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The Effect of modular portable clamp on electrical heat traces for wellhead icing prevention

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Abstract

Gas wells have numerous safety devices installed at the wellhead, including pressure sensors with high-high (HH) and low-low (LL) parameter set points that can close the shut-down valve (SDV). A phenomenon of icing was discovered on the wellhead tube wings during open well X operations (after shut-in wells). This occurs when wells are shut down for longer than three days, such as during turnaround operations or emergency situations. The occurrence of ice blocks on the wellhead tube wings during wellbore startup disrupts gas flow to well X and has the potential to result in an annual loss of production opportunity (LPO) of $960 million. When there is a significant heat release phenomenon around the wing tube area, the absence of a heating facility around the wellhead area is one of the most important factors in this icing. To prevent icing and ice blockage, a portable, modular electric heat trace with clamp-on attachment is installed. Heat Trace cable is connected to a portable generator for power. This device is capable of converting electricity into heat up to 167 °F (75 °C). The heat generated by the instrument will mitigate the sudden release of heat when the gas begins to flow. Modular portable clamp-on heat tracing has been demonstrated to eliminate the possibility of icing at the wellhead due to a significant drop in temperature and maintain the gas field's production rate.

Keywords:
Icing, Wellhead, Production losses, Joule-Thompson Effect, Gas Field.

1. Introduction

There are numerous safety devices installed in the wellhead area of gas wells, such as pressure sensors with High-High (HH) and Low-Low (LL) parameter set points that can close SDV. In 2018, 2019, 2020, and 2021, 40% of problems occurred in the vicinity of the wellhead, per historical records. The majority of these issues involve surface facilities in the vicinity of the wellhead. Plugging of gas wellbores is one of the most pressing issues to be addressed. Therefore, it is necessary to evaluate the consistency of gas hydrate dissociation with the existing wellbore.

There have been many studies related to gas hydrate production. Terzariol et al.[1] investigated gas hydrate depressurization using numerical simulation. Li et al.[2], [3] conducted experimental gas hydrate depressurization research. But the dissociation process of methane gas hydrate causes a drastic Joule-Thomson effect. Due to insufficient heat transfer, blockage problems caused by ice formation and gas hydrate reforming may occur in the depressurization process [4], [5]. Tarom et al [6] have examined the relationship between the Joule-Thomson coefficient and the temperature profile flowing in gas production wells. The limitation of heat transfer and the Joule-Thompson effect in the wellbore will reduce gas production so that gas production will not be optimal.

One of the issues associated with a high frequency is the formation of ice during well startup. During open wells X, the icing phenomenon was observed on the wellhead tube wings (after shut-in wells). This occurs when wells are shut down for longer than three days, such as during turnaround operations or emergency situations. These conditions lead to well shutdowns that have the potential to reduce the gas supply to well X and result in a production opportunity loss. The icing phenomenon is caused by the excessive and sudden release of heat when the gas first flows, causing the choke to become cold. In addition, the presence of water in the fluid leads to the formation of ice blocks, which stops the flow of gas. This is the primary reason why the well shuts down and the safety device activates.

The occurrence of ice blocks on the wellhead wings tube during well startup disrupts gas flow to well X and has the potential to result in a 960 million per year loss of production opportunity. One of the most important contributors to this icing is the absence of existing heating facilities near the wellhead when there is a significant heat release phenomenon in the wing tube region. To overcome the icing problem, a thermal electric heat trace [7]–[11] is made which functions as a heater and heat release controller to prevent icing on the wellhead tube wings when open wells are carried out.

In this study, a modular portable clamp-on electric heat trace was installed to solve the icing/ice blocking problem. The modular portable clamp-on electric heat trace is expected to reduce the potential for icing at the wellhead due to a significant temperature drop and was able to maintain the gas field production rate.

2. Materials and Methods

One of the most effective methods for overcoming icing is one that employs the principle of electrical heat trace. Self-Regulating (Self-Limiting), Power-Limiting, Parallel (Zone) Constant Watt, Flexible Series, and Mineral Insulated (M) Series Heaters are the various applications of this method.

