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RESEARCH ARTICLE

HEAT CONSERVATION & GLYCOL TRACING IN SAGD PROJECTS

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ABSTRACT

In today's world of cut throat competition for attaining maximum profits with minimum damage to the environment, imagine what would be the scenario if one is able to discover a methodology which uses the otherwise wasted energy for constructive purposes in the energy usage cycle primarily defining the functional process of that particular industry. Energy management thus becomes the inevitable aspect in any functional society. This paper identifies such a robust methodology of recovery of heat energy and its further use in the energy cycle. The recovered Heat energy from the hot crude product in a SAGD project can be reused effectively without being wasted by changing the medium of exchange. In SAGD projects usually glycol and BFW (boiler feed water) is used for cooling the hot crude product. The heated up glycol is used for heat tracing of lines instead of the electric tracing which is more common in Canada or polar countries where steam tracing becomes uneconomical. And the recovered glycol can be reused for cooling of the hot crude. The same glycol is also being used for heating up of the Working Areas with heat addition from heaters during winters. This is made possible because of glycol heat bearing capacity without change in state. Thus heat produced inside a facility is not wasted and is utilized effectively. Glycol (Ethylene Glycol) has been used as a heat transfer agent in automobile and air conditioning system for years now. Ethylene glycol is produce from Ethylene which oxidizes and reacts with water to form Ethylene glycol. It has a melting point of -12.9oC and a Boiling Point of 197.3oC. But Glycol when mixed in water, the Melting point and Boiling Point varies significantly depending on the concentration of the glycol, typically with a proportion of 70% glycol the freezing point reduced to -51oC. Hence by varying the proportion of the glycol in the mixture the heat carrying capacity can be changed according to the requirement. Thus, with this paper we intend to compare the various heat tracing methods, the energy consumption comparison in each method, the tracing system installation cost, the tracing system performance, the Steam Assisted Gravity Drainage (SAGD) project philosophies, the modifications in the system while using glycol medium, glycol properties, the advantages and the challenges faced during the utilization of the heat conserved.

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INTRODUCTION

Heat is a form of energy which runs most of the industries like automobile, oil & gas, manufacturing, refrigeration etc. Maintaining temperature or preventing loss of heat is a critical aspect of any industry. Energy conservation and the reduction of green house emission go hand in hand. In oil & gas industry, heat changes the composition and state of fluids so heat maintenance plays a vital role. Hence, heat tracing is used for retaining the temperature and preventing heat loss in equipments and in piping which is used for transportations. In this paper we will be focusing more on alternative type of heat tracing with more focus on Glycol tracing especially in SAGD projects.

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Objective of work: The main objective of our work is to provide an alternative yet effective method of heat tracing specifically in SAGD projects. This paper involves the comparison of tracing methods and explains how Glycol tracing can be superficial describing the huge potential it has by the virtue of its properties.

Types of Heat tracing:___ The heat tracing systems are classified as follows

- Electrical Tracing Systems
- Fluid Tracing Systems

Electrical Tracing systems: Electric heat tracing system converts electric power to heat and transfers it to the pipe and the fluid it contains. Majority of commercial electric heat tracing systems in use today are of restrictive type and take forms of cables placed as the pipe.

When current flows through the restrictive elements, heat is produced in proportion to the square of the current and the resistance of the element to current flow. Based on the data collected from 2000 to 2010, electric tracing accounts to 100 MW of connected load and tracing heating and insulation and would account to $700 million CAD investment in Alberta Oil sands [3]. The electric tracing also has limitations. Electric heat tracings often provides an unacceptably slow heat up period for the resumption of the flow especially after Emergency shut down or plant turn around. Electric tracing has the potential for sparking in hazardous or flammable area. Electricity for tracing can cost considerably more per Btu than steam tracing.

