तेल एवं गैस उत्पादन प्रौद्योगिकी संस्थान

Institute of Oil and Gas Production Technology

पनवेल, नवी मुंबई

Panvel, Navi Mumbai

Project Report

on

मेहसाणा परिसंपत्ति में इमल्शन गर्म करने की वैकल्पिक प्रणाली के लिए तकनीक

Technology for Alternate System for Heating Emulsion, Mehsana Asset

जुलाई - 2022

तेल एवं गैस उत्पादन प्रौद्योगिकी संस्थान

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कं.सं.: IO.22I.PT_MH.041S

दिनांक: 04/08/2022

विषय: मेहसाणा परिसंपत्ति में इमल्शन गर्म करने की वैकल्पिक प्रणाली के लिए तकनीक

Subject: Technology for Alternate System for Heating Emulsion, Mehsana Asset

" मेहसाणा परिसंपत्ति में इमल्शन गर्म करने की वैकल्पिक प्रणाली के लिए तकनीक " रिपोर्ट की प्रति आपके अवलोकनार्थ संलग्न है।

Please find enclosed a copy of the report on "Technology for Alternate System for Heating Emulsion, Mehsana Asset" for your kind perusal.

नितीन जोशी

एन.बी.जोशी
N. B. Joshi
Head of Department, SF & PE

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तेल एवं गैस उत्पादन प्रौद्योगिकी संस्थान

Institute of Oil and Gas Production Technology

पनवेल, नवी मुंबई

Panvel, Navi Mumbai

Project No: IO.22I.PT_MH.041S

Acc No: 3024

मेहसाणा परिसंपत्ति मैं पायस गर्म करने की वैकल्पिक प्रणाली के लिए प्रौद्योगिकी

Technology for Alternate System for Heating, Mehsana Asset

कार्यकेंद्र : मेहसाणा परिसंपत्ति

Work Centre: Mehsana Asset

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अनुमोदित : दिनेश कुमार , समूह महाप्रबंधक- संस्थान प्रमुख

Approved by Dinesh Kumar, GGM-HOI

Institute of Oil and Gas Production Technology

Panvel, Navi Mumbai

Executive Summary

This pertains to the project titled "**Technology for Alternate System for Heating Emulsion, Mehsana Asset**" taken up by IOGPT as a scheduled project under AWP 2022-23.

At Mehsana Asset, presently fuel gas system is used in bath heaters and heater treaters for heating the emulsion to the desired temperature for effective separation of oil and water. As intimated by Asset fuel gas availability is less, which is likely to aggravate in future. Hence, Asset is interested to explore alternate heating options in order to save on fuel gas.

In the present study, alternative heating systems namely solar-based and electrical-based heating systems have been explored. Literature survey was carried out to explore the latest technologies suitable for the instant case. Technology suppliers and vendors were contacted for getting information such as technology, capacity, foot-print requirement etc. Based on the details gathered, schemes were conceptualized for both the system considering minimum modifications required in the existing set-up.

Comparative study along with the ball-park estimates were made for the two systems. It reveals that the solar-based heating system may be preferred over electric-based system subject to availability of the area required at the respective installations. However, if availability of area is a constraint, electric-based heating system may be selected.

The details of both the systems along with schemes conceptualized are brought out in the report.

29/07/2022
Dinesh Kumar
Group General Manager
Head of the Institute

Contents

1. Background

Mehsana Asset lies in North Gujarat about 56 km North of Ahmedabad. The various structures in Mehsana Asset include North Kadi, Jotana, Santhal, Balol, Lanwa, Bechraji, Sobhasan, Nandasen, Linch, Unawa, Langnej and Mansa. At present, fuel gas is used in in-direct bath heaters (IDBH) and direct-fired heater treaters for heating the emulsion to the desired temperature. In Mehsana Field, there is less availability of fuel gas, which is likely to aggravate in future. Hence, Asset is interested to explore alternate heating options.

2. Scope of Work

- Study of the existing system, viz., bath heaters and heater treaters
- Technology scouting and vendor interaction for alternate heating system
- Scheme for retrofitting new heating system in existing plants

3. Basis of Study

Primarily, bath heaters and heater treaters are used in oil and gas industry to heat emulsions.

Indirect bath heaters are used mainly to heat process fluids. The mechanism takes place indirectly through a bath (utility bath) as opposed to heating directly by flames. A typical schematic of a bath heater is shown in Figure 3.1.

