

НЕФТЕГАЗОПРОМЫСЛОВОЕ ОБОРУДОВАНИЕ

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СОВЕРШЕНСТВОВАНИЕ ЭФФЕКТИВНОСТИ ОЧИСТКИ НЕФТЕПРОВОДОВ ОТ ОТЛОЖЕНИЙ ПАРАФИНОВ

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Как показывает мировая практика, процесс добычи, подготовки и транспорта нефти зачастую сопровождается образованием асфальтосмолопарафиновых отложений (АСПО) на внутренней поверхности нефтепромыслового оборудования, которое значительно снижает полезное сечение насосно-компрессорных труб, нефтепроводов. Толщина образующихся отложений со временем увеличивается, что ведет к увеличению гидравлических сопротивлений при движении жидкостей или газожидкостных смесей, приводит к сбою в работе скважин, контрольно-измерительных приборов и трубопроводных систем сбора и транспорта нефти. Интенсивное образование АСПО может привести к полному перекрытию подъемных труб и кольцевых каналов в затрубном пространстве на определенных участках, что вызывает необходимость проведения подземных ремонтов в целях депарафинизации скважин.

В статье проанализирован механизм образования асфальтосмолопарафиновых отложений на внутренней поверхности нефтепроводов. Показано, что такие факторы, как давление, температура, характер смачиваемости омываемых поверхностей, скорость движения нефти при транспортировке в трубопроводах, содержание смол, асфальтенов и твердых парафинов в составе пластовой нефти, играют ключевую роль в образовании асфальтосмолопарафиновых веществ.

Предложено устройство для очистки нефтепроводов от асфальтосмолопарафиновых отложений с обоснованными преимуществами перед аналогами. С целью улучшения качества и ускорения процесса очистки внутренней поверхности трубопровода перед устройством необходимо создать маловязкий мелкодисперсный поток жидкости с частицами парафинов, ржавчины и механических примесей. Размельченная твердая фаза перед устройством смешивается с перекачиваемой жидкостью и, образуя гомогенизированный поток, уносится по направлению движения. Показано, что устройство повышает надежность работы и срок службы трубопровода, обеспечивает качественную очистку трубопровода в местах его искривлений, а также требует низких затрат на производство.

Ключевые слова: отложения асфальтосмолопарафиновых веществ, нефтепровод, методы борьбы с отложениями парафина, очистительное устройство, повышение эффективности очистки нефтепроводов.

CLEANING EFFICIENCY UPGRADE OF OIL PIPELINE FROM WAX DEPOSITION

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Oil recovery, treatment and transportation is often followed by the wax deposition on the wall of on-field equipment, which significantly decreases useful cross section of production tubing and pipeline system. Thickness of wax deposits increases with time and leads to an increase in hydraulic resistance of pipeline during fluid movement. That leads to the disturbance of technological mode of wells, control and measurements equipment and oil collecting-transportation pipeline system. Intensive wax deposition could totally block well tubing, annulus or pipelines in certain areas, which would need a dewaxing workover.

The purpose of this paper is to present and analyze wax deposition mechanism on the inner wall of oil pipeline. It is shown that the factors such as pressure, temperature, wettability nature of washed surfaces, velocity of the oil during oil pipeline transportation, as well as concentration of resin, asphaltene and hard paraffin in the reservoir oil play key role in the wax matter deposition.

The pigging tool that removes wax deposits is proposed. Advantages of this tool are compared with analogues. In order to improve and speed up the process of cleaning the inner pipeline surface it is needed to create low-viscosity fluid flow with fine particles of wax, rust and impurities ahead of the tool. Pulverized solids phase ahead of the tool mixes with the liquid, form homogenized flow, and is entrained in the driving direction. It is shown that tool increases operation reliability, oil pipeline life, high grade cleaning of oil pipeline in the curved areas and has low-cost production.

Keywords: wax deposition, oil pipeline, methods of controlling wax deposition, pigging tool, improving of oil pipeline cleaning efficiency.

Introduction

The oil from different fields is characterized by wide variety of chemical composition, physical and chemical properties. In terms of physics and chemistry oil is complex dispersive system in which asphaltenes and resins are important elements.

Experimental study [1] shown that over a wide range of temperature, pressure, and composition it is possible to determine a point, at which asphaltenes start to be instable and precipitate on the surface. The extrapolation method allows determining instability point and predicting the conditions where precipitation of asphaltenes will start.