Self-regulating electrical heat trace is used in field X to prevent icing because it is simple to design, flexible, and resistant to a range of temperatures. To overcome the ice blocks problem that occurs, several alternatives can be done, namely using a larger bean size, injecting chemicals (ethylene glycol) [12], installing a downhole regulator to monitor sub-surface fluctuations, and installing a modular portable clamp-on electric heat trace to maintain the temperature in the pipe. The alternatives provided, the most efficient and most economical is to install a modular portable clamp-on electric heat trace. In addition, this tool does not require pipe modification (double pipe) or tapping for glycol injection because the installation is only temporary for 20-30 minutes before gas well start-up and then removed again.

This tool requires three primary components: cable heat trace, clamp modification housing, and a portable generator. This device operates by utilizing a portable generator that is connected to the Heat Trace cable as its power source. Fig. 1 depicts the subsequent design of a modified clamp that has become one unit with the heat trace cable. Fig. 2 depicts its installation on the wing of the Christmas tree when the well is opened for the first time. This device can convert electricity into heat up to a temperature of 167 degrees Fahrenheit (75 degrees Celsius). The heat generated by the tool will reduce the likelihood of a sudden release of heat when the gas begins to flow.

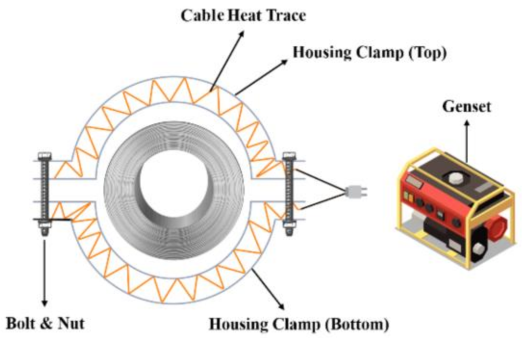

Fig. 1. Sketch Model of Modular Portable Clamp-on Electric Heat Trace

Fig. 2. The phenomenon of icing on valve wings in one of the gas field wells

The subsequent step is to collect field data when icing occurs and review the evaluation results after installing the modular portable clamp-on electric heat trace tool on the well, as well as other data to support the discussion.

2.1. Gas Hydrate and Icing Phenomena

In the production process, natural gas (natural gas) from the reservoir will be produced simultaneously with water. Generally, natural gas that is produced has saturated conditions. So free water and natural gas have the potential to form solids, namely "gas hydrated" [13].

Gas hydrates can potentially clog the flowline so that it can increase the loss of production opportunity and will cause several other problems such as icing which is formed during the gas expansion process when experiencing a pressure drop due to choke performance.

Gas hydrates are crystalline compounds that can form when water and gas molecules come into contact at a certain pressure and temperature [14]. Most gas hydrates can be classified into three kind of structures: 2 cubic and 1 hexagonal [15]–[17]. Gas hydrates are formed when gas molecules are trapped into hydrogen bonds in water. If gas hydrates form at the gas-water interface, the process of forming gas hydrates will take place quickly when water and gas molecules are available in large quantities[18].

Icing is one of the problems caused by the process of decreasing temperature due to gas expansion. When this phenomenon occurs, the pipe surface will experience a decrease in temperature so that the dew in the surrounding air will condense and then freeze on the pipe surface. This phenomenon causes pipe blockage by gas hydrate and icing to occur during re-start-up. Gas hydrate and icing have a high potential in the flow downstream from the choke when the fluid temperature decreases until it reaches the formation area of gas hydrate and icing at the wellhead based on the Joule-Thomson effect.

2.2. The Joule-Thompson effect.

The Joule-Thompson effect is the change in fluid temperature during expansion from high pressure to lower pressure in a steady-flow process that does not involve heat transfer or work (i.e., at constant enthalpy) [19], [20]. This occurs in throttling-type processes, such as adiabatic flow through a porous plug or expansion valve. In the experiments conducted by Joule and Thompson, throttling was done by flowing gas through a cotton plug [21].

