Disadvantages of Hot Oiling for Downhole Paraffin Removal in Rod Pumping Systems

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ABSTRACT

The use of hot oil as a paraffin removal technique has existed almost as long as the production of crude oil. It is still one of the most commonly used methods for the removal of paraffin deposits from the wellbore, tubing, flowline and tankage in the oilfield today. The relative simplicity of application, immediate results and low cost per application have made hot oiling an accepted, if not traditional form of paraffin removal. This paper discusses the disadvantages of hot oiling that have been overlooked in the past, but should be considered with our present knowledge concerning paraffin and asphaltene deposition. Topics discussed include the following problem areas; source of oil, loss of oil during hot oiling, formation damage, tubing plugging, flowline plugging, surface equipment problems and tank bottoms. Suggestions for minimizing each of these problems are made and an alternative to hot oiling is presented. These topics are presented for practical application on most rod pumping systems.

INTRODUCTION

The use of hot oil to clean crude oil production equipment is a commonly accepted practice in the oilfield today. It is so readily accepted that often the problems encountered during the hot oiling process are forgotten or overlooked. Hot oiling has become the traditional first step in solving production losses or pump problems on a day to day basis. It is done before pump changes, pulling jobs or any downhole maintenence procedure in a great many areas. It is so readily accepted that in many fields, wells are hot oiled on a regular basis (biweekly, monthly, etc.) without anyone really knowing if it is needed on every well. An example of this was found in a large field in Wyoming which had historically been hot oiled monthly for more than ten years. To determine how severe this downhole problem actually was, 5% of the pumping wells were taken off the hot oiling schedule. After one year none of the wells had any downhole paraffin plugging problems. This action reduced the number of hot oil jobs by 60 during this year. In addition no pump changes were needed where five to ten were expected based on historical records. This experience raises some major questions concerning the practice of hot oiling. Does a well need to be hot oiled frequently or does the practice of hot oiling contribute to the need to be hot oiled? Are production declines, pump pluggings, tubing and flowline problems, separator and tank problems cured or aggravated by hot oiling? In order to answer these questions we first need to understand the hot oiling process.

HOT OILING

The hot oil process involves using a truck equipped with a heater, usually a direct fire gas heater. A source of oil is chosen, a tank at the nearest battery. The truck draws oil from the bottom of the tank and transports it to the well. A hose is connected to the wellhead, the heater is fired and oil is circulated through the firebox to the well. The pump rate of the oil is maintained so that the oil exiting the firebox is maintained at the desired tempertaure (150-300°F). Some oil may be pumped into the flowline initially, to clear any paraffin from the wellhead area. The remainder of the oil is pumped into the annular space of the well. Sometimes the final few barrels will again be diverted to the flowline to clear any remaining

paraffin from the flowline. Hopefully when the truck drives off all the paraffin has been removed from the well and flowline.

This process is basically a thermal process. The hot oil entering the flowline or annular space melts the paraffin from the walls of the tubular goods. When hot oil is pumped into the annular space only thermal removal is possible. The hot oil pumped down the annulus never contacts the paraffin in the tubing. Heat from the hot oil is transferred into the tubing string and this heat melts the paraffin off the walls of the tubing. The melted paraffin dissolves into the oil in the tubing and is carried from the well. The hot oil never contacts the paraffin in the tubing, it continues to fall to the bottom of the well (losing heat continually), and is produced back over the next several hours.[1] This can be verified by catching samples from the flowline as hot oil is pumped into the annulus (See Table 1). Within five minutes large quantities of paraffin dissolved in the oil will raise the pour point of the oil coming from the tubing. It is often observed when pulling a well after hot oiling that the rods have some paraffin remaining on them. This occurs because the rods receive less heat since they are in the center of the tubing and only the lower melting paraffins are removed (See Figure 2).[2]

This process to remove accumulated paraffin deposits has a number of inherent disadvantages.

