5
554215	2.85	101	132	31	48964895	670295	2.13	44.1	68.2	24.1	34408253	70.27127	5
557200	2.85	110	147	37	58756740	670310	2.13	43.7	72.5	28.8	41119497	69.9826	7
558195	2.85	107	142	35	55679951	670288	2.13	43.7	73.2	29.5	42117546	75.64221	7
517400	2.85	99	126	27	39813930	670312	2.13	43.8	66.4	22.6	32267479	81.0457	8
573120	2.85	101	131	30	49001760	670303	2.13	43.8	67.7	23.9	34123115	69.63651	8
572125	2.85	100	128	28	45655575	670313	2.13	43.8	66.5	22.7	32410304	70.98871	8
574115	2.85	99	126	27	44178149	670307	2.13	43.9	66.8	22.9	32695565	74.00845	7
570135	2.85	97	124	27	43871888	670315	2.13	43.9	65.2	21.3	30411521	69.31892	7

As shown table (4.1) and graph (4.1) October data of crude oil and Hot oil fluid (theminol), the maximum crude oil temperature 73.2 degree and the fuel consumption is7m3/h with high efficiency 75.64%.

table (4.1) and graph (4.2) show October data of crude oil temperature 73.2degat theminol flow rate 558195Kg/ h, according to researchmust take in account the four items (crude oil temperature, theminol flow, efficiency rate and fuel consumption) together for example if the crude oil temperature is high against high fuel consumption this result is not considering, so this result is not suitable.

