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An Application of Vacuum Insulation Tubing (VIT) for Wax Control in an Arctic Environment

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Abstract

Vacuum insulated double-walled tubular products (VIT) have been employed over the years to provide downhole temperature management. Production of a paraffinic crude oil in an arctic environment is a big flow assurance challenge. There is a potential for significant productivity loss due to a flow restriction caused by the wax deposition inside the production tubing. Several options (prevention and mitigation) are evaluated to control the wax deposition. Preventive measures include improved heat retention using VIT, active heating using electrical heating elements inside the well tubing, jet pumps using water as a power fluid and downhole injection of paraffin inhibitors. In certain field cases, none of these measures is 100% effective in preventing wax deposition. Mitigation methods include mechanical scraping using wire line tools and hot oiling. Again the mitigation methods are not completely effective either and even a method with 99% effectiveness can seriously damage the well after several jobs. Cost of the wax jobs and the production downtime during the jobs are added losses. Our study showed that a right combination of the appropriate preventive and mitigation measures is needed for adequate wax control and to maximize the economic returns. Extensive field data (production rates and flowing well head temperatures) were collected to develop and tune the well thermal model. Laboratory flow loop data were obtained for wax deposition scale-up and predictions. The wax deposition model was tuned to match the field data including a production rate decline due to wax deposition. An economic model was developed to evaluate the benefits of VIT with appropriate polyurethane coupling insulation in achieving higher production rates and lower production downtime during the wax jobs versus capital expense of the VIT segment. The results showed that it is highly beneficial to run the VIT at least in the permafrost layer. Additional length of VIT below the permafrost layer has limited benefits. This paper presents a comprehensive study including key field data used for the evaluation of VIT.

Introduction

Crude oil is a complex mixture of hydrocarbons that contain different functional types such as paraffins, aromatics, naphthenes, resins, and asphaltenes. Among these types of hydrocarbons, high molecular weight paraffins (i.e., waxes) and asphaltenes are responsible for the various problems encountered during transportation and processing of these complex fluids. Paraffins, a broad fraction of crude oil, are straight chain normal alkanes of carbon numbers ranging from 5 to 100 or even higher. One of the main features of high molecular weight paraffins is their low solubility in most of the paraffin, aromatic, naphthene-base, and other oil solvents at room temperatures.

At reservoir temperatures (>50–70°C), the solubility of these paraffinic compounds is sufficiently high to keep these molecules fully dissolved in the mixture. Wax molecules start precipitating out of the liquid phase below a certain temperature known as wax appearance temperature (WAT). Below the WAT of a crude oil, waxes can start plating out on cold surfaces of tubular, flowlines, surface equipments or pipelines. When a deposited wax thickness grows inside a crude oil production tubing (as anticipated in the arctic environment), the crude oil production rapidly declines due to the flow restriction. In the worst cases, a complete wax plug forms in the production tubing, and the production must be stopped in order to remove the plugging.

In the arctic wells discussed in this paper, a combination of slickline scraping and hot oil treatments is commonly used to remove wax from the production tubing. Wax deposition can be controlled by thermal insulation and/or injection of wax inhibitor. An artificial lift technique that uses jet pumps to hydrolift crude oil using water as a power fluid has also been used to prevent wax deposition inside production tubing. Water helps in decreasing the wax deposition rate in two ways – one by increasing the thermal mass resulting in a higher wellhead temperature (heat capacity of water is twice that of oil) and second by making the production tubing water wet. Hydraulic lift was considered for artificial lift and wax control, but rejected due to higher capital and operating costs.

Several attempts have been made to develop internal surface coating materials which are less adhesive with paraffin

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