SOURCE OF OIL

The oil used for hot oiling presents the first disadvantage for the hot oiling operation. Since the wells to be hot oiled are assumed to have paraffin problems, the tanks closest to these wells usually contain high quantities of paraffin. Since hot oil trucks draw oil from the bottom of tanks, this oil usually has the highest paraffin content of any oil in the field. Samples of crude in hot oil trucks have been found to contain twice the amount of paraffin as oil being produced at nearby wells. This is due to the higher density of the paraffin and asphaltic components of the oil causing them to settle toward the bottom of the tanks. (See Figure 3) The crude used to hot oil may also contain more solids such as iron sulfides, sand, clay and iron oxide.[3]

Separation equipment also causes more paraffin to precipitate in the tanks than elsewhere in the system. Any equipment that allows gas to escape, such as 3 phase separators, heater treaters or gas recovery systems increase the cloud point of the oil by concentrating the paraffin into a smaller volume of oil.[5] (See Figure 4)

Depending upon treater temperatures, tank size and production rates the tanks are usually the coolest part of a system. These lower temperatures cause more paraffin to precipitate out of solution and settle toward the bottom of the tank.[6] (See Figure 5)

When this high paraffin content hot oil is pumped downhole, it immediately begins to cool. It loses heat to the walls of the casing, tubing and fluid being produced up the tubing. By the time this oil reaches the bottom of the annular space it can cool to a temperature low enough to start redepositing paraffin, asphaltic materials and solids. So in effect the paraffin deposition cycle can be started by the oil just used to remove paraffin from the tubing.

Possible solutions to the disadvantage of using high paraffin content oil are the following:

1. Use of top oil
   This will minimize the amount of paraffin in the hot oil but may increase the size and frequency with which tank bottoms develop.

2. Treat Oil with Chemical
Oil used for hot oiling can be treated with paraffin dispersants to keep paraffin from depositing. This method is being used at some locations to minimize damage but high dosage rates may be required to be effective.[7]

3 Change Fluids
Use another fluid that can be heated to remove the paraffin from the tubing and doesn't contain large quantities of paraffin. Condensate, diesel or water are being used in various locations for this purpose. Costs and availability are prohibitive for condensate or diesel as alternatives to oil. Condensate can also cause precipitation of asphaltenes in locations where dark oils are produced. Produced, fresh or KCl water are more attractive alternatives to oil.

OIL LOSS DURING HOT OILING

The second big disadvantage of hot oiling is the loss of oil. This loss of oil is a hidden cost of hot oiling which is frequently ignored.

Oil is lost during hot oiling due to its volatility at elevated temperatures (150-300°F). Pumping units usually have low annular pressures. When oil is heated during hot oiling and pumped into the annular space, rapid expansion of the oil takes place and the light ends are lost as gas. As much as three to ten barrels of oil can be lost during each hot oil job depending upon the volatility of the oil being used. Samples of oil heated to 200°F on a steamplate in the lab for one hour lost 15 to 60% by weight as gas. Losses in the field are smaller due to the increase in pressure in the annular space as more oil is pumped and pressure increases.

This loss of light ends from the first 10 to 20 barrels of oil causes an increase in the percentage of paraffin in the remaining oil. This in turn raises the cloud point of the oil, resulting in paraffin precipitation at a much higher temperature.

The volatility of oil is a disadvantage that is hard to avoid except by using a less volatile fluid. Produced water is again an excellent choice compared to other choices such as diesel or kerosene. These fluids are less volatile and have lower quantities of paraffin than crude but the cost and availability are prohibitive.

FORMATION DAMAGE

Another disadvantage of hot oiling that is frequently overlooked is formation damage. This is the slow accumulation of paraffin and asphaltic materials mixed with solids left on the formation face and in the formation near the well bore. Loss of production may result which is sometimes confused with or classified as natural decline. The larger the amount of hot oil used the farther into the formation this damage may extend.

The use of high paraffin content oil and loss of light ends both contribute to formation damage. These factors in conjunction with the increase in fluid level during hot oiling cause the oil to be pushed into the formation leaving the plugging agents behind.

Due to the high pump rate used most pumping units cannot unload the well fast enough to keep the well from developing a high fluids level. When the weight of this oil exceeds the formation pressure reverse flow develops. Any additional oil added will cause the first oil pumped to be displaced back into the formation. Remember that the first oil pumped into the well experienced the worst loss of light ends. This oil containing paraffin that may be out of solution, asphaltenes and solids is forced back through the perforations and into the formation. If this process is repeated over a long period of time production losses can be substantial. The paraffin that comes out of solution at the cloud point of an oil is the highest melting paraffin in

an oil so that once out of solution formation temperatures of 140-150°F may not be high enough to melt the paraffin back into solution. Once in place outside the perforations few treatments including acidizing have any removal effects on these solids particles of paraffin. This type of damage can explain losses of production that occur in some fields that have been hot oiled regularly for a number of years. This type of damage should be suspected if a chemical or solvent treatment causes a large production increase [8] or small temporary production increases occur immediately after hot oiling.