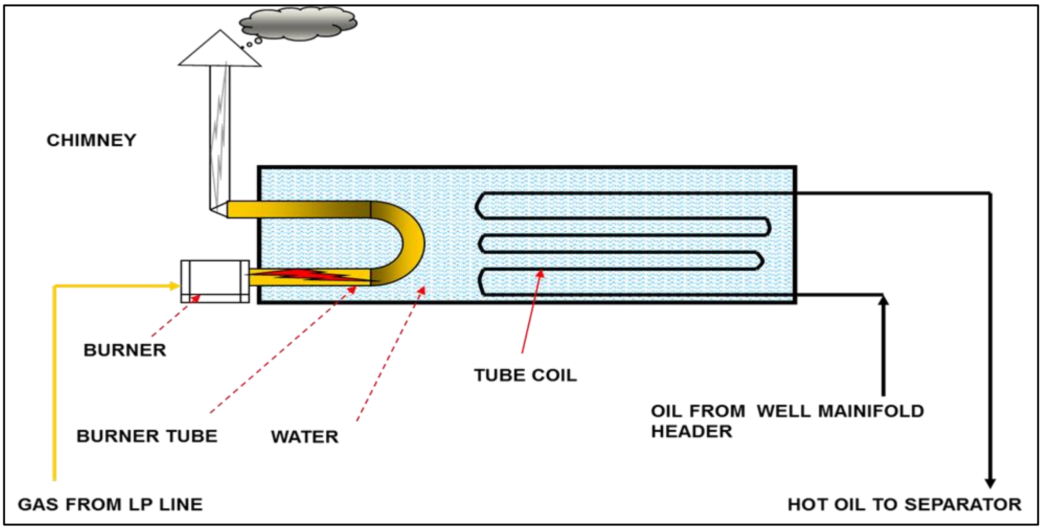

Figure 3.1: A typical schematic of a bath heater

A heater treater in oil and gas is a 3-phase separator vessel that utilizes heat and mechanical separation devices to facilitate the separation of oil-water emulsions before transporting the dry oil through pipelines.

A typical schematic of a heater treater is shown in Figure 3.2.

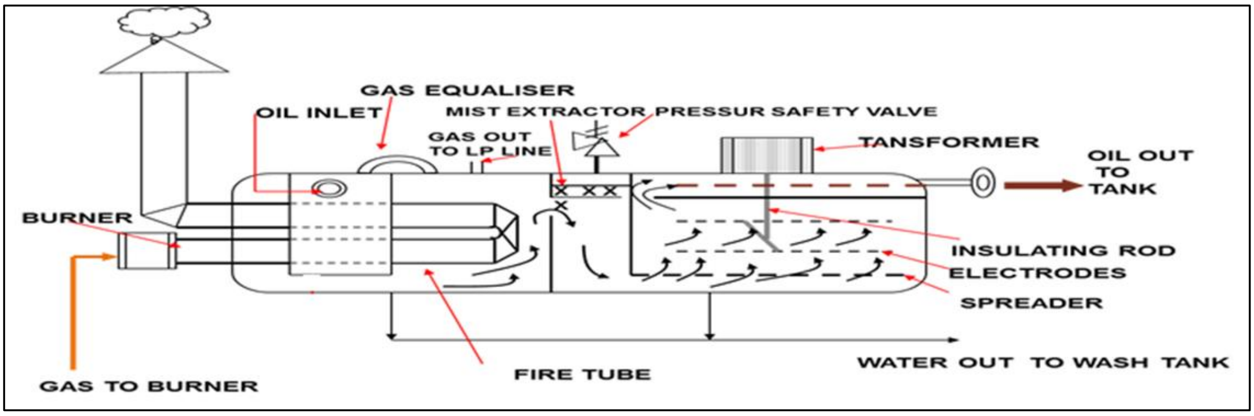

Figure 3.2: A typical schematic of a heater treater

3.1. Details of bath heaters used by the Asset :

The input data provided by the Asset for the existing bath heaters' process details etc. is given below.

- Inlet temperature of well fluid to bath heater: 25 ^{0}C – 40 ^{0}C
- Outlet temperature of well fluid from bath heater: 60 ^{0}C
- Range of operating pressure of bath heater: 2- 4 ksc
- Heat duty of the installed bath heaters at various installations varies widely.
    - Peak heat duty amongst all the bath heaters installed in Asset : 6,500 kW
    - Heat duty of CWS (Central Workshop) bath heaters: 351 kW

3.2. Details of heater treater used by the asset :

The input data provided by the Asset for the existing heater treaters' process details etc. is given below.

- Inlet Temperature of well fluid to heater treater: 50 ^{0}C – 60 ^{0}C
- Outlet temperature of well fluid from heater treater: 80 ^{0}C
- Range of operating pressure of heater treater: 1- 3 ksc
- Heat duty of the installed heater treater at various installations varies widely.
    - Peak heat duty amongst all the heater treater installed in asset : 6,500 kW
    - Heat duty of CWS (Central Workshop) heater treater: 415 kW

3.3. Other input data provided by the asset:

3.3.1. Installation wise gas composition analysis (attached at Annexure-1)

3.3.2. Installation wise gas analysis report (attached at Annexure-2)

3.4. In the present study, two options of alternate systems for heating emulsions have been explored in detail. These are:

1. Solar based heating system
2. Electric based heating system

4. Solar-Based Heating System:

4.1. Introduction:

Solar heating systems can be divided into two groups, passive solar heating and active solar heating. In essence, these systems harvest thermal energy from the sun and utilize the collected heat for space heating purpose or to heat domestic water. Passive solar systems rely on the structure of the building to collect heat. This could be in the form of a tilt or a roof orientation that allows for higher solar irradiance. On the contrary, active solar heating systems rely on heat pumps that transfer the collected heat from the solar collectors to the building. In this study a active solar based heating system is proposed in which has the following primary components:

a) Solar Concentrators
b) Solar Thermal Collectors

A solar based heating system has been conceptualized in which solar energy will be utilised to heat either water (for bath heater) or crude oil (for heater treater). In this scheme, solar concentrators are used in combination with solar collectors to extract the required solar energy. A schematic diagram of same is shown in Figure 4.1.