Fluid Tracing Systems: The fluid tracing system utilizes heating media at elevated temperatures to transfer heat to a pipeline. The fluid is usually contained in a tube or a small pipe attached to the pipe being traced. The fluid tracing is broadly classified into

Steam Tracing System

Other thermal Fluid tracing systems

Steam Tracing Systems: A number of desirable features make steam the original heat tracing system of choice to maintain process temperature and provide freeze protection.

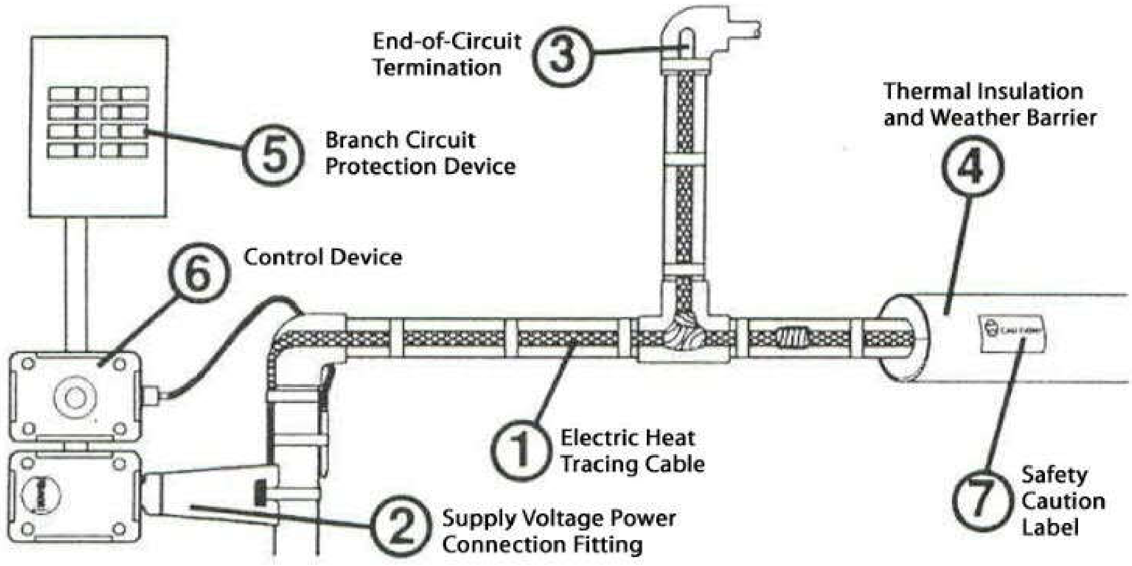


Fig. 1. Electrical Tracing systems [3]