Formation damage is a disadvantage of hot oiling that is a secondary effect. It occurs after the hot oil has cleaned up the tubing by heat transfer and can not be easily observed unless a sudden drop in production is seen. It is a slow process and may require a number of months or years to see. There are a number of ways that formation damage could be minimized or greatly reduced.

1. Use top oil to minimize damage.

2. Treat hot oil with chemical to minimize damage.

3. Periodically clean up the formation face with a solvent or chemical treatment to remove accumulated paraffin, asphaltic materials and solids.

4. Use other fluids that contain very little or no paraffin, that will not damage formation.

PUMP, TUBING AND FLOWLINES

After a hot oil job is done the tubing and flowline are assumed to be clean. Much of this optimism is generated by the observed results when a pump is changed immediately after hot oiling. The tubing is found to be clean because no paraffin is found on top of the pump when it reaches the surface. The rods are clean except for a few lower in the string where it is hard to raise the temperature high enough to melt all the paraffin in the center of the tubing. At this point the optimism is justified, the downhole equipment has been cleaned. The disadvantage of hot oiling at this point is the oil used to hot oil with is cooling off. As it cools, more and more paraffin comes out of solution. At this point in time the worst oil in the system is sitting at the bottom of the well waiting to be produced back through the clean system. This disadvantage is often overlooked except when a new pump plugs a day or two after running it into the hole. Since the well was just hot oiled the pump may be pulled without hot oiling again. Often when this is done a large quantity of paraffin is found on top of the pump or the pump can stick leading to another hot oil job. This paraffin, that shouldn't be there, is deposition from the previous hot oil. This oil has deposited the foundation layer for the next build up of paraffin in the tubing and flowline. It is not unusual that a flowline needs to be hot oiled the day after a downhole hot oil job. If solids were present in the hot oil, they may become the pump plugging agents as the oil is pumped back to the surface.

The solution to these problems is again the use of a fluid that contains as few plugging agents as possible.

SURFACE EQUIPMENT

All of the paraffin, asphaltic materials and solids removed from the well during hot oiling and those carried in the hot oil, eventually end up in the surface equipment present on the lease. Gunbarrels, separators, heater treaters and storage tanks all have problems handling the large quantities of these materials produced after hot oiling. A ¼" buildup of paraffin in 1000 feet of 2" tubing will amount to approximately 535 pounds of paraffin to be moved through a system. It is not unusual for interface pads to develop, dump lines to plug or tank bottoms to occur. The

disadvantage in this area of the system is that the cooled hot oil returning from the well will do little to clean the surface equipment. The hot oil actually increases the problems since it is carrying a large quantity of plugging materials. Periodic cleaning of surface equipment has to be done in most locations due to the redeposition of paraffin removed from downhole.

High concentrations of these materials in the tanks are the end result of the hot oiling process. This starts the cycle over again as these materials are used to hot oil another well. This is especially true when production is low enough that a number of days are required to fill the tanks giving the paraffin time to settle towards the bottom of the tank.

The entire hot oiling proces is a recirculation of the paraffin problem through the entire system on a periodic basis. Some method is needed to break this cycle so that the fluid used to clean the system is not part of the problem.

ALTERNATIVE TO HOT OILING

The primary problem with hot oiling is the oil used to clean the system carries the paraffin that helps create the next problem.

If another fluid could be used that would meet the following requirements we would be able to break the hot oiling cycle:

1. A fluid that contains no paraffin or asphaltic materials.

2. A fluid that would carry enough heat to melt the paraffin from the tubing and flowline.

3. A fluid that could be chemically treated to do no damage to equipment or formation.

4. A fluid that could be chemically treated to clean the formation face, pump, tubing, flowline and surface equipment as it is returned to the surface.

5. A fluid that is readily available in most locations at little cost.

The only fluid that meets all of these requirements is produced water. Depending upon the type of formation and produced water available, chemical packages are available today that can solve almost any problem encountered with the use of produced water.

Water has been in use sporadically for many years in various locations. The use of produced water (untreated) has gotton a bad reputation in some areas due to a number of factors.

1. The higher cost to heat water in a truck due to its higher density. This cost is more than offset by the cost of the lost oil during hot oiling.

2. Scaling, corrosion, oxygen or bacteria problems being introduced into a well. These problems can be solved chemically with only small amounts of chemical. The same type problems are overcome in acid jobs with chemical packages everyday.

