Non-Chemical Control Of Paraffin In Wells

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Introduction

It is generally accepted that the control and removal of paraffin deposits is a costly operating problem in many fields. A great variety of methods have been and are being used to combat paraffin formation and deposition and to facilitate paraffin removal. The purpose of this paper is not to present any new control methods, but rather to discuss generally the current practices and the status of the industry's thinking regarding paraffin control in wells. A logical starting point for this discussion would be the composition of that material commonly referred to as paraffin.

Composition of Paraffin Deposits

For practical purposes paraffin can be defined as organic material which is no longer soluble in the crude and consequently tends to precipitate. Paraffin normally is meant to include several types of pure petroleum waxes, crude oil, gums, resins, and asphaltic materials, sometimes along with sand, silt, water, iron oxides, and iron sulfide particles. The character of a paraffin deposit is dependent on the mechanism of deposition and, normally, on the amount of time the deposit has been accumulating. When precipitation of paraffin first occurs the deposit contains a high percentage of oil which results in a soft, semi-liquid material. Over a period of time oil "bleeds" from the wax and the deposit becomes firmer and harder. A typical composition of a paraffin deposit, after removing suspended material, is as follows:

60 percent petroleum waxes
10 percent gums, resins and asphaltic material
30 percent oil

Causes of Paraffin Deposition

It is rather obvious that for paraffin to deposit two requirements must be met. First, the solubility of the paraffin must decrease with the consequent result that paraffin materials precipitate out of the crude. Then the paraffin must collect and adhere as a mass that is not removed under normal operating conditions.

It has been known that the solubility of paraffin in crude oil is affected by two major factors, which are temperature and crude oil composition. A reduction in temperature can occur due to expansion of gas or to heat transfer to cooler surrounding formations or to cool air on the surface, resulting in a lower solubility of paraffin. Normally, when pressure on a well fluid is reduced, some of the lighter components of the crude vaporize. The loss of these lighter ends from the crude lessens the natural solvent tendencies of the crude, with the result that paraffin precipitates.

In the process of precipitation, very fine wax crystals are formed. Agitation of the fluid then causes these crystals to collect as small grains. These are carried in the fluid to some place where conditions are favorable for them to accumulate, such as rough pipe surfaces or dead fluid spaces, where they deposit. Also, when a condition prevails of alternate wetting and drying with crude, such as in a surging well, deposition sometimes occurs.

Effect of Paraffin Deposits

The effects of paraffin accumulation on well production are well known. It might be appropriate, however, to mention some of the difficulties experienced with severe paraffin deposits. Probably the most common occurrence is the plugging or partial plugging of tubing and flow lines with paraffin. If a deposit is not removed periodically, it will accumulate and restrict the flow opening, like a choke, and less production is obtained. Eventually, a solid plug is formed and flow ceases completely. In the case of a rod-pumped well, a large quantity of deposited paraffin can bind the rods to such a point that production stops and the rod cannot be pulled, necessitating a costly stripping job.

Although it is not common, cases are known in which conditions were such that paraffin depositions occurred in the producing formation and on the face of the bore hole. Normally this happens only in a nearly depleted reservoir. The problem can be extreme with a small amount of oil production which drains down a large exposed sand face surface. The result of deposition of paraffin on or in the formation is production decline which might be mistaken for natural well decline, and could cause premature abandonment of a well.

Prevention of Paraffin Deposits

In the past, it has been the general practice of the industry to place emphasis on methods of paraffin removal rather than prevention. It should be recognized, however, that a considerable reduction in deposition can be realized through proper operating practices, and that in some cases paraffin problems can be entirely eliminated. The approach to prevention should be to consider any means available to change those conditions which cause paraffin deposition, i. e., temperature drop, loss of light ends, and the opportunity for precipitated crystals to accumulate and agglomerate.

Sand Face Deposits

In the case of a stripper well, deposits can occur on the face of the producing formation if a well is being pumped from bottom. Here a small amount of oil draining down the bore as a thin film is being continually dried out, leaving an accumulation of paraffin. The deposition probably could be reduced by maintaining the fluid level near the top of the formation.

Deposit In Tubing

Formation of deposits of paraffin in the tubing strings, in both flowing and pumping wells, can be minimized by keeping the strings as nearly full of fluid as possible. The use of a gas anchor is a pumping installation to prevent entry of gas into the tubing with the oil helps in this respect by reducing heading in the well. The use of a back pressure valve has also proved to be of value in maintaining the tubing full of oil, thereby keeping light ends in solution.

The surging effect and high rates of paraffin deposition are more pronounced in some flowing wells, and are even artificially induced in wells that are flowed intermittently. Considerable paraffin deposition is also found in high gas-oil ratio wells in which the gas tends to strip the lighter fractions out of the crude. It follows that paraffin problems can be reduced by producing with as little gas as possible.