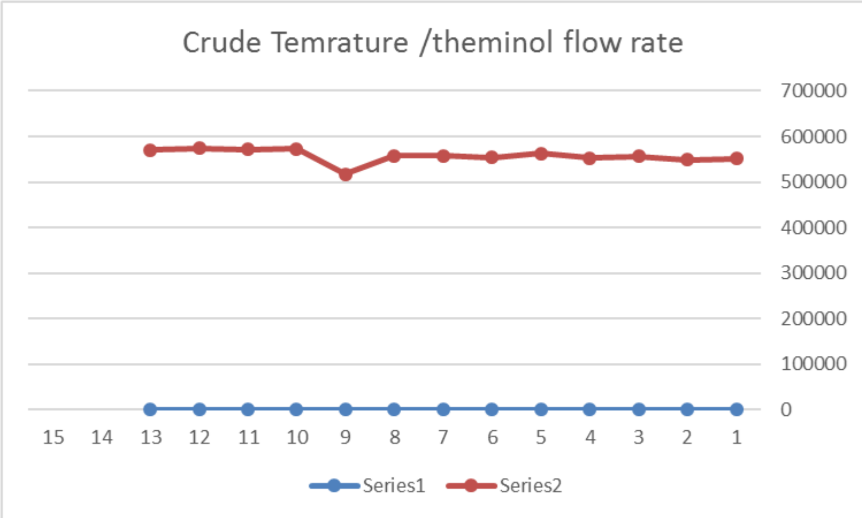

Figure (4.1) show Maximum crude temp 73.2when therminol flow rate is 558195Kg/ h

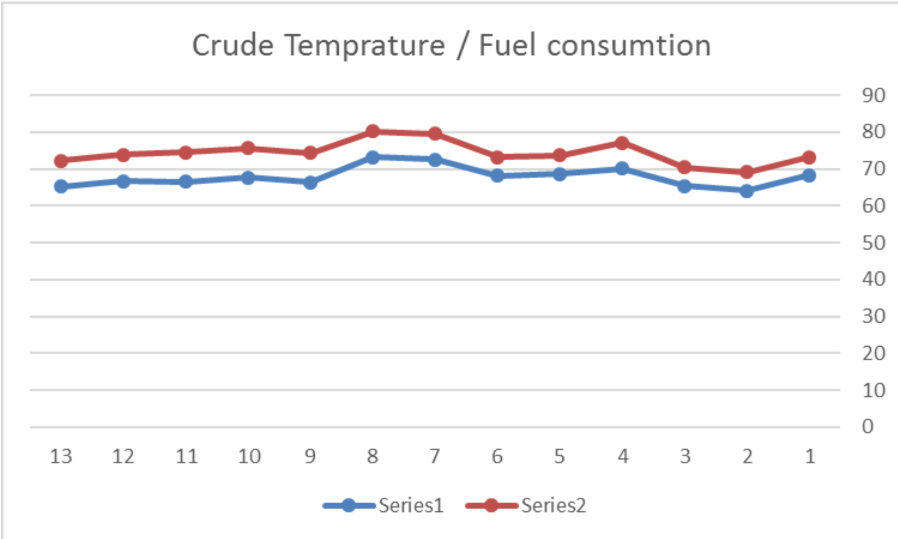

Figure (4.2) show Maximum crude temp 73.2 deg when fuel consumption is 7m3

Table (4.2) show November data of crude oil and theminol

			thetmi					crude								
M th	CP th	T out	T in	delt T	Q th	M cr	CP cr	in	out	dekt T	Q cr	thermal eff	fuel cons	therm capact	crud capacty	
567150	2.85	103	134	31	50107703	670301	2.13	43.8	72.6	28.8	41118945	82.06113	7	2.85	2.13	82.06113
570135	2.85	99	128	29	47121658	670305	2.13	43.8	68.5	24.7	35265416	74.83908	7	2.85	2.13	74.83908
575110	2.85	103	134	31	50810969	670288	2.13	43.8	69.2	25.4	36263921	71.37026	7	2.85	2.13	71.37026
569140	2.85	98	126	28	45417372	670319	2.13	43.8	65.7	21.9	31268370	68.84672	7	2.85	2.13	68.84672
572125	2.85	102	133	31	50547244	670307	2.13	43.8	68	24.2	34551645	68.35515	7	2.85	2.13	68.35515
567160	2.85	112	152	40	64656240	670313	2.13	43.7	74	30.3	43261331	66.90975	8	2.85	2.13	66.90975

As shown table (4.2) and graph (4.3) November data of crude oil and Hot oil fluid (theminol), the maximum crude oil temperature 74 degree and the fuel consumption is 8 m3/h with high efficiency 66.9%.

table (4.2) and graph (4.4) show October data of crude oil temperature 74 deg at theminol flow rate 567160Kg/ h , according to research must take in account the four items (crude oil temperature, theminol flow, efficiency rate and fuel consumption) together for example if the crude oil temperature is high against high fuel consumption this result is not considering, so this result is not suitable

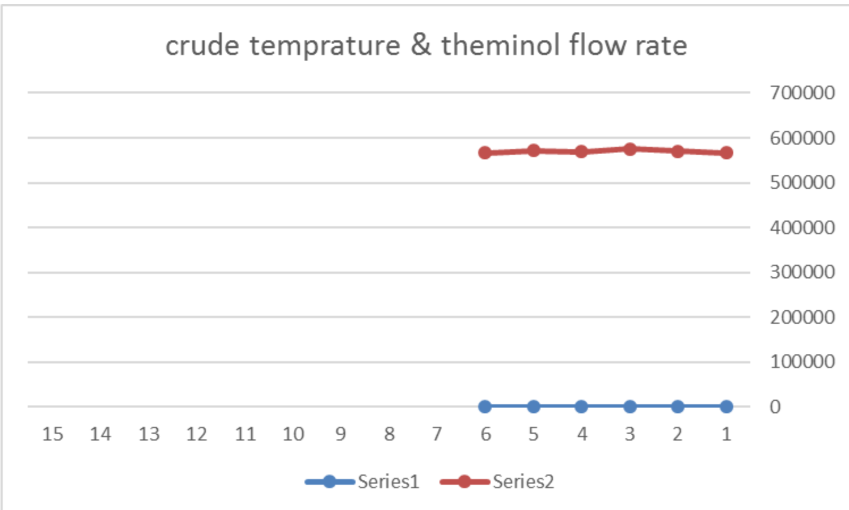

Figure (4.3) show Maximum crude temp is 74 deg when theminol flow rate is 567160 Kg/ h