3. Water will not dissolve and dilute paraffin as oil does. This only occurs in flowlines where hot oil comes in direct contact with the paraffin. Chemicals are available that will keep paraffin dispersed and keep it from plugging flowlines or surface equipment even after it cools. These same types of chemicals when added to a hot water job will clean the formation face so that the tubing cleanup also helps to clean the formation face and well bore area instead of causing redeposition of paraffin.

4. Water causes swelling of some formation types and may lead to production losses. Chemicals are available to overcome these problems in conjunction with the use of produced or KCl water.

5. Water may cause emulsion problems leading to production losses. Chemicals are available to keep this from occurring.

All of the above historical problems using water can be tested for and any suspected problems taken care of with the wide range of chemicals on the market today. No hot watering program should be instituted without looking into these areas as a precautionary step.

Produced, fresh or KCl water in conjunction with chemicals are being used more often and more successfully today than ever before. Hot water jobs can reduce the frequency with which paraffin problem occur by:

1. Not recycling the paraffin.

2. Cleaning the formation, pump, tubing, flowline and surface equipment as it is produced back.

For these reasons hot watering is much superior to hot oiling as a downhole paraffin removal process. Oil, once produced, should be sold not recycled to aggravate an existing problem.

SUMMARY

Hot oiling has a number of disadvantages.

1. Oil used for hot oiling has a large concentration of paraffin, asphaltic materials, and solids.

2. Barrels of oils are lost during the heating and pumping operation.

3. Paraffin, asphaltic materials and solids in the oil cause damage to the formation face and well bore area.

4. Paraffin in the oil redeposits in pumps, tubing, flowline and surface equipment to help start the next deposition cycle.

5. Paraffin in hot oil eventually ends up back in tanks to be pumped downhole in the next hot oil job.

Hot watering with chemicals is an acceptable alternative to hot oiling that can be used to clean up a system without the disadvantages of hot oiling.

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Table 1
Paraffin in Tubing Fluids
Returning During Hot Oiling

These are the percentages of paraffin in the oil returning from the tubing during the ½ hour that the oil is being pumped downhole.

Well	Before Hot Oil	Time Interval After Start of Hot Oil Treatment: 3 Min.	8 Min.	18 Min.	28 Min.	1 Day
264	3.2%	30.6%	42.3%	49.4%	46.7%	3.3%
266	4.4%	15.7%	49.8%	28.2%	32.8%	3.3%
284	2.2%	11.9%	21.8%	25.2%	35.4%	1.9%
285	2.1%	12.2%	32.8%	46.8%	28.5%	2.1%
286	2.5%	14.2%	77.7%	67.3%	54.4%	2.2%
305	5.6%	34.6%	31.1%	14.4%	44.2%	3.2%
306	3.1%	22.4%	33.4%	26.4%	22.6%	-
307	3.3%	10.2%	33.5%	28.3%	19.9%	2.0%
315	-	10.7%	36.5%	43.7%	60.4%	5.1%