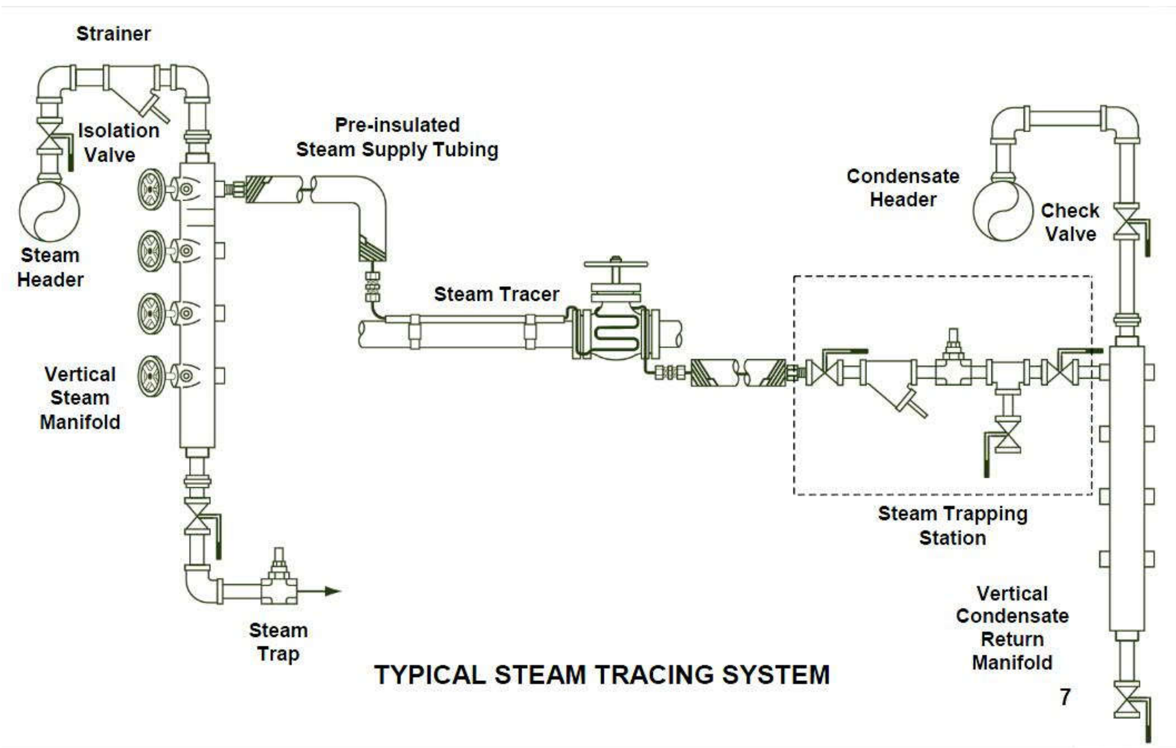


Fig. 2. Typical Steam Tracing Systems [3]

High latent heat of vaporization of steam is ideal for heat transfer applications. Only a small quantity is required for a large heating load and it can heat a line quickly, can condensate at constant temperature and also flow without the use of pumps. Steam is universally available and non-toxic. The ability to continuously remove condensate via a steam trap assembly allows the steam tracer to provide a constant-temperature source heat. The limitations of steam tracing system are that periodic leaks and failed steam traps in a steam- traced system waste energy and demand additional labor cost for repair and replacement.

Other Thermal Fluid tracing systems: There are various other Thermal fluids to cover a wide range of heating and cooling application. An ideal Thermal fluid processes a good thermal stability which does not change in chemical composition even with repeated heating and cooling. It should not present a fire hazard and chemical hazard. It should have low viscosity and low vapor pressure at operating temperature and good physical properties.

Factors to be considered while selecting tracing: The following factors are to be considered while selecting tracing systems

- The specific application
- The tracing system's functional performance
- The tracing / pipe system energy performance
- The tracing system's installation cost

The specific application: Typical information required to begin an assessment.

- Plant location
- Climatologic Data : minimum, maximum and average ambient temperatures
- material to be heated :Process, utilities or services
- Temperature control of product and monitoring requirement.
- Energy requirement: This includes location of site, type of tracing, quantity and cost of tracing.
- Pipe requirement which includes material, length, size and grade level.
- Insulation type, their thickness and weather barrier.
- Rates and maintenance hours required.
- Tracing system alternatives under consideration.

The Tracing system functional performance: Any tracing method meeting the functional requirements of the process piping and the equipment requirements is always desirable. The piping system equipped with tracing system must heat up and maintain the prescribed temperature. A heat up requirement may be fulfilled by the system for the initial start up and also for startups after a turnaround or emergency shutdown.

The tracing / pipe system energy performance: The energy consumption characteristics of a tracing system are primarily a function of the following

- Insulation system
- Tracing temperature control
- The energy consumption

The insulation system: Temperature maintenance being the most common application of a heat tracing system, it is designed to replace only the heat that may be lost through the thermal insulation. The energy consumption is directly related to the energy loss characteristics of the insulator, which is a function of the insulation type and thickness. [2]

Tracing Temperature control: To further reduce the energy consumption, a pipe temperature sensing controller is used which activates and deactivates the tracing so that the tracer delivers only the energy required to maintain the pipe temperature. This is applicable particularly when there is no material flowing in a piping system. Flow at temperatures above the controller set point, de-energization of the pipe-sensing controller occurs and the energy consumption is minimized. [2]