Asphaltene macromolecules being in the colloidal state may be attraction and precipitation centers for the dissolved in oil resin molecules.

Formed asphaltene-resin complex (ARC) interacts with liquid hydrocarbon molecules that are in ARC's zone of influence (attraction zone) [2]. Under the temperature below starting point of crystallization of hard paraffin they being tiny elements coagulate with ARC. As a result asphaltene-resin-paraffin complexes are formed (ARPC).

At the moment mechanism of ARP precipitation was studied in details in the experiments [3]. The results shown that among hard particles some of the precipitated waxes deposit on the pipe walls in the form of a wax-oil gel. The gelation of the waxy crude is because of the flocculation of orthorhombic wax crystallites that appear in the solution during cooling. The overlapping paraffin platelets trap the oil inside them.

Nevertheless, Cloud point, Pour point, Gelation temperature and other parameters are empirical values and vary under different conditions of different hydrocarbon fields.

According to the world experience oil recovery process, oil treatment and transportation is often followed by the wax deposition on the wall of on-field equipment, which significantly decreases useful cross section of production tubing and pipeline system and leads to the disturbance of technological mode of wells, control and measurements equipment and oil collecting-transportation pipeline system. The aspiration to maintain oil recovery on the design level leads to increase of equipment deterioration, increase of electricity consumption (due to hydraulic resistivity increase) and probability of accident. For example, intensive wax deposition could totally block well tubing and annulus in certain areas, which would need work over in order to dewax the well [4]. The issue of oil upstream and main

pipeline dewaxing is extremely relevant as well. Their purpose is to transport oil constantly over the long distance.

The examples of most spread technologies are presented in the table.

World used technologies of cleaning pipelines

Country	Name of object/field, owner	Used technology
USA	Trans-Alaska Pipeline System	Scraper pigging, Intelligent pigging [5]
USA	Natural gas transport pipeline in TX, USA	Scraper pigging + chemicals [6]
Abu Dhabi	Intelligent Pigging Project	Scraper Pigging included (Intelligent pigging) [7]
India	Deen Dayal Field Development Pipeline Project & Slug Catcher project	Scraper Pigging included (Intelligent pigging) [7]
USA	West Coast offshore in-field pipeline	Scraper pigging + chemicals [6]
Iran	Persian Bay gas pipeline, National Iranian Oil Company	Scraper pigging [8]
United Kingdom	Gas pipeline on Mungo field, BP	Scraper pigging + glycol [9]
Angola	Deep offshore oil pipeline, The Angola Deepwater Consortium	Scraper pigging [10]
Bangladesh	Gas pipeline «Bakhrabad-Chittagong», Gas Transmission Company Ltd	Scraper pigging [11]
USA	Oil pipelines of Pennsylvanian field	Chemical solvents, dispersants + scrapers [12]

It shows that scraper use as a mechanical mean of pipeline wall cleaning from wax deposits is the most used method currently. However, all mentioned technologies are labor-consuming, hard in use, not always reliable (depends on construction) and expensive.

According to that there is need to create cleaning mean, which would meet such requirements as higher efficiency, reliability, ease of fabrication and low price.

Description of wax deposition process

Analysis of wax sedimentation in the pipeline Kumkol-Aryskum-Josaly

From the observation of technological mode of main oil pipeline Kumkol-Aryskum-Josaly (Kazakhstan) the wax deposits appear quite inhomogeneously along oil pipeline during oil transportation. At the first stage of oil pipeline, where the temperature is higher than starting

point of paraffin crystallization the deposition is negligible. Then the temperature becomes lower, paraffin release intensively and its deposits become significant. Next stage paraffin deposition thickness decreases due to the fact that oil flows with almost constant temperature which is equal to ground temperature and main part of paraffin which deposits under this temperature is already deposited onto previous section. In particular intensive paraffin deposition happens in the downtime period, when oil in the pipeline starts cooling down. The freeze process starts near by the inner wall of pipeline and spreads to the center gradually; the velocity of formation of freeze layer is higher nearby top wall of pipeline, in other words most cold area. In the pumping period freeze paraffin layer is not swept by oil flow and is kept in the pipeline until summer season, when pipeline and pumped oil temperature increase up to the value, which is enough to soften and wash freeze layer [13].