Considerable success has been obtained in some instances in preventing paraffin accumulation through the use of plastic coated equipment. The smoothness of the plastic surfaces does not provide a gathering point for the accumulation of paraffin, even though precipitation of paraffin crystals from the crude has occurred. The costs of plastic coatings are high compared to the nominal cost of paraffin removal from most wells. There are, however, certain fields in the Permian basin in which extremely severe paraffin problems are encountered, and where coatings have been proved to pay out in a relatively short time. For example, the cost of paraffin scraping in a newly completed flowing well in the Monahans Fusselman Field was approximately $45 per week from February to April 1945. Since the installation of 5,000 feet of plastic coated tubing in April 1954 there has been no evidence of paraffin accumulation in the well.

Some use has been made in the industry of down-hole electric heaters for paraffin prevention. In general, the cost of the units plus the power costs will probably make this method economically unattractive. An exception may be an instance where paraffin is depositing on the sand face and production can be maintained by heating.

Deposits In Flowlines

Attempts to prevent paraffin in flow lines should be based on the probable cause of the deposition. Some use has been made, in cold climates, of small line heaters near the wells to maintain the crude temperature. Back pressure valves, for maintaining pressure on the lines, have minimized deposition in several instances through holding light ends in solution and by preventing "heading" flow and drying out of the oil film on the pipe surfaces.

During the last few years considerable use has been made of plastic and plastic coated lines to prevent paraffin accumulation. A major portion of these have been successful in a least minimizing paraffin troubles, although several instances have been reported in which the problem was not completely eliminated.

A simple method of minimizing paraffin deposition in flowlines which is often overlooked is the elimination of excess pipe fittings and dead fluid spaces which promote paraffin accumulation.

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Removal of Paraffin Deposits

In normal practice, the operator sometimes finds it impossible or impractical to prevent paraffin deposition and consequently is faced with the problem of removing accumulated paraffin from the well or flowline. The nature of most of the common means of removal permits classification in one of the following groups:

1. Mechanical
2. Heating
3. Chemical

The scope of this discussion will be limited to the first two of these groups. In order to simplify the discussion, specific cases of removal problems will be considered on the basis of the type of lift method employed and the location of the paraffin deposit.

Deposits In Tubing of Flowing Wells

The most common method of removing paraffin deposits from the tubing of a flowing well is with wire-line scraping tools. Any number of special devices have been designed and patented for this purpose. Essentially all of these tools incorporate a knife-edge or a series of knives of some sort which fit closely to the inside circumference of the tubing and which will thoroughly scrape the inside surface when the tool is pulled up through the tubing. Such tools make provision in some manner for by-passing fluid in the tubing when they are being run into the well.

Additionally, several other devices, commonly referred to as "rabbits," are available which are similar in action to scrapers. With the well shut in, these are lubricated into the tubing and fall to a stop ring placed in the tubing below the paraffin level. When the well is opened, well pressure forces the "rabbit" to the surface and its cutting edges clean the paraffin from tubing.

The prime consideration in using mechanical scrapers is to use them frequently enough to prevent large accumulations. Paraffin cutting can be extremely difficult if a deposit is permitted to build up and harden over a period of time.

Some success has been reported in removing semi-fluid paraffin deposits from high capacity wells by periodically flowing at high rates. This practice, however, should be carefully examined from the point of view of damage to the well from gas or water coning in the reservoir.

The use of heat for removing paraffin from the tubing of flowing wells is not common practice, except, of course, as is the case when tubing has been pulled and is racked on location.

Deposits In Tubing of Hydraulically Pumped Wells

The methods of paraffin control applicable to hydraulically pumped wells are dependent on the type of hydraulic eequipment used and the type of problem encountered. Deposition may be classified into the two following general groups: (1) deposits which form in annular spaces between two tubing strings, and (2) deposits which form inside of a tubing string or flowline.

In the case of a hydraulic conventional insert installation, power oil is pumped down a small inner tubing string and exhausted power oil is produced with the well fluids through the annulus between the power oil tubing and the production. If a paraffin problem exists with the particular produced crude, deposits will occur in this annulus. The most effective known means of mechanically removing such deposits is through the use of scrapers attached to the outside of the power oil tubing through the paraffined section. A hydraulic lifting device is utilized to raise and lower the entire power oil tubing string and the attached scrapers, thereby cleaning the production tubing walls. Paraffin which is removed in this operation is then pumped out of the well with the produced fluid.

In other types of hydraulic systems, and in the flowlines, paraffin accumulation occurs only in full opening lines or tubing strings. For removing such deposits, the use of soluble plugs has been found to be very effective. A soluble plug is a short solid cylinder made of material that will dissolve in oil after several hours exposure. The plug will keep its shape long enough to push deposited paraffin down a line when fluid pressure is applied behind it. These plugs are available in various sizes to fit the several sizes of pipe and tubing found in the field. Plugs can be placed in small lines using special injector valves which allow them to be inserted in a line without shutting off flow through the line.

The major point to consider in using soluble plugs, as is true with most mechanical removal methods, is to use them frequently. They are relatively cheap and regular use can prevent a large paraffin accumulation.