The energy consumption

- The energy consumption of parallel and series resistance electric tracers is limited to the Joulian (I^2R) heating ability of the cable. Most plants will have electricity available for electrical tracing either purchased or produced at the plant site.
- Steam Tracers are a constant temperature heat source. Their consumption is proportional to the steam temperature minus pipe temperature differential.
- A thermal fluid tracing system requires multiple tracing circuits before it can be justified due to the cost of the fluid handling unit. The fluid handling unit is made up of

1) An expansion tank to provide space for fluid expansion and NPSH for the pumps.
2) A circulating pump to tap the hot fluid flowing.
3) Heating and reheating by heater to heat the liquid to the required temperature and reheat the liquid when returning from the tracers. Process temperature control can be accomplished via flow control valves for multiple users or by process temperature sensors that controls the heater for single users. The total installation cost, energy costs and the intended operating pattern should be considered when selecting the type of heater for the system. [2]

The tracing system Installation cost: The installation cost of steam, fluid and electric tracing are a strong function of

- Piping complexity
- Temperature maintenance / Control Monitoring.
- Area Classification

Piping Complexity: Electric tracing cables are normally flexible than tubing and thus installation time is less for regular objects such as valves, pumps, fellers, elbows, flanges etc. As a trade off, however the number of electric circuits and controller will increase the cost as the complexity increases and will thus increase the cost of electric tracing comparison to uncontrolled steam tracers.

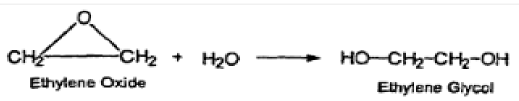
Temperature Maintenance / Control monitoring: The relative costs of steam, electric or thermal fluid systems are related to some degree by the control / monitoring applied to each system. In electrical tracing freeze protection can be attained up to 5 °C by using mechanical thermostats and microprocessor based temperature control can provide monitoring up to 500 °C. Thermal fluid tracing system can be used for temperature range from 260 °C to 400 °C which is beyond steam tracing. Temperature control can be provided by control valves and /or microprocessor based control system. Steam tracing is generally associated with high heat delivery for applications where steam is in the pressure range of 3 to 21 bars. Steam tracing is usually used for temperature range of 5 °C to 93 5 °C. Control methodology involves detecting ambient conditions, pipe sensing condensate, control traps and tracers that are isolated. However, where very tight temperature differentials are required, the lactic tracing or thermal fluid tracing methods are generally the best choice. In high heat delivery applications, fluid and electric tracings requires multiple passes hence steam tracing is economical.

Area Classification: In hazardous area, watt per foot output may be limited in order to comply with runaway temperature restrictions. Hence it requires multiple passes and includes the installation cost. Hence steam tracing becomes economical as it doesn't fall under run away restriction and enjoy the installation cost benefits.

So this is how a heat tracing method is selected as per the above classification. Here in this paper we will be mainly focusing on one of the Thermal Fluid system, Ethylene Glycol. We shall have a look on the Glycol properties and how it enables us for tracing.

Glycol Properties: Ethylene glycol is produced from the reaction of Ethylene oxide with water. The chemical equation being

$C_2H_4O + H_2O \rightarrow HO\text{-}CH_2CH_2\text{-}OH$



FORMULA (I)