Main factors affecting wax deposition in oil pipelines

From this example it is obvious that for efficient pipeline cleaning from wax matter first of all it is needed to understand wax deposits process formation (in two and three phase flow). Under the conditions of oil temperature decrease below starting point of paraffin crystallization nucleation and crystal rise of dendrite-spherical structure start in the some active surface points, which concentrate at the beginning along scratch, crack and roughness in general. Gradually all surface becomes covered by paraffin seeds. On the grown-up crystallites new crystals appear increasing the total thickness of formed deposits and making grainy surface full of big amount of browns and cavities filled by oil.

Mechanical inclusions and particles formed in the oil volume gas microbubbles [14], electrokinetic phenomena and magnetoelectric properties of the dispersed phase in the oil exert significant influence on the formation of deposits. Before the beginning of hard paraffin intensive crystallization the occurring processes are determined by the influence of intermolecular interaction forces. During the formation under the influence of cohesion and adsorption of large particles of the dispersed phase strengthens the role of the forces associated with the surface electric charges and the effect of hydrodynamic factors (particle transport, including in the direction perpendicular to the flow motion).

In addition to paraffins, aromatic and naphthenic hydrocarbons are included in the refractory composition of hydrocarbons. They are strongly polarized; their particles connect with each other much less and form less dense deposits; besides they are easier to dissolve. The normal paraffin hydrocarbons are less polarized; they connect easier and form dense and poorly soluble deposits. A high content of aromatic and naphthenic hydrocarbons reduces adhesion and cohesion (connection of molecules in phase) the paraffins.

It was determined [15] that wax deposits may actively participate in the formation of hard erodible sediment complex composition including wax, mineral salts (gypsum, calcite) and iron sulfide. Wax matter play role of a process «initiator», as a basis for the formation of other types of deposits. During the oil transportation solid hydrocarbons adsorb hydrophobic thin film due to high wettability of the metal. The difference in potential and polarity between the hydrophobized surface and the surrounding fluid layers is created. The formed salt crystals, iron sulfide and wax matter are attracted to the surface of tubing, downhole equipment and pipelines. The strengthening process of wax particles formation with liquid temperature decrease and gas discharge in free vapor phase from the oil lead to crystal coating and attraction of new particles of salt and iron sulfides from the volume of liquid to the forming conglomerates. The iron sulfide particles in the bulk liquid play role of centers of nucleation and growth of salt crystals.

If the list of conditions (that is below) in which the paraffin is in the dissolved state are maintained in the pipeline, use of cleaning technologies is not required.

Flow temperature, change in which leads to the change of phase flows and changes in the composition of oil.

Saturation pressure, below which the gas passes into the free vapor phase, and also disturbs the balance of the hydrocarbon system.

The level of roughness and hydrofobisation of equipment that increases the rate of wax formation [16].

However, taking into account the level of development of major fields in the Russian Federation, adherence of those conditions is difficult. As a result, in most cases, oil pipeline exploitation is complicated by wax formation because the resin and asphaltic complexes begin to deposit already in the well.

Solutions against wax deposition and its consequences

ARP precipitation prevention in the well

It is necessary to use the technique to determine the depth of start point of deposition, one of which is considered to be «The mathematical model for determination the depth of the start point of the intensive waxing in the oil wells». According to calculations, and based on the conditions of formation and chemical composition of the wax picking of possible chemical reagents is done (in order to add them into oil flow to prevent wax formation and increase period between tubing cleaning procedures) [17, 18].

Protecting layers

During the oil movement in the pipeline asphaltenes, the smallest complexes of asphaltenes and resins hydrophobize metal surface even with presence of water in the pipeline fluid, therefore the crystallization of hard paraffin and wax deposition formation take place at high water cut also.

Professor, Doctor of Engineering Sciences Valentin Petrovich Tronov proved that the mechanism of formation of resin-paraffin deposits on the surface of equipment does not depend on the flow mode parameter, but these parameters entirely determine the intensity of the process of deposits accumulation on the surface of pipeline communications. His research showed that the process of accumulation of resin-paraffin deposits due to creation and growth of wax crystals directly on the surface is observed with the oil solvent power decrease on the surface of any type. That means if the inner pipeline surface does not have protecting layer which decrease the connection with oil paraffin the process of wax deposition is inevitable [19]. The most reliable covering materials for that are proven to be glass epoxy and polymer composites [20]. Such kind of coating inner pipeline wall technologies is costly. Use of a hydrophilizing chemical additives and chemical reagent-solvents is a laborious process, expensive and needs a high repetition rate.

Use of chemicals

The carried out analysis showed that the most common way to prevent the formation and removal of paraffin on the number of developments and technologies of their application is use of chemical reagents, i.e. agents of different classes which serve for different purposes while

wax deposition prevention and removal. As a rule such kind of agents does not interact with processed fluids.