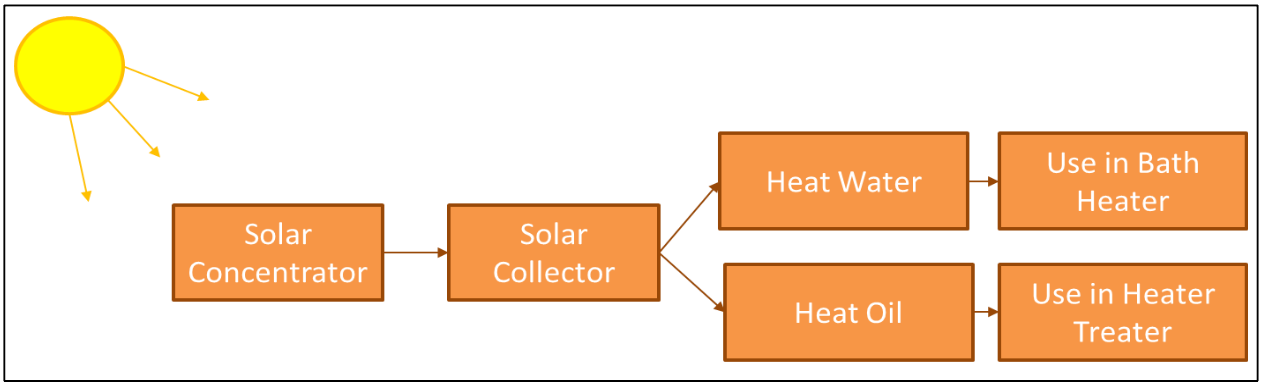

Figure 4.1: Scheme for solar based alternate heating system

4.2. Solar Concentrators:

Solar concentrators are systems that reflect or refract the incident solar radiation from one reflective "aperture" of surface Aa (m^2) to an "absorber" (or receiver) of area Ar (m^2), where Aa≫Ar applies. These systems are used to increase the intensity of the incident solar radiation. These systems are generally used in combination with solar thermal collectors to utilize the concentrated solar radiation. A schematic diagram of solar concentrators is shown in Figure 4.2.

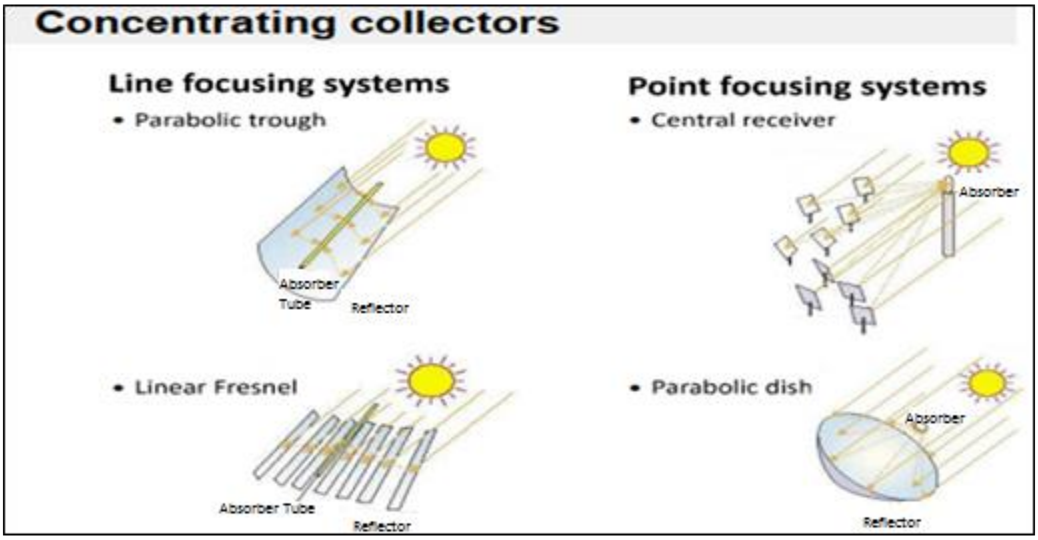

Figure 4.2: Schematic diagram of concentrating collectors

4.3. Solar Thermal Collectors:

A solar thermal collector collects heat by absorbing sunlight. Solar thermal collectors are either non-concentrating or concentrating.

In ***non-concentrating collectors***, the aperture area (i.e., the area that receives the solar radiation) is roughly the same as the absorber area (i.e., the area absorbing the radiation). A common example of such a system is a metal plate that is painted a dark color to maximize the absorption of sunlight. The energy is then collected by cooling the plate with a working fluid, often water or glycol running in pipes attached to the plate. Non-concentrating collectors are typically used in residential, industrial and commercial buildings for space heating. Two types of non-concentrating solar thermal collectors are prominently used in industry in corroboration with presently available R&D.

a) Flat Plate Collector(FPC)
b) Evacuated Tube Collector(ETC)

A **flat-plate collector (FPC)** is a device to collect solar energy and transform it into thermal energy (low-grade energy) by using water as a working fluid. It is a heart of solar thermal devices that has many applications in a medium temperature range ≅100 °C from domestic to preheating to industrial sectors. The hot water available from flat-plate collectors (FPC's) can be also used to conserve fossil fuel. The schematic diagram of the same is shown in Figure 4.3.

