Paraffin Control And Removal In Hydraulically Pumped Wells

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Paraffin control is a major operating problem with practically all oil producing companies in the Mid-Continent Area. It is generally so in the Permian Basin and particularly so in certain pools or fields in this area. Fields particularly troublesome, from a paraffin control standpoint in this area, are Levelland, Slaughter, Vacuum, Foster, North Cowden, Spraberry Trend and many others.

The occurance of paraffin in the piping systems of producing oil wells account for control problems varying from very mild to severely troublesome. Paraffin control, then, is a major operating problem in certain fields with any type production method, whether natural flow, conventional rod pump, gas lift or hydraulic pumping.

Paraffin accumulation in the piping systems of producing wells consists generally of grannular particles of wax with gum resins, asphaltic materials and crude oil. While the percentage of paraffin contained in crude oil varies widely between various crudes, the composition of the freshly formed paraffin itself can be approximately stated as follows: wax 50 to 55%, gums and resins 10 to 15%, asphaltic material 0 to 5%, crude oil 30 to 35%. Naturally during the depositing process if other solids such as sand, iron oxide, salt, water, etc. are contained in the crude oil these particles will be trapped in the deposit.

The control of the depositing action is mainly in the solubility of the wax in the crude oil which in turn depends on the melting temperature of the wax, the solvent power of the crude oil and the temperature of the oil. While the melting temperature of a particular wax remains constant, the solvent power of the crude oil may be reduced by loss of lighter constituents or by decrease in temperature. In as much as the wax is in solution in the oil under formation conditions of temperature, pressure and oil characteristics, deposition occurs when these factors are changed.

The effect of pressure changes is practically negligible and under conditions of continuous production, decrease of solvent power by losing light ends is not a general problem. Consequently the most important factor is loss of temperature.

If the temperature of the produced crude oil is decreased either due to the normal difference in the earth's temperature between formation and the surface or due to the refrigerating effects of gas expansion, as the critical temperature is reached the oil becomes supersaturated with wax and the wax begins to crystallize and adhere to the pipe walls. A general critical temperature range can be taken as 50 to 80 degrees F with an average figure of 60 degrees F. With this wax deposit are included the other constituents making a mushy mass due to the contained crude oil. As the oil of the paraffin deposit drains or "sweats" out, the deposit changes progressively from a viscous liquid to a drier, harder accumulation. The nature of the final deposit will depend on its initial character and the time it has aged.

The effect of paraffin depositing on tubing walls is to reduce the effective inside diameter of the pipe or tubing, and the smaller the diameter of the tubing the more the effective inside diameter will be reduced. This reduction in effective diameter increases the fluid friction in the tubing, and in turn, more pressure is required to force fluid through the tubing. If the paraffin deposits are permitted to keep accumulating the point will ultimately be reached where a bridge is formed, and flow through the tubing will be cut off entirely.

The hydraulic pumping system produces crude oil and uses crude oil as the power fluid. The power fluid is transmitted to the production unit oil at the bottom of the well by means of tubing. Without equivocation, paraffin control, with the hydraulic pumping system is in one sense personified or increased, if consideration was not given to fact that by having a hydraulic pumping system, facilities are constantly available for paraffin control.

When producing by natural flow, it is customary to control well tubing and flow line paraffin deposition by special means such as wire line paraffin cutting units for the well tubing and steam or hot oil for the flow lines.

When producing by sucker rod pumping units paraffin deposition in the flow lines is generally removed by steam or hot oil.

This obviously entails a constant operating expense and often results in off production down time. Hydraulic pumping offers constant paraffin control by the operating personnel as a regular duty. It is true that the operating person has a duty not before required of him in operating a producing lease or well, but it has been definitely established he can also control paraffin with the hydraulic pumping system with no more overall effort applied in totally operating the lease than with any other pumping equipment.

The hydraulic pumping system as generally applied to producing oil is divided into two major classes. These are the conventional insert type and the free type. The method of controlling paraffin in either system differs according to the type of installation.

In the conventional insert hydraulic installation, one type of paraffin forms in the annular spaces between the power tubing and the production tubing, and in many cases forms in the surface production line to the stock tanks. There is a second type of paraffin forming in the surface power line to the well and in the well and in the well power tubing. In hydraulic pumping systems it is possible that the power oil being pumped from the surface and down the well to operate the subsurface production unit may lose temperature through the critical wax deposition range and deposit paraffin in the power oil surface lines or the subsurface power oil tubing. On the production side of the pump in the annulus between the power tubing and production tubing, paraffin usually commences deposition 800′ to 1500′ from the surface due primarily to two reasons: loss of bottom hole temperature and refrigerating effects of gas expansion.