The temperature drops increase with increasing pressure drop and is proportional to the experimentally measured Joule-Thompson coefficient, eq. (1).

$$\mu_{JT} = \lim_{\Delta p \to o} \frac{T_1 - T_2}{P_1 - P_2} \qquad (1)$$

What will happen, taking into consideration that this process is isenthalpic, eq. (2):

$$\mu_{JT} = \left(\frac{\delta T}{\delta P}\right)_H \qquad (2)$$

And finally, the Joule-Thomson coefficient for a gas that satisfies the Van Der Waals equation is by eq. (3):

$$\mu_{JT} = \frac{\frac{2a}{RT} - b}{C_p} \qquad (3)$$

The calculation result of μJT is shown in Table 5. For each gas, there is an inversion point that depends on temperature and pressure. When the gas is below its inversion point it cools and when above it warms as seen in Fig. 3.

Table 1. Joule Thompson coefficient calculation result

Variable	Value	Unit
T_{up}	388.04	K
T_C	216.9001	K
P_C	5146.004	kPa
R	8.314	kJ/kmol K
C_P (0ºC)	35.89053	kJ/kmol K
C_P (150ºC)	43.39560	kJ/kmol K
C_P (47.437ºC)	38.22908	kJ/kmol K
a	266.5958	
b	0.043804	
μ_{JT}	0.00317	K/kPa

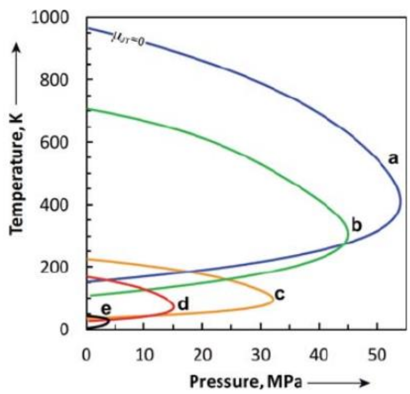

Fig. 3. J–T inversion curves of common cryogenic fluids a) Methane; b) Air; c) Neon; d) Hydrogen; e) Helium Cooling by isenthalpic expansion is only possible left (inside) of the respective inversion curve

In the process of gas expansion when the pressure drops, the Joule-Thomson effect occurs which causes a heating or cooling effect. If the gas temperature is below the inversion point, the μ_{JT} value is positive, the ∂_T value is positive then the gas condition is cooling. Meanwhile, if the gas temperature is above the inversion point, the μ_{JT} value is negative and the ∂_T is negative, the gas condition is heating.

3. Results and Discussion.

Heat trace cable, clamp modification housing, and a portable generator are used to construct the installation of a modular portable clamp on electrical heat traces. The clamp modification housing and heat trace cable are attached to the portable generator as one unit. The working principle of this modular is by utilizing the power source from the portable generator to convert electricity into heat to a temperature of 167 °F (75 °C). The heat generated in the tool will minimize the sudden release of heat when the gas starts to flow. The device is installed on the Xmas Tree when the well is first opened, as seen in Fig. 4

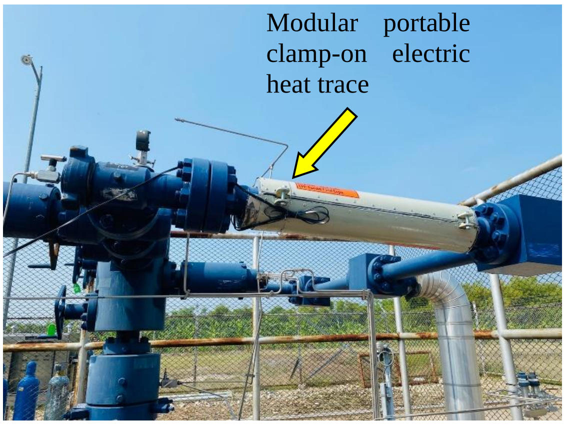

Fig. 4. Installation of Modular Portable Clamp-on Electric Heat Trace at Well Y.