Figure 4.3: Schematic of Flat Plate Collector

The **evacuated tube collector (ETC)** consists of a number of sealed glass tubes which have a thermally conductive copper rod or pipe inside allowing for much high thermal efficiency and working temperature compared to the flat plate solar collectors even during a freezing cold day. The schematic diagram of the same is shown in Figure 4.4.

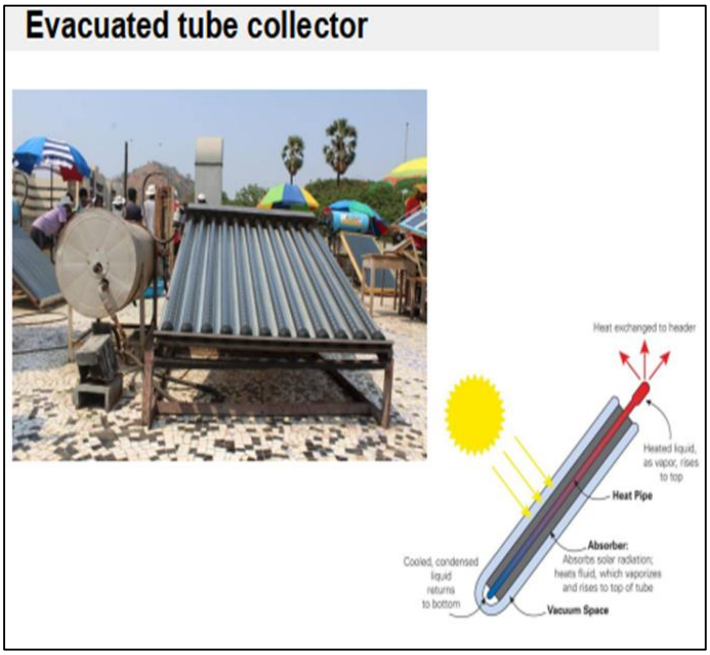

Figure 4.4: Schematic of Evacuated Tube Collector

Concentrating collectors (solar thermal collectors used in combination with solar concentrators) have a much larger aperture than the absorber area. The aperture is typically in the form of a mirror that is focussed on the absorber, which in most cases are the pipes carrying the working fluid. Due to the movement of the sun during the day, concentrating collectors often require some form of solar tracking system, and are sometimes referred to "active" collectors for this reason. Concentrating collectors in concentrated solar power plants generate electricity by heating a heat-transfer fluid to drive a turbine connected to an electrical generator.

A most commonly used type of concentrating collectors is Compound Parabolic Collectors (CPCs). CPCs are non-imaging concentrators and have potential as collectors of solar energy. They have the capability of reflecting to the absorber all of the incident radiation within wide limits. Necessity of moving the concentrator to accommodate the changing solar orientation can be reduced by using a trough with two sections of a parabola facing each other, as shown in Figure 4.5.

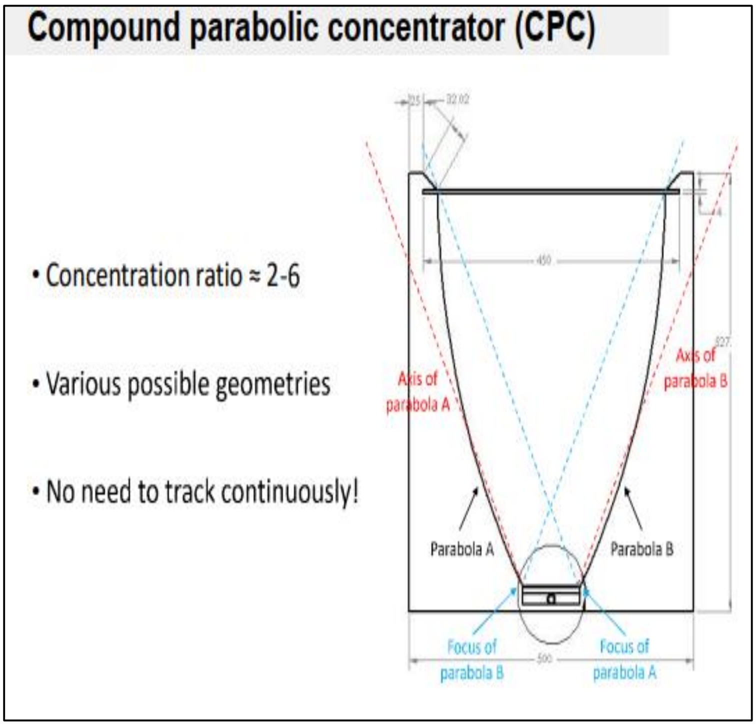

Figure 4.5: Schematic diagram of Compound Parabolic Concentrator

4.4. Proposed solar based heating system for bath heater:

A scheme of alternate heating based on solar heating has been conceptualised for bath heater. In this, water is first heated using the solar radiations received via solar concentrator- collector (evacuated tube) unit. Then heated water will be routed to a vessel where an auxillary heating unit will be provided to maintain the required water temperature depending upon the flow rate and required heat duty. Next the regulated heated water will be routed to the bath heater for heating the well fluid followed by recirculating water back to the solar heating unit. The existing fuel gas-based heating system will be retained as a back-up (Ref.: Sec 6.1). The schematic of same is shown in Figure 4.6.

