SOLVING PARAFFIN DEPOSITION PROBLEM IN TUBING BY HEATING CABLE APPLICATION

by

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The production of paraffin-base crude is expensive and more complex then of other oil types. In northern Serbia, where majority of oil and gas fields are located, about 25% of oil production accounts for the high paraffin oil. During this oil type production, the paraffin deposition occurs in tubing's upper zone, ranging from 700 m depth upwards.
In this article is presented original way of heating cable application, for solving paraffin deposition problem in tubing that can be easy and quickly installed in the well. Paraffin deposition problem is solved by heating, and at the same time the increased temperature causes the oil viscosity reduction resulting with improved oil flow rate. Application of this method and the results are exemplified by the flowing well B-3 where are used two different heating cables. This method, which is very successfully solves the problem of paraffin deposition in the tubing, can also be applied to wells producing by different artificial lift methods.

Key words: *heating cable, tubing, heavy oil, paraffin, deposition*

Introduction

Nowdays for solving the problem of paraffin deposition during heavy oil production, the mechanical, chemical, and thermal methods are applied [1, 2, 3].

The mechanical removal of paraffin is done by simple method of scraping. Results of chemical methods application depend on used additive type. It has effects as paraffin deposition removal, deposition prevention, improvement of oil flow rate, or at temperature pure point reduction [4]. The mostly used thermal method is hot oiling [5].

Scraping and thermal methods have to be applied periodically depending on the reported paraffin deposition. It varies from several days to several weeks. In most cases when thermal methods are used, continuous additive injection is needed. Analysing advantages and lacks of the mentioned methods, it can be concluded that chemical injection solves the paraffin deposition problem efficiently, but it represents an expensive treatment method.

All these conventional methods for solving the paraffin deposition problem do not show always the satisfactory effects, and besides that, can be expensive and even not economical.

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With an objective to overcome disadvantages of above methods, application of electric heating cable installing in tubing has started [6].

The tubing electric heating method is primarily used for prevention of paraffin deposition. The heating cable represents the already applied solution, but besides its use in prevention of paraffin deposition, in our exemplified application, using of tubing electric heating method also increases oil well production. Increased oil production is a result of improved fluid characteristics due to heating process (reduction of oil viscosity and density). From the economical point of view, increased oil well production compensates the electric power costs and reaches a certain profit [7].

Until nowadays, the most used method for tubing heating was heating mechanism by skin electric current tracing (SECT) system [8]. This type of heating system is very efficient, but its installation is complicated concerning practical point of view. The SECT system can not be welded by the tube on the tubing. The reason is that the tubing has to be disinstallated during the well workover and its welding would disable that process. SECT system only can be welded on the pipeline.

Also, it is known that SECT system application is more suitable for longer pipes and for oil transporting by pipeline, while the installing depth of heating cable is relatively small (400-700 m).

Because of mentioned reasons, the developed spiral way of installing a heating cable around tubing represents the advantage comparing to installation process of SECT system.

Heating cable application for tubing heating

In fig. 1. is shown a heating system of tubing by electric heating cable system [7]. The system is made of five separate elements: control heating unit, equipment for heating cable handling during pulling of the tubing in or out of well hole, fitting for electric heating cable insertion, heating cable, and tubing.

Control heating unit provides automation of heating process control. On the basis of sensor that measures well head temperature, processing computer calculates needed heat for paraffin deposition prevention. In dependence of fluid flow, system increases or decreases heat quantity that is released by heating cable.

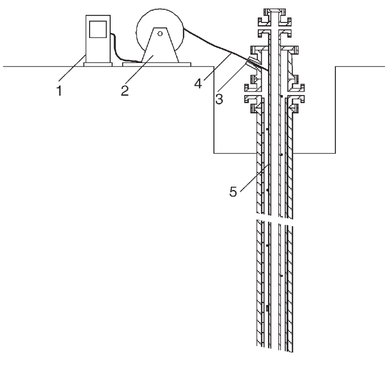

Figure 1. Scheme of electric heating cable system for tubing heating
1 – control heating unit, 2 – eqipment for heating cable handling during pulling of the tubing in or out of well hole, 3 – fitting for electric heating cable insertion, 4 – heating cable, 5 – tubing

Heating cable handling element is used for cable carriage and storage. The heating cable is rolled on a drum that enables simple and quickly heating cable manipulation. Since angular flexure of heating cable is undesirable, it is eliminated by rolling it on a drum. During the heating cable installing into the well, the cable is rolled of a drum, and in the opposite way just simple rolls on.

Fitting enables either pulling in or pulling out of the heating cable. It is placed between the well head and the Christmas tree.