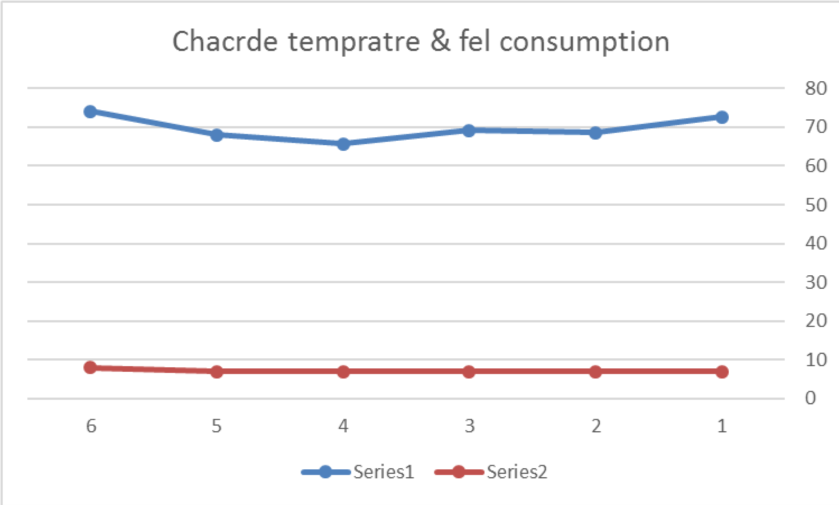

Figure (4.4) show Maximum crude temp 74 deg when minimum fuel consumption is 7 m3

Table (4.3) show December data of crude oil and theminol

			thetmi					crude					
M	C P th	T out	T in	delt T	Q th	M	C P cr	T in	T out	dekt T	Q cr	thermal eff	fuel cons
571130	2.85	103	132	29	47203895	670300	2.13	41.9	71.9	30	42832170	90.73864	4
567150	2.85	103	136	33	53340458	670305	2.13	41.8	71.8	30	42832490	80.30019	4
568145	2.85	100	128	28	45337971	670295	2.13	41.6	70	28.4	40547485	89.43383	4
572125	2.85	106	139	33	53808356	670310	2.13	41.4	70.5	29.1	41547825	77.21445	4
577100	2.85	106	141	35	57565725	670307	2.13	41.5	70.1	28.6	40833762	70.93416	5
563450	2.85	106	141	35	56204138	670315	2.13	41.4	70	28.6	40834249	72.65346	5
593020	2.85	110	141	31	52393317	670280	2.13	41.4	70.2	28.8	41117656	78.47882	5
595010	2.85	110	142	32	54264912	670295	2.13	41.4	69.8	28.4	40547485	74.72137	5
596005	2.85	111	141	30	50958428	670288	2.13	41.5	69.4	27.9	39833205	78.16804	5
597000	2.85	117	156	39	66356550	670312	2.13	41.7	67.5	25.8	36836326	55.51272	7
599985	2.85	120	160	40	68398290	670303	2.13	42.4	68	25.6	36550282	53.43742	7
601975	2.85	118	157	39	66909521	670313	2.13	42.6	67.9	25.3	36122497	53.98708	7
590035	2.85	116	155	39	65582390	670298	2.13	43	68	25	35693369	54.42523	7
600980	2.85	118	158	40	68511720	670292	2.13	43.4	69.2	25.8	36835227	53.76485	7
598990	2.85	119	160	41	69991982	670297	2.13	43.4	69.7	26.3	37549368	53.6481	7

As shown table (4.3) and graph (4.5) December data of crude oil and Hot oil fluid (theminol), the maximum crude oil temperature 71.9 degree and the fuel consumption is 4 m3/h with high efficiency 90.7%.

table (4.3) and graph (4.6) show October data of crude oil temperature 74 deg at theminol flow rate 571130 Kg/ h , according to research must take in account the four items (crude oil temperature, theminol flow, efficiency rate and fuel consumption) together for example if the crude oil temperature is high against high fuel consumption this result is acceptable so is suitable.