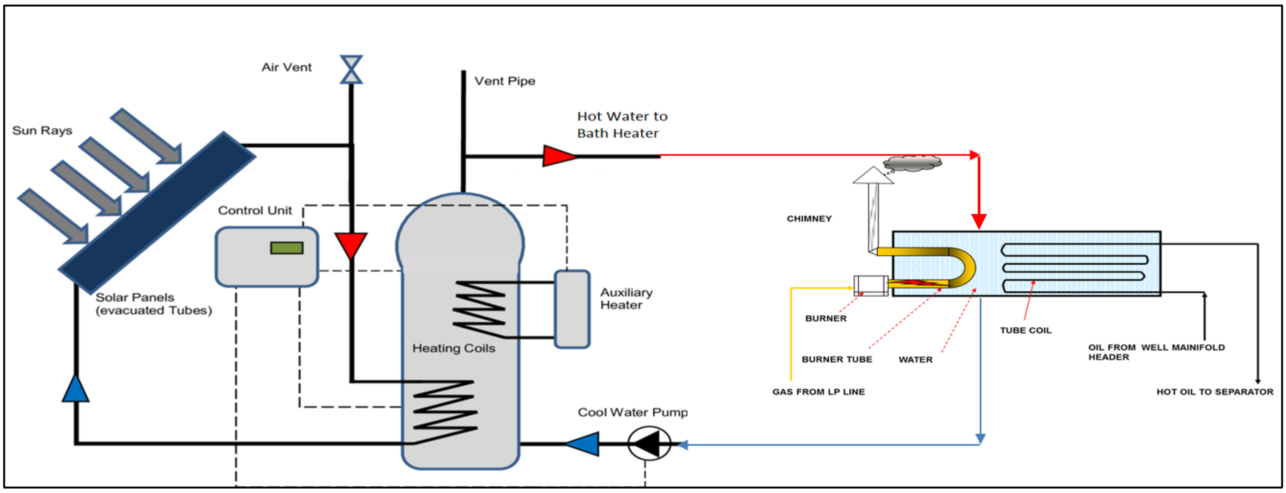

Figure 4.6: Schematic of proposed solar based heating system for bath heater

4.5. Proposed solar based heating system for heater treater:

A scheme of alternate heating based on solar heating has been conceptualised for heater treater. In this, crude oil is first heated using the solar radiations received via solar concentrator- collector unit. Then heated oil will be routed to a vessel where an auxillary heating unit will be provided to maintain the required oil temperature depending upon the flow rate and required heat duty. Next the regulated heated oil will be routed to the heater treater for further separation. The existing fuel gas-based heating system will be retained as a back-up (Ref.: Sec 6.1). The schematic of same is shown in Figure 4.7.

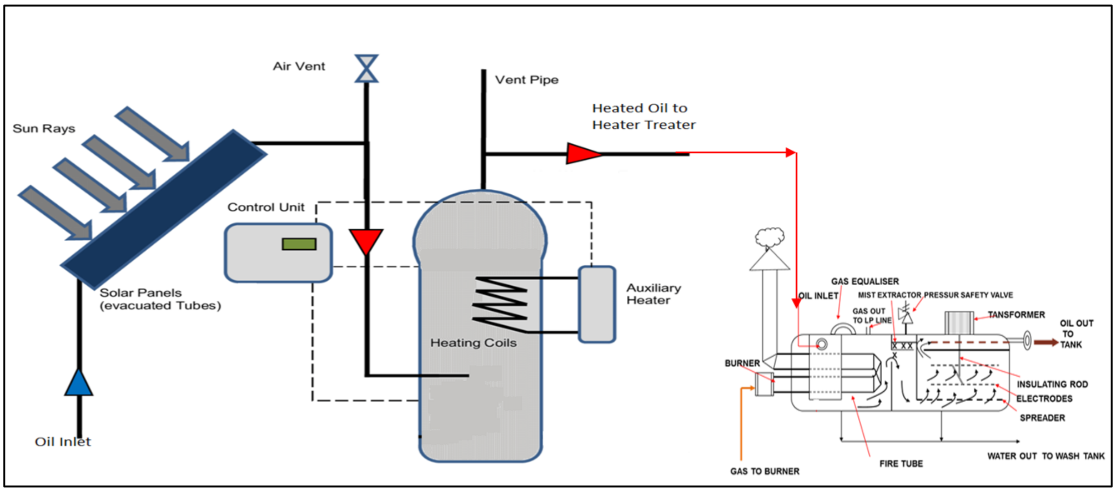

Figure 4.7: Schematic of proposed solar based heating system for heater heater

5. Electric-Based Heating System:

5.1. Introduction:

Electric heating is a process in which electrical energy is converted directly to heat energy. Common applications include space heating, cooking, water heating and industrial processes. Three electric-based heating systems are explored in this section to heat either water (for bath heater) or crude oil (for heater treater).