Figure 2 illustrates the construction of the fitting containing the hole for heating cable pulling in or pulling out of the well. At the end of fitting is leak proof element that isolates space around heating cable when cable is installed in the well. Such a construction prevents eventually oil leak from the well. Installed heating cable provides tubing heating that will be explained in details in further text.

In fig. 3 is presented the mechanism of tubing heating by means of SECT system [8]. Tubing heating is carried out by alternate current that produces electro-magnetic field (4). The heating pipe (1) is installed on the outside tubing wall (5) diameter of 6 to 38 mm; cooper cable (2) cross-section of 8 to 60 mm^2 is inside the pipe and isolated by polyethylene (3).

Figure 4 shows installing of SECT system into the well. The steel pipe with cable is installed into the well while running tubing into the well. This pipe is attached to the tubing by joints.

For steel pipe attachment is needed lot of joints what slows down installing process while tubing running into the well, or disassembling during pulling of the tubing. Instead of using SECT system, heating cable application represents a simplified solution for tubing heating. This cable is less expensive than SECT system, with similar heating effects. Tubing heating is carried out through transfer of heat from the heating cable to the tubing.

Original way of installing heating cable without joints is developed, fig. 5. [7]. When the heating cable is installing into the well, it is helically placed

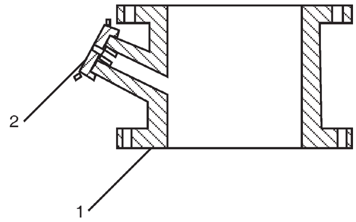

Figure 2. Fitting for electric heating cable insertion
1 – fitting, 2 – leak proof element

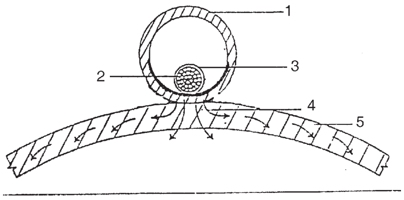

Figure 3. Tubing heating by SECT system

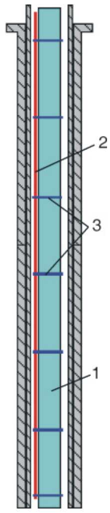

Figure 4. Installation of steel pipe with cable to the tubing
1 – tubing, 2 – steel pipe with cable, 3 – joints

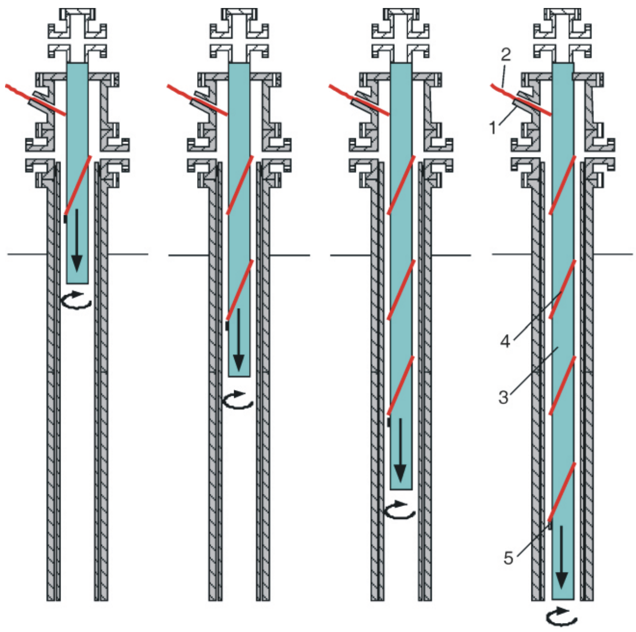

Figure 5. Installation of heating cable into the well
1 – fitting for electric heating cable insertion, 2 – heating cable, 3 – tubing, 4 – helical installation of heating cable in the well, 5 – heating cable junction for tubing

around tubing. That way of cable installing is enabled by tubing rotation, *i. e.* by rolling the cable on a tubing.

By helical installing, the cable is at the same time attached to the tubing that eliminates need for using the joints. It is necessary that beginning of a cable is fixed to the tubing, so it wouldn't move during further tubing rotation and pulling in. This developed method provides a simple and easy way for heating cable installing, and it doesn't slow down process of pulling in or out of tubing. Also, by helical installation of heating cable in the well is enabled better tubing heating comparing to the parallel installment.

During the practical application FibertraceTH KF^{TM} and Econothace heating cables are used, fig. 6. [9].