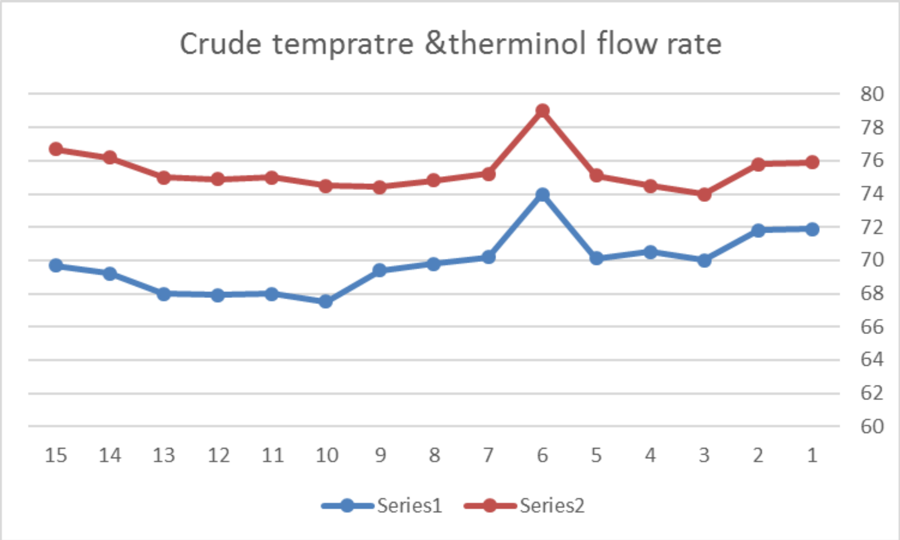

Figure (4.5) show Maximum crude oil temperature 71.9 deg   at theminol flow rate 571130 Kg/ h

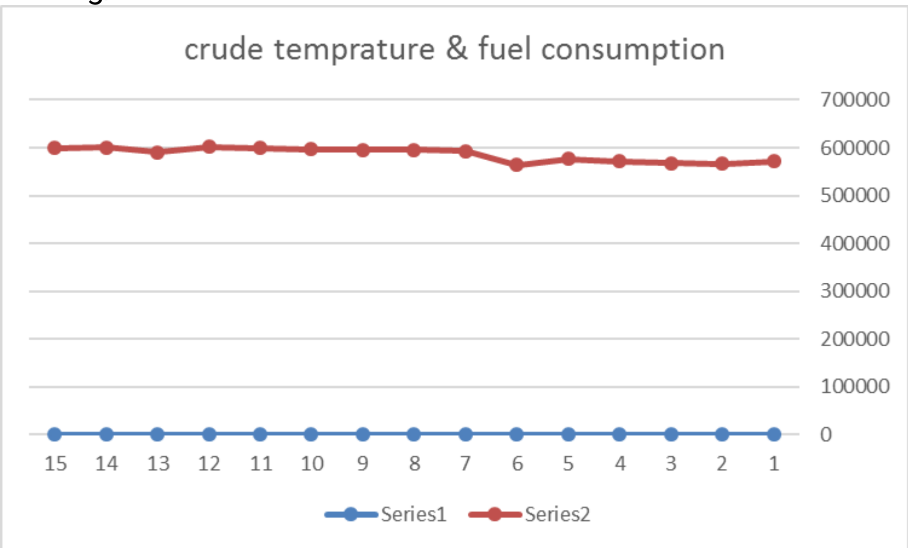

Figure (4.6) show Minimum fuel consumption 5m3/h with maximum crude oil temperature 71.9 deg

Table (4.4) show January data of crude oil and theminol

			thetmi					crude					
M th	CP th	T out	T in	delt T	Q th	M cr	CP cr	Tin	T out	dekt T	Q cr	thermal eff	fuel cons
593020	2.85	111	144	33	55773531	670980	2.13	43.5	67.9	24.4	34872173	62.52459	5
594015	2.85	111	145	34	57560054	670292	2.13	43.4	67.7	24.3	34693644	60.27382	5
598990	2.85	116	153	37	63163496	670288	2.13	43.2	71.5	28.3	40404290	63.96779	7
597000	2.85	109	141	32	54446400	670312	2.13	43.1	67.5	24.4	34837455	63.98486	5
596005	2.85	117	152	35	59451499	670303	2.13	42.1	72	29.9	42689587	71.80574	7
595010	2.85	117	152	35	59352248	670311	2.13	41.9	71.2	29.3	41833439	70.48333	7
597995	2.85	117	152	35	59650001	670298	2.13	41.9	71.7	29.8	42546495	71.3269	7

As shown table (4.4) and graph (4.7) January data of crude oil and Hot oil fluid (theminol), the maximum crude oil temperature 72 degree and the fuel consumption is 7 m3/h with high efficiency 71.8%.

table (4.4) and graph (4.8) show October data of crude oil temperature 72 deg at theminol flow rate 596005 Kg/ h , according to research must take in account the four items (crude oil temperature, theminol flow, efficiency rate and fuel consumption) together for example if the crude oil temperature is high against high fuel consumption this result is not considering, so this result is not suitable