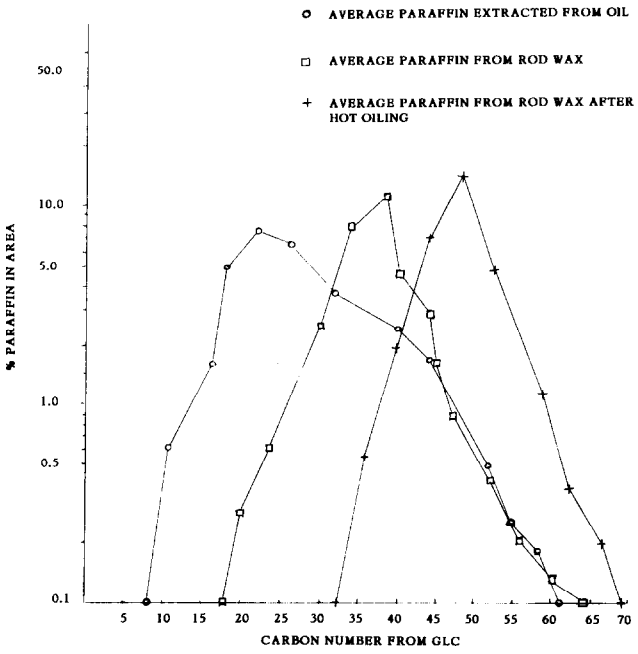

Figure 2 - Carbon number vs. % paraffin

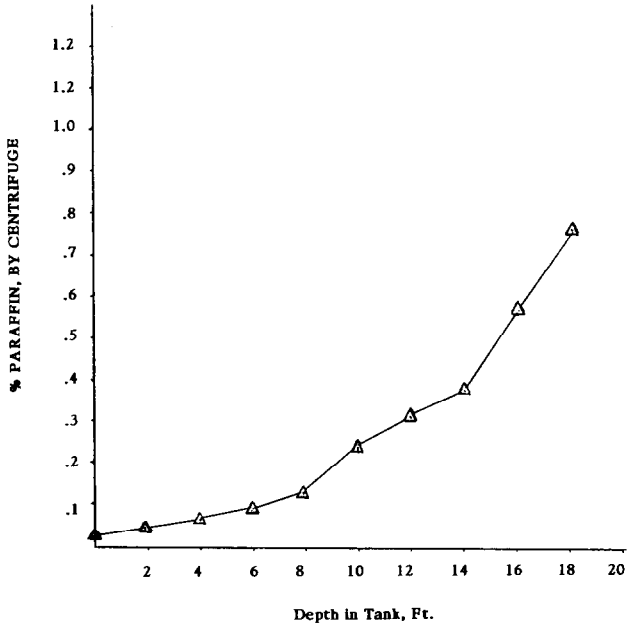

Figure 3 - % paraffin vs. depth in tank

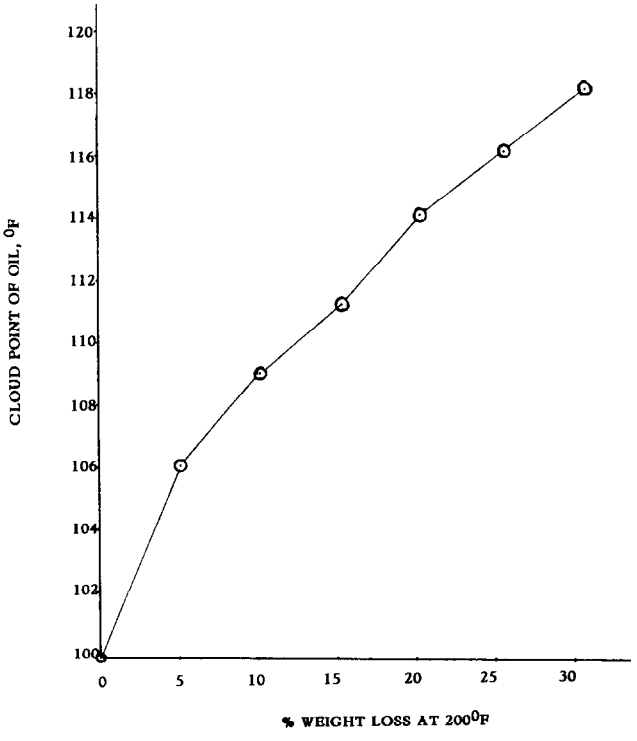

Figure 4 - Cloud point vs. % weight loss as gas

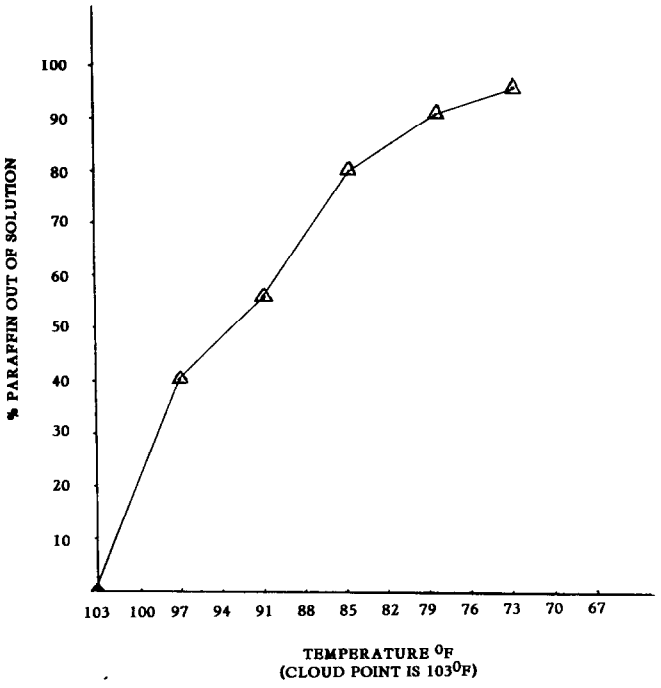

Figure 5 - % paraffin out of solution vs. temperature