Deposits In Tubing of Rod Pumped Wells

Wells from which production is lifted with sucker rod actuated pumps comprise by far the greatest portion of artificially lifted wells. The basic nature of the pumping action in such wells provides a very convenient means of removing accumulated paraffin, since the normal reciprocation of the rods can be used in conjunction with mechanical scrapers to provide continual cleaning of the tubing surfaces.

Several types of rod scrapers are currently marketed commercially. Typically, these consist of short metal scrapers which are attached by friction grip to the sucker rods throughout the zone of paraffin deposition in the tubing. Particular care should be exercised in attaching scrapers to the sucker rods to insure that adequate holding power is obtained. Consideration should also be given to proper spacing of scrapers on the rod string to obtain complete coverage of the tubing with the normal length of rod stroke. Experience has indicated that overlap of the tubing areas contacted by rod scrapers is necessary. Rod scrapers have been used widely and perform adequately in many fields. Their use should definitely be considered if the economics are favorable.

One somewhat unique approach to paraffin removal in rod pumped wells was introduced in the West Texas area a few years ago. This method incorporates an extra string of small tubing running from the surface to a depth below the paraffin level where it joins the large tubing. Production is diverted through the smaller tubing and the rods operate in static fluid which eliminates paraffin around the rods. Deposits in the small tubing are cleaned out by pumping down soluble plugs using pressure from a hydraulic pump which is powered by the motion of the walking beam on the pumping unit. The initial cost of this removel system is relatively high, making the system economically applicable only to wells where paraffin deposition is very troublesome.

The most common paraffin removal methods for rod pumped wells use heat in some manner to soften and dissolve accumulated paraffin. In general, this heat is applied to deposits from an external source. The two methods which are most widely practiced are steaming and hot oiling. With these methods, steam or crude oil which has been heated to the neighborhood of 300 degrees F. is injected into the casing while the well is being pumped. Heat is then transferred through the tubing walls to the produced fluid in which the paraffin becomes soluble. Operations of this nature require a considerable initial capital investment in steaming or hot oil equipment, but the practice is so widespread that service is available on a contract basis in most areas. Heating methods for paraffin control have been highly successful in many areas.

One fairly recent development in hot oiling equipment merits mention here. This is the use of a hollow sucker rod string, and related equipment, to a depth below the zone of paraffin accumulation. With this arrangement, hot oil is injected down the hollow rod string and goes into the tubing through a check valve at the bottom of the hollow section. Using this system, it has been found possible to reduce the amount of hot oil necessary to remove deposited paraffin, since considerably less heat is lost to the formation. The expense of the hot oil job is consequently reduced, since less unit time is required. Needless to say, the cost of hollow rods is higher than that of conventional rod installations, and the difference can be economically justified only with a particularly troublesome paraffin problem which requires frequent treatment.

Deposits In Gas Lifted Wells

In general the removal of paraffin from wells produced by gas lift is accomplished by methods similar to those used for flowing wells, scraping for example. One unusual control method has been reported, that of heating the injected gas to prevent depositions, although this method is somewhat limited due to the low heat capacity of gas. It is mentioned here

to demonstrate that an out of the ordinary approach to field problems sometimes is fairly successful.

Deposits On The Sand Face

In some fields, the accumulation of paraffin on the face of the formation and in the formation constitutes a serious problem. Conventional mechanical removal methods are rarely applicable in such cases. Scraping would not be effective against paraffin in the formation, and scraping the walls would be an expensive operation requiring killing the well and pulling the tubing.

Limited use has been made in some areas of explosives to remove sand face deposits. In such cases, nitroglycerine shots are usually used to shatter the sand face. This method is, of course, expensive, but has proved to be economically justified in some places through being able to maintain production.

Commonly, sand and sand face deposits are removed by means of dissolving them with steam or in hot fluids such as solvent, gasoline, or crude oil. Heat can be supplied from the surface, but several other means of creating bottom hole heat have been developed. Among these methods are heating by means of electrical resistance heaters or electrical induction heaters which are used in the bottom of the hole opposite the pay. Electric heating methods are, in general, expensive, but are reported to be profitable in certain instances.

Paraffin can be melted using heat generated by the reaction of various chemical materials. These chemicals are normally used in conjunction with fluid solvents of some sort. Several different heat-generating reactions have been used for this purpose, among the common ones being the reaction of lye and aluminum filings. Heat from chemical reactions is expensive, but has reportedly proved profitable in some places.

Deposits In Flowlines

Removing paraffin deposits from flowlines is generally done by means similar to those used in cleaning tubing. Mechanical methods available include scrapers, rabbits, and soluble plugs. Heating methods are commonly employed, with steaming most used in this area, although when wells are hot oiled, flowlines are usually cleaned in the process.

Summary

In closing it should be noted that the solution of any paraffin problem should be based on the economic considerations involved in the specific case. If paraffin prevention can be accomplished more cheaply than removal, that is the thing to do. On the other hand, if paraffin prevention is not practical, the over-all least expensive removal method is the one your management wants you to find and use.

It should be emphasized, too, that the first consideration in removing paraffin by any method is to use the method regularly. Here, like in many other instances, keeping up with the problem is the way to stay ahead of it.