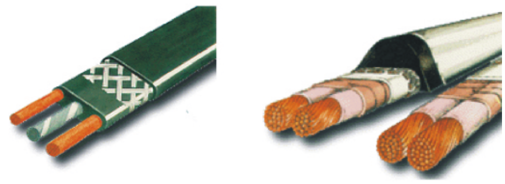
(a) FibertraceTH KF^{TM} (b) Econothace

Figure 6. Heating cables

Using the conductive fiber technology, the parallel FibertraceTH KF^{TM} heating cables with constant heat output are suitable for freeze protection applications and process pipes temperature maintenance. Extremely flexible, this cable combines a durable and resilient fiber heating element with a tested thermoplastic rubber.

Econothace cables are parallel heating cables with constant heat output per meter. Suitable for freeze protection applications, temperature maintenance or the heat-up of process pipes, vessels, and instruments.

In tab. 1 the characteristics of FibertraceTH KFTM and Econothace heating cables [9] are presented .

Table 1. Characteristics of FibertraceTH KF^{TM} and Econothace heating cables

Heating cable	FibertraceTH KF^{TM}	Econothace
Insulation	Thermoplastic rubber	Thermoplastic rubber
Output available, [Wm^{-1}]	10-24	5.5-30
Supply voltage, [V]	240	380
Max. temperature, [°C]	100	120

Heating cable application in flowing oil wells B-3

Tubing heating effect analysis was done on the example of the flowing oil well B-3. This well belongs to the group of low producers, with daily production of 13.5 m^3 per day. Oil contains high amounts of paraffin and the pour point is 39 ºC. Both temperature and pressure values, measured in the dynamic conditions before tubing electric heating application, reach 17.9 ºC and 46 bar, as shown in fig. 7.

It was necessary to determine tubing interval where the paraffin deposition occurs. Zone of the paraffin deposition is defined by deposited paraffin curve. The curve of paraffin deposition is obtained by measurement of the paraffin deposition mass using the flow deposition

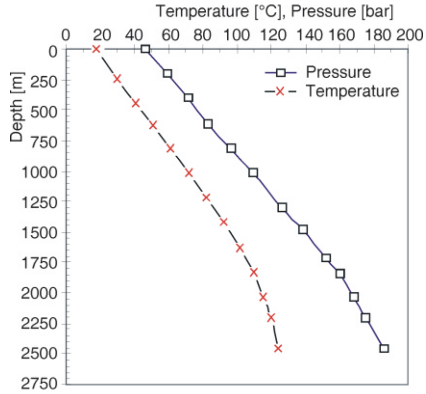

Figure 7. Temperature and pressure drop curves in well B-3 before tubing electric heating application

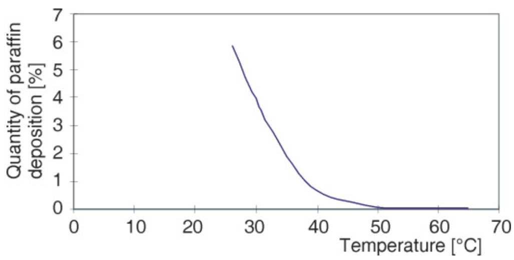

Figure 8. Curve of the paraffin deposition depending on temperature

experiment (fig. 8). An error of the measurement is 0.1 bar and 0.1 °C. On the basis of curve of paraffin deposition, the temperature where the deposition occurs is determining, and using its value the depth of deposition beginning is defined. That depth enables determination of well heating zone in order to prevent the paraffin deposition.

It is evident from fig. 8 that the crystallization process begins at the temperature of about 51 ºC. Starting from this temperature, the paraffin separation, namely, its deposition slowly begins in linear form. Significant paraffin deposition begins at the temperature under 38.5 ºC, representing actually the temperature where the intense deposition takes place.

As can be seen from the temperature drop curve in well B-3 (fig. 7) more significant paraffin deposition begins at the depth of 380 m. For that reason, it is necessary to obtain a higher temperature in the upper oil well zone (from 380 m up to the well head) than is the temperature of intense paraffin deposition.

The heating system is dimensioned using the value of temperature drop which is calculated by software "Pipesim", Schlumberger Logelco, Inc. [10]. The heating cable influences at the increase of well temperature above the temperature of paraffin deposition, and on that way deposition is prevented.

The temperature drop curve, related to new conditions of 38.5 ºC on well head is measured and shown in fig. 9. Before heating system application, well head temperature was 17.9 ºC.

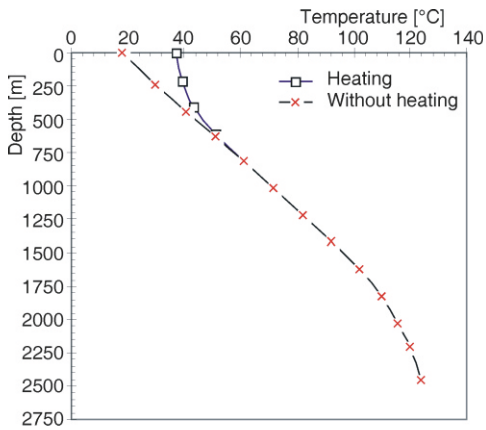

Figure 9. Heating influence on temperature increase in the upper tubing zone in well B-3

Heating cable application analysis

Analysis of heating cable application in flowing oil well B-3 is considered according to the effect of temperature increase on upper tubing zone.