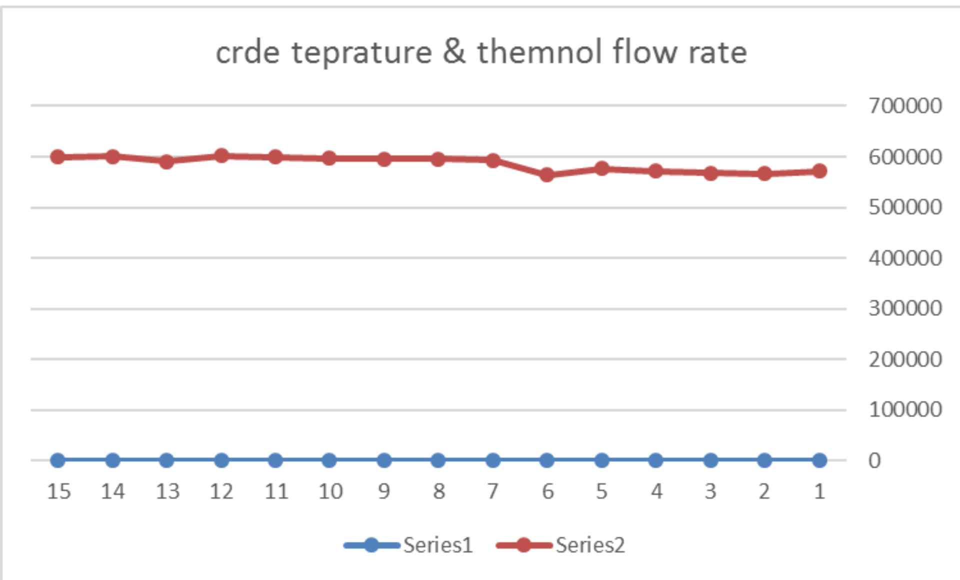

Figure (4.7) show Maximum crude temperature 72 deg when theminol flow rate is 596005 Kg/ h