An installation of the free type hydraulic system has relatively the same type deposition and for the same reasons. Control measures are different due to type of installation only. There is some controversy relative to the effectiveness of one type hydraulic installation versus the other. It appears that either controls paraffin effectively with no particularly outstanding advantage or disadvantage to be given either system.

In the hydraulic conventional insert type system, the problem of removing annulus paraffin is best accomplished by installing mechanical scrapers through the paraffin zone at regular intervals on the power oil tubing string.

For actuating these scrapers there is available a hydraulic lift for use with mechanical tubing scraping devices. The hydraulic lift is essentially a cylinder and piston that is attached to the power tubing string at the wellhead. By using the high pressure fluid available to actuate the piston in the cylinder it is possible to raise and lower the entire power tubing string. The hydraulic lift's stroke is more than the spacing of the scrapers; thus it is possible to scrape the entire inner surface of the production tubing throughout the paraffin zone with the scrapers. Paraffin removed by the scrapers can then be pumped up the annulus and into the surface production line.

Other than annulus paraffin encountered in the conventional type pumping system, the problem of paraffin control in either the conventional or Free Type pumping systems is confined to depositions in the full open spaces of pipe and tubing. To remove paraffin deposits in open tubing, various types of plugs or go-devils are used that can be pumped or forced through the tubing to mechanically scrape paraffin from the walls. The Hydraulic Pumping System is especially well suited for this type of paraffin control since the high pressure fluid used to operate the subsurface production unit is readily available to force plugs through surface lines or well tubing. However, in running any solid type of plug there is a disadvantage that the plug normally has to be retrieved, which means breaking out surface connections or pulling well tubing. It is also somewhat difficult for solid type plugs to pass through elbows, tees and other common field fittings. To overcome these difficulties various soluble plugs have been developed.

Soluble plugs generally are short cylindrical plugs compounded of materials that are soluble in oil after a few hours exposure, and that are melted by temperatures above the critical paraffin deposition range. The plug can be inserted in the line ahead of the section to be cleaned, and then pumped down the line with the hydraulic fluid power of the system. The plug, the diameter of the pipe, has sufficient shear strength to push the paraffin accumulation from the walls and soon a continuous core of the paraffin itself is being moved through the line pushed by the soluble plug. Since most plugs are plastic and somewhat elastic they will travel through and around tee and ell fittings encountered in the system. The basic design of the present hydraulic system provides a larger opening at the end of each line to be cleaned, that allows the plug when pushed through the line to cease its travel and be eroded by the oil washing over and around it. When run down the well this eroding action is assisted by bottom hole temperatures.

Field performances has justified the thought behind this manner of paraffin removal. It has been entirely successful. Soluble plugs are now manufactured for all common size oil lines. Automatic soluble plug injectors are now available for purchase. This type of paraffin control is now accepted for use on rod pump installations, natural flowing type production to clean the flow lines. Some operators even use them to clean well tubing of flowing wells by "rocking" down the hole with casing pressure.

The effectiveness of using soluble plugs in preventing serious complications is dependent entirely on running plugs with sufficient frequency to prevent extreme conditions. Run soluble plugs before the paraffin deposition has become severe. Thus it is essential to watch for indications of paraffin and to establish and maintain a definite schedule for running plugs.

The frequency with which plugs must be run varies widely, and is dependent on many factors such as the characteristics of the produced crude, weather conditions, etc. However, experience and various indications can be combined to establish a schedule for any particular well or group of wells.

When a soluble plug is inserted and run in any particular part of the hyrdaulic system the pressure gauge is a good indicator of the amount of paraffin accumulated. As the plug encounters paraffin the pressure required to push the plug will show up as an increase of the pressure gauge reading. The amount of the increase will be somewhat proportional to the amount of paraffin being removed.

The simplest and safest method of establishing schedules for running plugs is to run plugs at frequent intervals initially. If pressure increases noted when the plugs are run are only nominal, the intervals can be safely extended. However, in all cases plugs should be run often enough that only moderate increases in pressure are required to push the plugs.