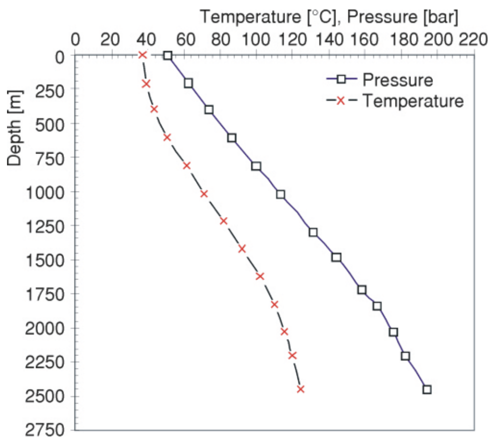

Figure 10. Temperature and pressure drop curves in well B-3 after tubing electric heating (for FibertraceTH KF^{TM} cable)

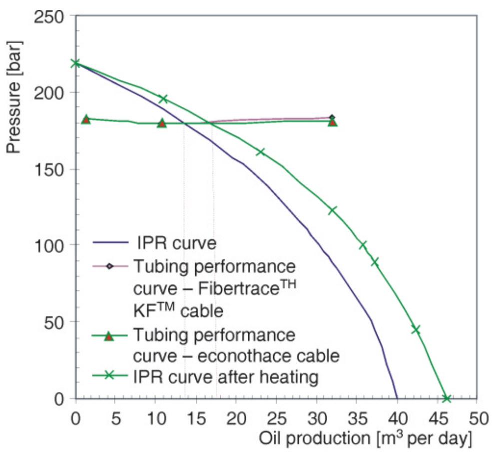

Figure 11. Oil production before tubing electric heating method application

The temperature drop curve measured (in the dynamic conditions) for new conditions of 38.5 ºC on the well head, and the pressure drop curve are given in fig. 10.

On the basis of the curves measured after heating, it is evident that the well head pressure increased from 46 bar to 52 bar applying FibertraceTH KF^{TM} cable, and is close to value of 54 bar when Econothace cable is used. Dynamic pressure at the well bottom increased from 181 bar to 190 bar, and to 191 bar (for the value of reduced pressure drop in vertical flow rate and with measurement error of 0.1 bar). The dynamic pressure increase is primarily result of viscosity and density reduction due to heating. The paraffin deposition can reduce cross-section area of a tubing and cause the dynamic pressure and production decrease. Measuring of the paraffin deposition mass and measuring of the production shows the effects of paraffin deposition.

The production measurement has been done by measuring separator. The measured production values before and after heating cable application, are also confirmed on the basis of calculated inflow performance relationship curve (IPR) and tubing performance curves [10].

By oil production measurement it is determined that it is 16.4 m^3 per day when FibertraceTH KF^{TM} cable is used, and 16.5 m^3 per day for Econothace cable application. In this case the production increase of almost 18% was caused by tubing heating.

In fig. 11 are shown the IPR and tubing performance curves before heating. Intersection represents the well production of 13.5 m^3 per day. In fig. 11 are presented IPR and tubing performance curves for FibertraceTH KF^{TM} and Econothace cables application.

On the basis of performed analysis, positive effects of tubing electric heating application in flowing well can clearly be noticed. By heating cable application the paraffin deposition hasn't occurred, and by reduction of oil viscosity and density the well production has been increased.

Conclusions

In this paper is considered the heating cable application in solving paraffin deposition problem in tubing. By heating of the tubing interval with the temperature exceeding the one when paraffin deposition occurs, the problem of paraffin control is solved. Also, the oil viscosity reduction due to higher temperature is another effect that can result in improved oil flow rate. Uniform heat distribution is achieved by tubing electric heating along whole paraffin deposition zone.

The possibility of heating cable application is analyzed on the oil well B-3 example. Heating will cause well head temperature increase from 17.9 to 38.5 ºC, and consequently the problem of paraffin deposition at tubing's wall will be solved.

The application of this method will influence on increase of well head pressure and dynamic pressure at well bottom hole. The results of these effects are improved the flow rate conditions and oil production increase of 12% to 14% in dependence of applied heating cable type.

Based on the presented analysis, positive results of the heating cable application in flowing well are obvious. In comparison to conventional mechanical method that only removes paraffin deposition, the heating cable application method is multi-effective, as it both prevents paraffin deposition on tubing's wall and increases oil well production.

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