a) Electrical Heat Pump
b) Induction Based Heating System
c) Immersion Heaters

5.1.1. Electric heat pump:

A heat pump is a device that can heat a building (or part of it) by transferring thermal energy from the outside using the refrigeration cycle. Many heat pumps can also operate in the opposite direction, cooling the building by removing heat from the enclosed space and rejecting it outside. Units that only provide cooling are referred to as air conditioners. When in heating mode, a refrigerant at outside temperature is being compressed. As a result, the refrigerant becomes hot. This thermal energy can be transferred to a central heating system. After being moved outdoors again, the refrigerant is decompressed, i.e., evaporated. In the process it has lost some of its thermal energy and returns colder than the environment. It can now take up the surrounding energy from the air or from the ground before the process repeats. Compressors, fans, and pumps run with electric energy. The efficiency of a heat pump is expressed as a coefficient of performance (COP), or seasonal coefficient of performance (SCOP). The higher the number, the more efficient a heat pump is and the less energy it consumes. A heat pump can achieve around 300% efficiency for heating, or 3.0 Coefficient of performance, because it uses electric power only for transferring existing thermal energy from the surrounding area, mostly air.

5.1.2. Induction based heating system:

Induction heating is the process of heating electrically conductive materials like metals by electromagnetic induction, through heat transfer passing through an induction coil that creates an electromagnetic field within the coil to melt down steel, copper, brass, graphite, gold, silver, aluminum, and carbide. An induction heater consists of an electromagnet and an electronic oscillator that passes a high-frequency alternating current (AC) through the electromagnet. The rapidly alternating magnetic field penetrates the object, generating electric currents inside the conductor, called eddy currents. The eddy currents flow through the resistance of the material, and heat it by Joule heating. In ferromagnetic and ferrimagnetic materials, such as iron, heat also is generated by magnetic hysteresis losses. The frequency of the electric current used for induction heating depends on the object size, material type, coupling (between the work coil and the object to be heated) and the penetration depth. A typical induction based heating unit is shown in Figure 5.1.

Figure 5.1: A typical induction based heating unit

5.1.3. Immersion heaters:

An immersion heater is a fast, economical, and efficient method for heating liquids in tanks, vats, or equipment. Known as bayonet heaters, they have heating elements that can be directly inserted into a container of water, oil, or other material in order to heat the entire contents.

By using the direct heat transfer of an immersion heater, liquids quickly reach the desired temperature. Made of bundles of tubing, immersion heaters can be mounted on the side of a container or submerged in the contents. Their heating coils transfer heat to the contents, which spreads throughout the container.

Immersion heaters are a cost effective and ecologically sound method for heating material and provide a clean source of energy without leaving residual discharge or pollutants. In nuclear reactors, immersion heaters are used to keep heated water at a constant temperature for creating steam. A typical industrial immersion heater unit is shown in Figure 5.2.

Figure 5.2: A typical industrial level immersion heater element

5.2. Proposed electric based heating system:

A scheme for electric based heating system has been proposed in which either of the above three mentioned methods, viz., electric heat pump, induction heating or immersion heating system can be used to heat either water (for bath heater) or crude oil (for heater treater). A simplified conceptual diagram of same is shown in Figure 5.3.