Chemical against wax deposition are subdivided into agents and their mixture (solvents, solutions of surfactants) and compositions for preventing the formation of paraffin deposits (inhibitors). Recently, the growing problem of wax depositions has given a push to the large-scale use of chemical methods and research in this area.

Hydrocarbon solvents

An effective method of removing paraffin from the well and surface equipment, oil pipeline is the use of solvents on the basis of light oil fractions, the compositions of light oil fractions, naphthenic and aromatic hydrocarbons, as well as surfactants, byproducts and waste of various surface-active substances production [21].

Intensive pipe paraffinization sections are also washed with solvent. In case of well cleaning its underground equipment and the pipeline at a short distance are cleaned. Surfactants as additives to solvents increase dispersing properties of removers. However, they increase the cost of reagents by 20–25 %.

As it is typical in Russia Federation, light hydrocarbons (hexanes, gasoline, solvents, and aromatic fractions), reforming catalysis products (Stabikar) and composite solvents based on them SNPCH-7R-14 and FLEK are widely used as hydrocarbon solvents [17].

Wax deposition inhibitors

In case of wax high formation rate several promising methods of physical and chemical influence, including chemical inhibitors, are exercised.

Hydrofilizators

Most of the inhibitors currently available in the market of oil recovery reagents refer to the type of so-called hydrofilizators, mixtures of multifunctional hydrophilic surfactants [22]. Their function effects on adsorption on metal surfaces with a constantly renewable and sustainable in dynamics hydrofilization according to the film mechanism. Such kind of mechanism prevents wax formation [23]. The advantages of these inhibitors include the effective performance under conditions of increasing water cut and possibility to input the reagent in the interval of the beginning of wax deposition. Surfactants, wetting agents are polycomponent, and as a consequence, are multifunctional; they are water-

soluble, therefore not applicable for inhibitor protection of equipment during recovery and transportation of highly paraffinic waterless oil.

While selecting wax reagents-inhibitors and reagents-removers it is needed to take into account following:

- level of research of the reagent and its preparedness (according to the level of study) for use;
- the reagent impact on the quality of the produced product (on the oil collection and preparation processes, on the quality of commercial oil);
- technological properties of the reagent (ease of use, dosing, safety at work, effective prevention wax formation);
- economic indicators (capital expenditures, operating costs).

Detergents-dispersants. Another type of wax reagents inhibitors is detergents-dispersants. During injection into the system they are working on the process of crystallization of the solid components of oil on the macromolecular level with the formation of the adsorption layer of reactant molecules on small embryonic crystals hydrocarbons.

By doing so the ability of solid components to stick together is decreased as well as to be deposited on the inner walls of oil-field equipments. Their mechanism of this action has physical nature. For example, the same effect gives heating of oil with crystallized paraffin, when as detergents-dispersants there are asphaltene-resin oil components [24]. Except the effective wax prevention under wells and pipelines conditions another advantage of detergent-dispersant is that sometimes not less effective protection from sediments in reservoirs by retaining suspension of microcrystals in the volume of oil. A disadvantage of such inhibitors is that there is need to deliver their main mass point at a temperature above the oil saturation by paraffin temperature (which may be in the well itself) and increased doses of the inhibitor proportionally to the amount of solid oil hydrocarbon.

Dispersators. Another group includes depressant, the substance that can effectively modify the terms of wax crystallization, reducing the tendency of individual molecules to the nucleation and subsequent formation on-crystal structures [25]. Advantages and disadvantages of this group are identical to the above-described inhibitors of detergent-dispersants.

Modifiers. If the mentioned above inhibiting wax additives are represented mainly by surfactants of different classes, the group of modifiers

has different chemical nature, similar to the nature of solid methane-naphthenic oil hydrocarbon. Under the temperatures of about the saturation temperature of oil by paraffin these reactants interact with molecules of solid hydrocarbons, modifying the system by giving it the required complex of properties [26].

Wax crystals modification mechanism, when wax is depositing, could be different. The choices are following:

- modifier precipitates out of solution at a temperature slightly higher than the cloud point of the oil and forms numerous nucleation sites;
- modifier precipitates out of solution at the cloud point of oil and a co-crystallizing solid hydrocarbons;
- modifier precipitates out of solution at lower temperature than the cloud point and absorbs the formed crystals.