Pure ethylene glycol has a specific heat capacity about one half that of water. Ethylene glycol disrupts hydrogen bonding is lost when dissolved in water. Freezing point for pure ethylene glycol is −12 °C, but when mixed with water, the mixture does not crystallize easily, and thus the freezing point of the mixture dips, a mixture of 60% ethylene glycol and 40% water freezes at −45 °C. Aqueous ethylene glycol has boiling point that increases monotonically with increase in ethylene glycol percentage. Depressing the freezing point and at the same time elevating the boiling point, the operating range for the heat transfer fluid is broadened on both ends of the temperature scale. The reason for increase in boiling temperature is that pure ethylene glycol has a much higher boiling point and lower vapor pressure than pure water. [3] Hence ethylene glycol is used as a medium for convective heat transfer in automobile, air conditioning and many more industry. In geothermal heating/cooling systems, ethylene glycol is the fluid that transports heat through the use of a geothermal heat pump. Depending on the utility of the system, ethylene glycol extracts energy from lake, ocean, and water well if used for heating. Ethylene glycol dissipates heat to the sink when used as a medium for cooling. So because of this heat storing properties Ethylene glycol becomes an ideal fluid for heat tracing and building & facilities heating. Here we will be concentrating more on the SAGD (Steam Assisted Gravity Drainage) projects. Before that we can have a quick look about the SAGD philosophy.

Steam Assisted Gravity Drainage (SAGD): Steam assisted gravity drainage is an enhanced oil recovery technology for producing heavy oil and bitumen. It is an advanced form of steam stimulation in which a pair of horizontal wells are drilled into the oil reservoir, one few meter above the other. High pressure steam is continuously injected into the upper well bore, this heats the oil and the viscosity is reduced, heated oil drained into the lower wellbore, where it is pumped out. The steam and gases rises because of their low density compared to the heavy crude oil below, ensuring the steam is not produced at the lower production well, tend to rise in the steam chamber, filling the void space left by the oil and to a certain extent, forming and insulated heat blanket above the steam. Oil and water flow is by a counter current, gravity driven drainage into the lower well bore. Water in condensed form, bitumen or crude oil is recovered to the surface. Pumps like progressive cavity pumps work well for the movement of high viscosity fluids with suspended solids. [3]

Heat tracing using Ethylene glycol in SAGD projects

The crude oil or bitumen which is extracted through Gravity drainage is called Produced emulsion because these contain lot of condensed steam and other impurities. This Produced emulsion is in very high temperature and has to be cooled down to ambient temperature before it is transported to the processing facilities. Now this heat can be utilized for heating of this glycol and preheating boiler feed waters for generating steam. The Produced emulsion which is pumped out from the Well pads of the oil well using a submersible pump from underground is passed through the series of heat exchangers. Here in these exchangers the heat from the produced emulsion is transferred to Ethylene glycol. Ethylene glycol which is stored in the tank is pumped through glycol pumps into the Glycol header. From this Glycol header the glycol is passed the series of exchangers where it picks up the heat which is required for the heat tracing and building heating. This hot glycol is passed into the hot glycol header and is run throughout the plant. The tracing procedure is same as that of the steam tracing. A tapping is taken from the header which is in the pipe rack and is connected to the Glycol tracing manifold. From the glycol tracing manifold, the glycol is passed on to the lines that are to be traced through the pre-insulated tubing. The glycol then is passed on to the tracers which are usually stainless steel pipes which run in contact with the process pipe whose temperature is to be maintained. The number of tracers depends on the temperature to be maintained. Expansion loops are provided at the regular intervals for the glycol tracers. Connectors can be provided at the module breaks in case of modularization concepts are being used. The Glycol is received in the condensate manifold once again through the pre insulated tubing which is in turn connected to the tracers. The tracing length is usually decided by the client standards which is usually around 75-90 meters. There is no steam trap assembly like setup here and the complete glycol is recovered. This recovered glycol is further cooled by passing through the air fin coolers and then is sent for storage in tanks. Similar type of arrangement is used for Building heating and winterization. Instead of a manifold type arrangement a dedicated line is connected to the passes of the HVAC system from which heat is transferred to the building to maintain the workable temperature.