Gas operational data at well Y is used to determine the X field gas operating conditions. The selection of gas operational data at well Y as observation data is due to the high-pressure conditions in the tubing and low-pressure conditions in the flowline, so that the pressure expansion from the tubing to the flowline provides an opportunity for the formation of gas hydrates in the flowline. The results of the calculation of the temperature value on the flowline (Tdown) can be seen in Table 6.

Table 6. Calculation results of Joule-Thompson coefficient after installation of of Modular Portable Clamp-On Electrical Heat Trace Tool at Well Y

Variabel	Value	Unit	Value	Unit
Tup	320.59	K	47.44	°C
Tdown	348.15	K	75	°C
Pup	21819.84	kPa	3150	psia
Pdown	3270.87	kPa	460	psia
µJT	-0.00149	K/kPa		

Based on the temperature obtained in the flowline of 261.9 K (-11.250C) and the value of the Joule-Thomson coefficient, which is positive (+) of 0.00317 K/kPa, this indicates that cooling is occurring around the choke pipeline, so that the wellhead at well Y has the potential to experience icing, causing the sensor on the shutdown valve to detect low-low parameters, resulting in the closure of the shutdown valve and a decrease in the gas supply production rate in Upon restart, this phenomenon causes pipeline blockage by gas hydrate and icing. On the basis of the Joule-Thomson effect, gas hydrate and icing have a high potential in the flow downstream of the choke when the fluid temperature decreases until it reaches the formation region of gas hydrate and icing at the wellhead.

After installing the modular, portable, clamp-on electric heat trace tool at the wellhead of well Y, the temperature of the fluid was measured. The temperature in the flowline has increased to 348.15 K (750C) (Fig. 5), causing a change in the Joule-Thomson coefficient value of -0.00149 K/kPa (Fig. 6). This value indicates that the gas expansion is warming up in order to resolve the icing issue.

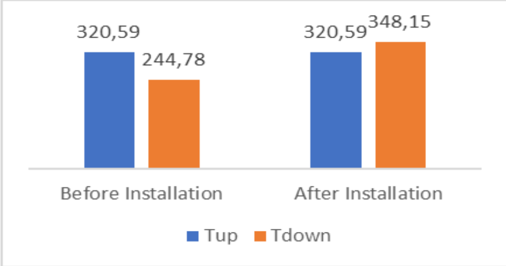

Fig. 5. Temperature Comparison Before and After Installation of Modular Portable Clamp-On Electrical Heat Trace Tool at Well Y

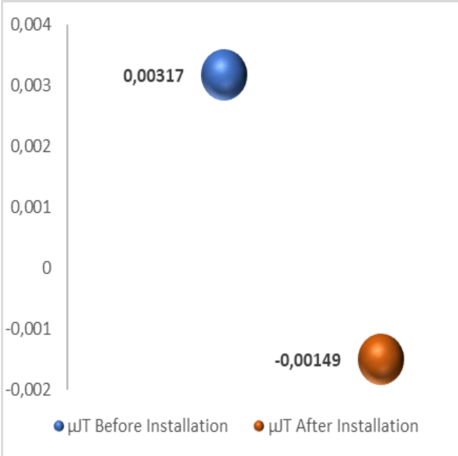

Fig. 6. Joule-Thompson Coefficient Before and After Installation of Modular Portable Clamp-On Electrical Heat Trace Tool at Well Y

4. Conclusions

The successful installation of the Modular portable clamp-on heat trace tool is characterized by an increase in the value of the Joule-Thomson coefficient, which was previously positive at 0.00317 K/kPa, changing to a negative value of -0.00149 K/kPa, where the gas temperature has increased and the icing problem at well Y has been resolved. Modular portable clamp-on heat trace has been demonstrated to have a function that can eliminate the potential for icing at the wellhead due to a significant decrease in temperature and reduce the potential for a decrease in the rate of gas supply productions as a result of the sensor detecting freezing temperatures. Low-low variables.

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