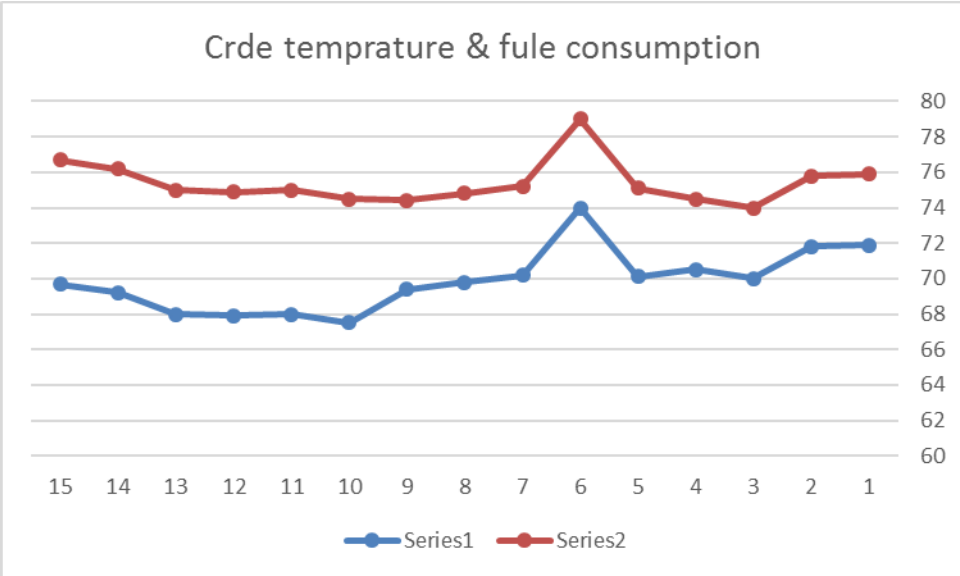

Figure (4.8) show Maximum temp72 deg when fuel cons 7 m3/h

Table (4.5) show February data of crude oil and theminol

			thetmi					crude					
M th	CP th	T out	T in	delt T	Q th	Mcr	CP cr	T in	T out	dekt T	Q cr	thermal eff	fuel cons
595010	2.85	117	153	36	61048026	596005	2.13	41.8	70.4	28.6	36307433	59.47356	7
596005	2.85	116	153	37	62848727	595010	2.13	41.8	69.8	28	35486396	56.46319	7
597000	2.85	115	150	35	59550750	597995	2.13	41.7	69.7	28	35664422	59.88912	7
613915	2.85	109	147	38	66486995	593023	2.13	41.7	70.7	29	36631031	55.09503	7
597030	2.85	122	160	38	64658349	595000	2.13	41.7	72.5	30.8	39034380	60.37021	7
651725	2.85	111	140	29	53865071	596005	2.13	41.7	72	30.3	38465567	71.41096	5
623865	2.85	111	140	29	51562442	597000	2.13	41.5	66.5	25	31790250	61.65389	7
605955	2.85	109	138	29	50082181	670288	2.13	41.5	64.9	23.4	33408494	66.70735	5
607945	2.85	121	156	35	60642514	670319	2.13	41.5	70.1	28.6	40834493	67.33641	7
611925	2.85	126	155	29	50575601	670307	2.13	41.5	69	27.5	39263233	77.63275	7
612920	2.85	120	156	36	62885592	551230	2.13	41.5	69.4	27.9	32757945	52.09134	7
609935	2.85	120	155	35	60841016	549240	2.13	41.5	69.1	27.6	32288721	53.07065	7
608940	2.85	122	158	36	62477244	556205	2.13	41.6	69.8	28.2	33409010	53.47388	7
610930	2.85	122	157	35	60940268	553220	2.13	41.6	69.3	27.7	32640533	53.56152	7
613915	2.85	123	158	35	61238021	597010	2.13	41.7	69	27.3	34715534	56.68951	7

As shown table (4.5) and graph (9.4) February data of crude oil and Hot oil fluid (theminol), the maximum crude oil temperature 72.5 degree and the fuel consumption is 7 m3/h with high efficiency 60.3%.

table (4.5) and graph (10.4) show October data of crude oil temperature 72 deg at theminol flow rate 597030 Kg/ h , according to research must take in account the four items (crude oil temperature, theminol flow, efficiency rate and fuel consumption) together for example if the crude oil temperature is high against high fuel consumption this result is not considering, so this result is not suitable