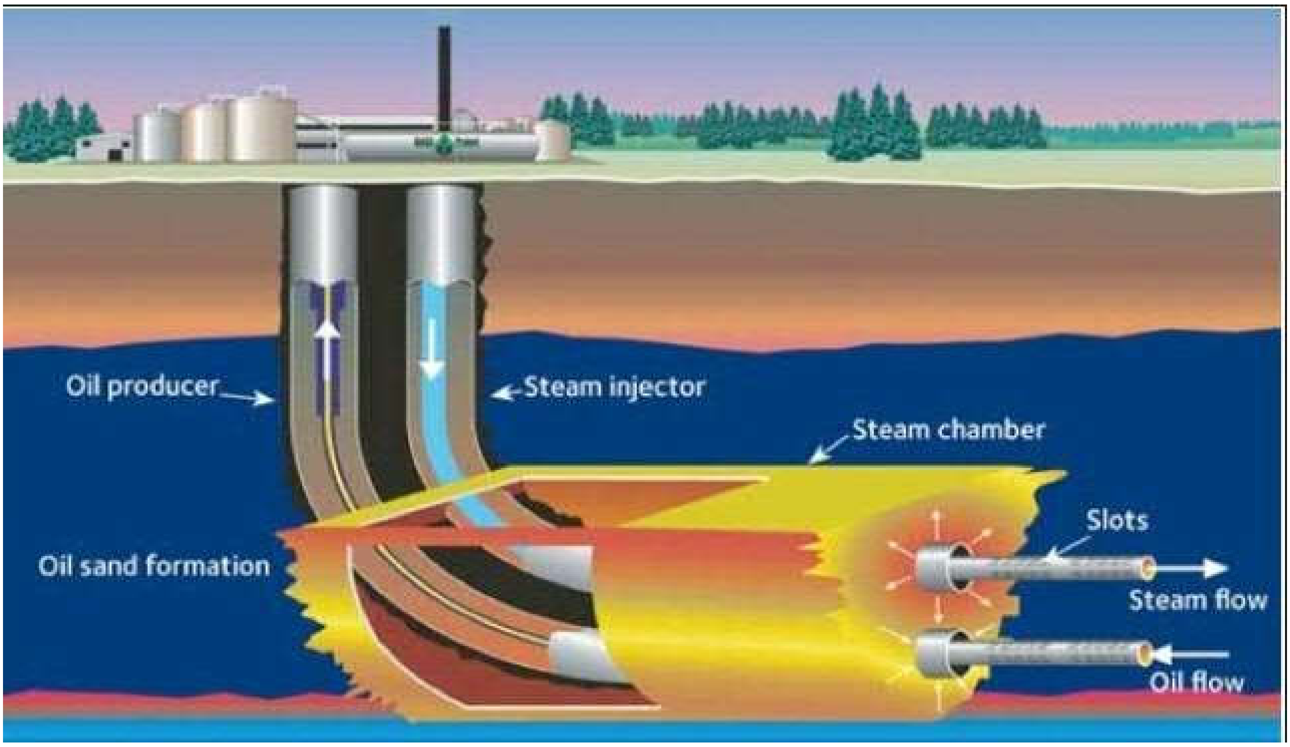


Fig. 3. Steam assisted Gravity Drainage [3]

Advantages of Glycol Tracing

- The main advantage of this Glycol tracing process is that there is no wastage of heat. Heat is recovered to the maximum level possible.
- Glycol, because of the heat carrying capacity can be used alternative to electric tracing which is very costly and steam tracing becomes non-economical
- The Glycol used in the heat tracing and winterization is completed recovered and hence there is very minor loss of glycol.
- No steam trap type of arrangement is required as there is no condensate formation.
- Since the heat source being the crude itself, no additional heat source is required (depends on the usage of heat if the number of users are more an intermediate heater type arrangement may be required and this pertains to SAGD projects only).

Conclusion

In today's scenario, oil recovery has become very critical as the oil reserves are fast depleting. For that practices like Gravity drainage play a vital role.

To further enhance the existing technology we have methods like Glycol tracing which has huge potential. It's a robust technology which when put to use can save time, efforts and money thus proving effective. It has proven its worth in cold countries like Canada; it can be superficial in other climatic conditions too.

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