There has been on many occasions plugging of crude oil lines from paraffin when attention is not paid to this phase of the hydraulic operation. However, there has never been any occasion where the soluble plug manner of controlling paraffin has caused operational trouble when the following simple, basic steps are followed.

1. Put the soluble plug in the line.
2. Put the soluble plug in line before an extremely hard and volumous paraffin deposit has accummulated.
3. Push the plug through the line with the available pressure.

Although there are other methods of controlling paraffin the soluble plug method is used almost entirely in the hydraulic system. All hydraulic systems provide facilities for the use of plugs in their respective systems as a matter of course.

Obviously there has developed different ideas among oil operators as what constitutes a proper soluble plug The point of contention appears to center around degree of hardness required for different weather conditions. It has been pretty well determined, however, that if paraffin is removed on schedule, while the paraffin is comparably soft, any plug does a good job.

As it has been stated previously that paraffin deposits when the temperature of the oil drops past the critical point for that particular crude oil, this discussion naturally should not be concluded without examination of effective paraffin control in a hydraulic system by use or application of heat.

There have been many instances, and there are at this time several instances, where heat application or temperature maintenance is all that is required to eliminate a paraffin problem in the hydraulic system. The basic requirement for this type control is a large volume of produced fluid and a large volume of power oil. Hence the power fluid is moved down the hole fast enough that the critical temperature for paraffin deposition is not reached prior to the time this fluid reaches bottom hole temperature conditions and the temperature of the oil starts to raise again.

The produced fluid, if traveling at a sufficient rate, controlled, of course, by the volumes involved does not actually have time to cool to the critical point until it reaches the surface. As a result except in extreme weather conditions there is no paraffin problem. There have been many instances where a very small amount of heat applied to the power fluid at the origin has accomplished the above.

For the above reasons and due to gas refrigeration being less effective it is very unusual to encounter a paraffin problem in the production lines on large volume water wells.

Solar heat must not be ignored. Decidedly, paraffin control in the hydraulic system is easier when operating conditions allow all lines to be placed on the surface.

With the exclusion of solar heat benefits—operations in the Permian Basin do not appear to be adaptable to use of heat. This is primarily due to the small volumes of fluid generally handled and the long lines usually involved.

In many instances, especially in cultivated areas, all lines are buried very deep. It is obvious then when considering small volumes, that paraffin deposition is extreme under this condition. Running soluble plugs on a strict schedule is absolutely necessary for paraffin control here. Heat can not be carried very far at a slow rate.

At present, and particularly so during the past, power oil tankage piping arrangement, treating policies, type tanks used personified deposition problem in the power transmission lines.

As heat can not be transformed under average conditions in the Permian Basin it has been determined by field experience that the alternative, most desirable type of power fluid is as cold a power fluid as possible.

Oil in steel tanks cools faster than in wood tanks hence steel tanks are more desirable for power oil tanks. It is recommended that as small amount of heat be used in treating as is possible to conform with that just stated.

It has been determined that paraffin precipitates in a tank after cooling. It has been determined that oil can become supersaturated in a tank if temperatures are held high in the tank. It has been determined that paraffin super-saturated oil concentrates in the bottom of a tank and if not dissipated will eventually constitute the power fluid. Hence the extreme paraffin control problem in the hydraulic system is hand made.

After observing and considering this phase of paraffin control present recommended power oil tanks provide plumbing which tends to minimize this action by withdrawing oil to stock at a much lower level on the tank than the power fluid is withdrawn.

Supporting one phase of that situation just discussed,, it has been continually observed that when the power oil is cool as desired, during the course of years of operation a thick paraffin cake forms on the bottom of the power tank. It is most desirable that this be removed.

In many wells the deposition of paraffin can be controlled by operating practice. In some cases chemicals can be used to inhibit or discourage the precipitation of wax crystals. However, in most pumping problems there is usually little to be done in changing the operation to prevent paraffin, and other preventative methods are impractical because of expense. Consequently the best answer found to date has been the development of simple means to remove the paraffin after it has formed.

Summary

The discussion that has been presented summarizes the result of many years of trial and error testing for best methods of paraffin control in the hydraulic system. Oil companies and equipment concerns have given much time, money and effort to this problem.

At this time, as stated previously,, paraffin control is now a minor problem in the hydraulic pumping system. Facilities are readily available for this purpose. Better methods will be developed. When they are developed they will be readily accepted, to be sure.

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