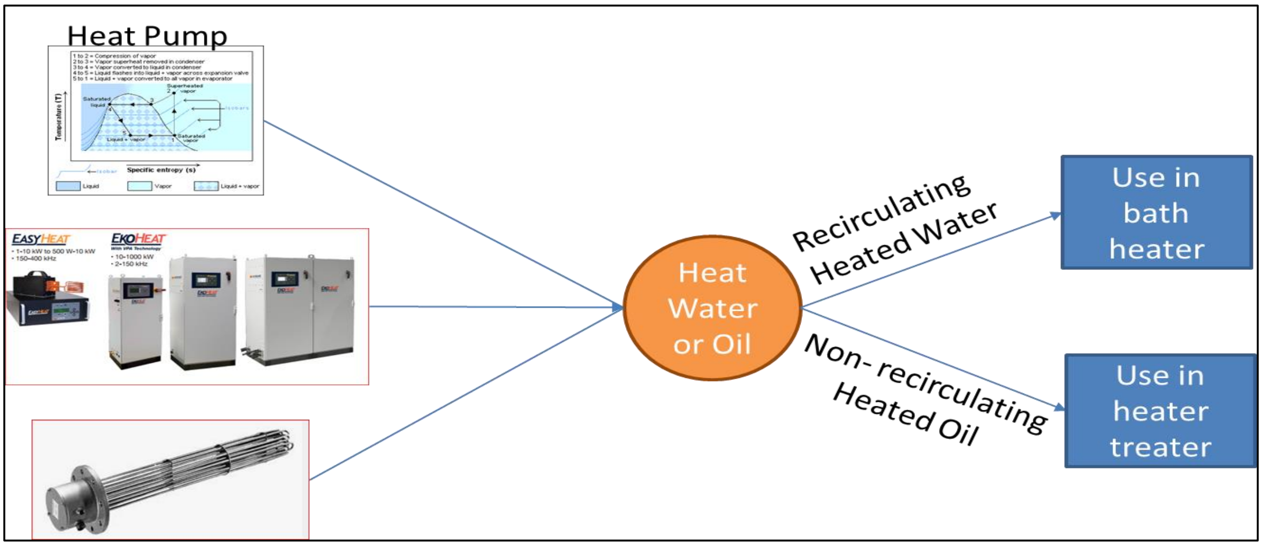

Figure 5.3: Scheme for electric heating system

6. Vendor Interaction:

6.1. Solar-based heating system:

Various vendors for solar-based heating system have been contacted. A few of those who have responded positively are mentioned below.

1. Sunbest Solar: Theni, TN based company
2. Heatray Solar: Mumbai based company
3. Yash Corporation: Currently working in Mehsana Asset, maintaining the existing PV Solar panels

Following points have emerged while having brief deliberations with the above-mentioned vendors about the specifications of the system:

1) Cost of one unit for a 350 kW heating unit is approximately 7.5 cr INR to 8 cr INR for whole day operation.
2) Approximate area requirement of an evacuated tube-based solar system for a 350 kW heating unit will be 4200 sq. meter (~65 m x 65 m).
3) Cost of unit and area required to lay down the solar heat collectors are linearly proportional to the power requirements.
4) For night operation/ monsoon season, following back-up systems can be used:
   a) Battery units to store solar powers: Extra PV (Photo Voltaic) based solar panels will be required, which will require extra area to lay down PV solar panels for it
   b) Hybrid system: Can use the auxiliary heating equipment along with a smaller solar battery unit
   c) Use of existing system: Gas can be used as a last resort subject to availability of fuel gas in future.

6.2. Electric-based heating system:

Various vendors for electric-based heating system have been contacted. A few of them those who have responded positively are:

1. Ambrell: USA based company, distributers available in India
2. Aestus induction: Bangalore based company
3. Heatray Solar: Mumbai based company

Following points have emerged while having brief discussion with the above-mentioned vendors about the specifications of the system:

1) Cost of one unit for a 350 kW heating unit is 1.5 cr INR to 2 cr INR.
2) Approximate area requirement of the electric-based heater of 350 kW capacity is 200 sq. meter.
3) Cost of unit required to install the electrical heaters is linearly proportional to the power requirements.

7. General Comparison and Preliminary Economic Analysis:

A general comparision of solar-based heating system and electric-based heating system has been done based on some common parameters. The same has been shown in Table 7.1.

Table 7.1 General comparision of solar and electric based heating system

S.N.	Comparison Parameter	Solar- based system	Electric-based system
1	Heating Efficiency	Heating efficiency depends upon weather and climatic conditions.	Heating system depends upon power availability.
2	Size and Installation	Bulkier unit	Light unit
3	Capex and Opex	Solar energy is like something from nothing.	Electric heaters are way cheaper than solar units, however operational cost is very high as compared to solar energy.
4	Durability	Both units have almost same durability subject to the timely maintenance.	Both units have almost same durability subject to the timely maintenance.
5	User Friendly	Frequent maintenance may be required than the electric- based system.	Despite high OPEX in the electric-based heating system, it is more user-friendly.
6	Energy Efficiency	More efficient	Less effiecient

7	Carbon Credit	1 kWh unit of energy generated by solar unit = 0.932 kg of CO_2 reduction. Solar energy use helps in gaining carbon credits.	No carbon credits
8	Environmental Impact	Use of solar energy reduces the burden on environmental resources and helps to achieve self- sustainability.	No positive impact on environment
9	Taxation Benefits	Tax breaks and cash incentives are provided by central and state governments as a promotional initiative in case of solar energy.	No tax benefits/ reliefs

In solar-based heating system, the CAPEX is around 7.5- 8 crores INR contrary to 1.5- 2 crores INR of electric-based heating system. However, when it comes to OPEX, solar-based heating system has a very minimal OPEX compared to electric-based heating system. In fact additionally there will be tax benefits and carbon credit gains, if solar-based heating system is adopted.

A sample calculation for OPEX of electric-based heating system for a 350 kW unit considering electricity cost as 7 ₹/ kWh:

Annual electricity consumption cost = 7 ₹/ kWh x 350 kW x 24 hours x 365 days= 2.1 cr

This shows that the annual OPEX of electric-based heating system itself is more than its CAPEX.

CAPEX and OPEX of both the systesms as mentioned above indicate that in long term, solar-based heating system will be highly economical in comparison to electric-based heating system.

8. Summary and Conclusion:

At present in Mehsana Asset, fuel gas-based system is used in bath heaters and heater treaters for heating the emulsion to the desired temperature. Fuel gas availability is less in the Asset, which is likely to further aggravate due to increased lift gas requirement in future; hence Asset is interested to explore alternate heating options. Accordingly, solar and electric based alternative heating systems have been explored in this study.