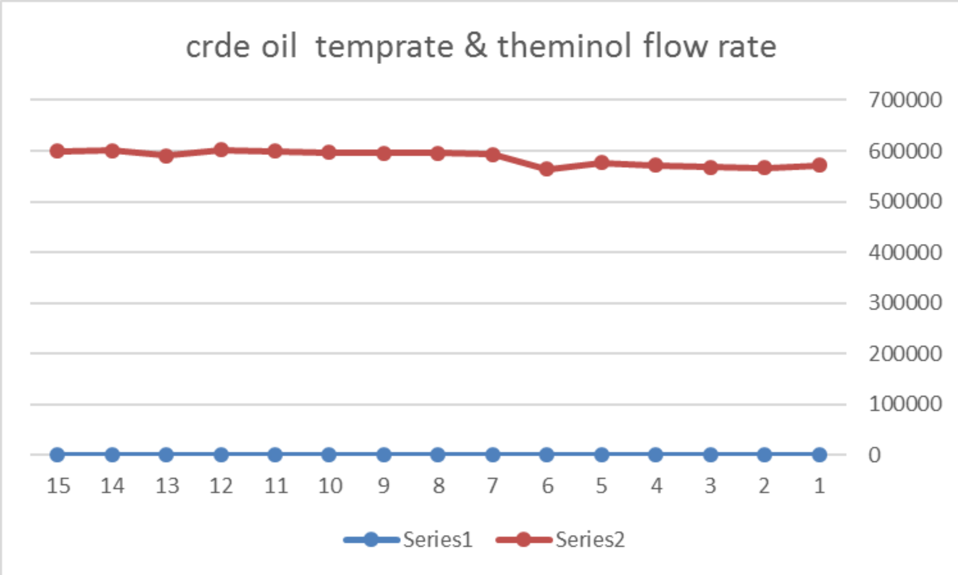

Figure (4.9) show Maximum crude temp is72.5deg when flow rate 597030 Kg/ h

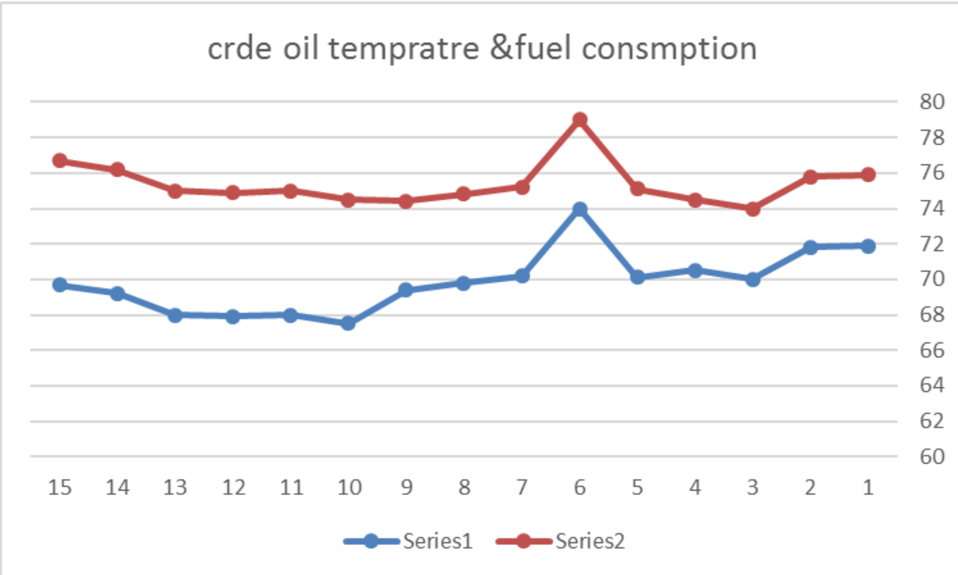

Figure (4.10) show Maximum crude temp 72.5 when minimum fuel consumption 5

4.2 Result

1. Maximum thermal efficiency is 90.7 with low fuel 4 meter cubic per hours consumption occurs in December 2017 when thermal flow rate was 571130 Kg/ h .
2. It can increase the crude oil temperature out let of heat exchanger to some extend with the same fuel consumption when change thermal flow rate.
3. the suitable fuel consumptions 4 meter cubic per hours which give the highest crude oil temperature about 71 degrees Centgarde, the result can be taken as operation reference procedures.

4.3 Discussion

This result is not give high accuracy because it is not taking in account the calculation of quantity of heat which gain by the fuel consumption to rise up the thermal fluid temperature.

The data is taken from local gage and control room computers

In petrodar operating com pany there are two heater in the station one on line and the other stand by so the data taken from both of them if it taken from one heater the study will be very accurate because there are different in the heater performance.

CHAPTER V

CONCLUSION AND RECOMMENDATION

CHAPTER V

Conclusion and recommendation

5.1 Conclusion

Increase of the heat transfer coefficient as the flow rate for the heat exchanger increased. This means that increasing flow allows for more heat to be transferred between the two fluids. By taking into account the size and flow rate, the desired temperature can be reached while maximizing efficiency and reducing costs

5.2 Recommendation

1. The operation method of the heater to obtain the optimum crude temperature degree Celsius with low fuel consumption and high efficiency 90.7%.by flow thermal rate571130 Kg/ h .
   In the next study mut taking in account the calculation of quantity of heat which gain by the fuel consumption to rise up the thermal fluid temperature .result can obtain high accuracy.
2. The operation method which obtained can be used for all petdodar operating co as manual procedure.

References

Aaron, e. a. (2016). *small shell and tube heat exchanger.* che0101 groub A-4. luke barone,tanner boyle.

Beck, D. (1998). *Classification of heat exschangers.* New York: Chapman& Hall.

Beck, D. D. (1996). *Gas Turbine Regenerators.* New York: Chapman &Hall.

company, P. O. (2018). *petrodar anual report.* khartoum: Carrancy printing.

Fakheri, A. (2007). Heat exchanger effciency. *journal of heat transfer*.

Jonathan Fiedler. (1998). *an overview of pipeline leak detection technologies.* London.

Lab, U. o. (n.d.). *Heat exchanger.*

prod technol, J. p. (2013, 10 22). *A review of technologies for transporting heavy crude oil and bitumen via pipelines*. Retrieved from Springerlink.com.

Su Thet Mon Than, e. (2008). *Heat exchanger desigin.* world Academyof Science,Engineering Technology.

tutorial, f. s. (2011). *heat exchanger .*