A comparative ballpark estimate indicates that solar system will be a better option than electrical system. However, approximate area requirement of the solar system (considering evacuated tube based) for a 350 kW heating unit is 4200 sq. meter (~65 m x 65 m). Hence, depending upon installation-wise space availability, solar system may be selected for individual installations.

However, despite high OPEX in the electric-based heating system, it can be easily installed and is more user-friendly.

1. Annexures

Annexure-I

Installation wise gas composition report:

Oil and Natural Gas Corporation Limited
Chemistry Section, ST, Mehsana

Santhal Main ICP
Date: 21.02.2022

Test Report No: S. Main / CHEM / GAS / 12 /2022
Gas analysis and calculation (as a real gas) done by ISO 6974-4 and ISO 6976 methods respectively.
H_2S determination done by ASTM D-4810 method.
D.O.C:- 21.02.2022

Sr.No.	Sample Source	N_2	C1	C2	C3	iC4	nC4	iC5	nC5	C6	CO_2	GCV	NCV	Sp.Gr.	Mol. Wt.	H_2S
		mol %										KCAL / SCM		wrt air	gm / mol	ppm
1	NK CTF HT Fuel gas	0.21	85.58	2.21	1.36	0.92	0.48	0.20	0.25	2.14	6.65	9864	8928	0.7257	20.96	12
2	NKGGS-1 HT Fuel gas	0.36	92.79	0.93	0.29	0.24	0.10	0.05	0.06	0.47	4.71	8925	8047	0.6277	18.15	2
3	NKGGS-3 HT Fuel gas	0.24	94.88	0.79	0.12	0.19	0.02	0.02	0.01	0.12	3.61	8838	7962	0.6023	17.41	10
4	SS CTF HT Fuel gas	0.38	87.81	2.74	2.21	0.82	0.79	0.20	0.19	0.76	3.90	9793	8855	0.6796	19.64	Nil
5	NS CTF HT Fuel gas	0.73	81.17	5.22	4.43	1.27	1.27	0.27	0.26	0.94	4.44	9504	10487	0.7401	21.37	Nil

Annexure-II

Installation wise gas analysis report:

ओएनजीसी ONGC

Oil and Natural Gas Corporation Limited
Chemistry Section, ST, Mehsana

Santhal Main ICP
Date: 16.10.2020

Test Report No: S. Main / CHEM / GAS / 30 / 2020
Gas analysis and calculation (as a real gas) done by ISO 6974-4 and ISO 6976 methods respectively.
H_2S determination done by ASTM D-4810 method.

Sr.No.	Sample Source & D.O.C.	N_2	C1	C2	C3	iC4	nC4	iC5	nC5	C6	CO_2	GCV	NCV	Sp.Gr.	Mol. Wt.	H_2S
		mol %										KCAL / SCM		wrt air	gm / mol	ppm
1	BECHRAJI GGS-I (D.O.C-16.10.2020)	0.09	80.10	4.34	4.65	1.49	1.50	0.35	0.39	2.10	4.99	11009	9991	0.7800	22.51	NIL
2	SOB GGS-II (D.O.C-12.10.2020)	0.27	81.83	3.98	3.59	1.04	1.08	0.24	0.25	1.20	6.52	10137	9183	0.7436	21.47	5
3	JOTANA GGS (D.O.C-13.10.2020)	0.32	76.58	6.25	6.81	1.78	1.90	0.37	0.39	1.87	3.73	11595	10535	0.8042	23.20	NIL
4	NK GGS-II (D.O.C-14.10.2020)	0.43	92.63	1.06	0.15	0.17	0.04	0.03	0.03	0.31	5.15	8777	7911	0.6249	18.07	5
5	NK GGS-IV (D.O.C-14.10.2020)	0.20	85.43	2.12	1.49	0.90	0.54	0.19	0.23	1.69	7.21	9678	8756	0.7210	20.83	5
6	NANDASAN GGS (D.O.C-12.10.2020)	0.08	83.68	4.66	4.26	0.99	1.34	0.27	0.32	1.54	2.86	10807	9796	0.7306	21.09	7
7	LINCH GGS (D.O.C-12.10.2020)	0.10	77.63	6.71	6.51	1.65	1.79	0.38	0.44	2.34	2.45	11848	10766	0.7993	23.06	4
8	MEHSANA CTF (D.O.C-12.10.2020)	0.22	87.18	2.04	1.12	0.75	0.29	0.13	0.14	1.25	6.88	9380	8477	0.6943	20.06	NIL
9	Lanwa GGS-I (D.O.C-15.10.2020)	0.10	72.96	5.92	8.03	2.42	3.02	0.54	0.59	2.93	3.49	12600	11470	0.8706	25.09	NIL
10	Lanwa GGS-II (D.O.C-15.10.2020)	0.21	70.97	6.26	8.93	2.36	2.71	0.56	0.69	3.71	3.60	12949	11797	0.8988	25.90	NIL
11	Lanwa GGS-III (D.O.C-15.10.2020)	0.16	73.84	5.91	7.94	2.42	2.89	0.49	0.51	2.43	3.41	12356	11243	0.8524	24.57	NIL

16/10/2020
R.Saikia
GM(Chem.)

16.10.2020
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Sr.Chemist

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