Crystal modifiers are oligomeric and polymeric materials, e.g. polyethylene, copolymer esters, derivatives from polyhydrocarbons and others. The main advantage of modifiers is to hold paraffin dispersed in oil all the way from down-hole to the refinery. This determines the benefit of their use in comparison with other methods and technologies against wax deposition.

From these groups of inhibitors the most effective is modifiers [27]. It should be noted that in the domestic of petrochemical industry the production of complex oligomeric and polymeric components for trade state of inhibitors-modifier is underdeveloped.

The problem of the wax deposits formation and complex precipitations is reasonably to solve by using chemicals with application of inhibitors of salt formation and the formation of wax deposits, i.e. reagents with complex properties. Research and experimental experience (oil and gas division of Krasnoholskneft JSC OC Bashneft) shown high efficiency of Reapon IF reagent [28], which has properties of demulsifying compound, wax deposition and corrosion inhibitor, bactericide in relation to sulfate-regenerating bacteria.

The significant results were achieved in the development of chemical methods of preventing the formation of wax deposition, however, high cost of effective reagents not allow to use them on-field in required volumes, in particular due to variety of composition and properties of reservoir fluids and difference in conditions if the wells and oil pipeline systems. If after applying the selected optimal methods complete avoidance is not possible, then the most rational (most efficient, least

time-consuming and has a low price) is a mechanical method of pipeline cleaning.

Wax composition is complex and unstable over the time and in different parts of the system, which complicates problem of its deposits. The main oil pipeline Kumkol-Aryskum-Zhosaly example shows, that even if at the beginning of the pipeline wax-dissolution-in-liquid conditions are supported (this can be achieved either naturally or by installing lines of electric heating), then further, at the particular section, they will deposit anyway. Moreover, in conditions of low temperatures this phenomenon is inevitable. Hence, periodic mechanical pipeline cleaning is an integral procedure in the upstream field and main pipelines.

Pigging is an operation to remove debris or unwanted deposit build-up in a pipeline. Debris and deposits in a pipeline will result in a pressure build-up and if no pigging activities exist the debris and deposit build-up could continue to rise which will create greater back pressure on the line, causing higher maintenance on pumps and the line could eventually become blocked.

During mechanical pipeline cleaning such tools as spacers, balls, brush and scraper for springs, pistons, torpedoes and ultrasonic devices with moving jet vanes are used.

There is a problem with type of scrapers that carry spring arm on which brushes are motioned in small diameter pipelines because of too little space for attachment. Because of substitution they become not so efficient. Moreover, the frictions between scraper and pipe are always higher in pipelines with small diameter.

The advantage of scrapers with bypass washing system is that there are no frictions, for instance, while cleaning gas pipelines because of liquid flow through the tool [29].

The work principle of some of them is based on movement with fluid flow, removing deposits from the inner pipeline surface and their pushing (a disadvantage of these tools is pipeline separation that leads to the accumulation of paraffin and pipeline blockage).

Other's principle is removal of sediments, their dilution and washing out with fluid flow passing through the bypass channels of tool (disadvantages are: point leaching of solids phase, crushing and compaction of solid precipitation, low reliability while long not achievement of the required pressure drop and hence, low lifetime; corrosion).

There is a number of scrapers with bypass systems, but mostly they represent just a channel inside of passage between several sealing discs. That provides washing out of some wax deposits

but best part of it is still pushed by scraper [30]. Thus the cleaning mechanism is not optimized.

There are also examples of more complex scraper design of this kind, but from the mechanical point of view they are not so reliable and require simultaneous service [31]. Moreover, they are expensive.

Description of the proposed pipeline cleaning technology

In order to improve and speed up the process of cleaning pipeline surface it is needed to create a low-viscosity fluid flow with fine particles of wax, rust and impurities ahead of the tool. In case of tools with rotating jet vanes unlike torpedoes, pistons and separators pulverized solids phase ahead of the tool mixes with the liquid, form a homogenized flow and is entrained in the driving direction.

The pigging tool for cleaning pipelines from paraffin has been developed in the Perm National Research Polytechnic University [32].

It contains body 1 which is made as a hollow hemisphere of elongated elastic material, such as oil-resistant rubber, with a profound cut. Along the axis of rotation of the pig through metal tube 2 is installed and fixed in the body 1 by curved washers 3 and nuts 4. On the outer side of the body on the figural nut 4 there are the fluoroplastic washers 6 planted. Fixed fluoroplastic hollow sleeve 7 and vane 8 are fixed by nut 5 and placed on figural nu 4.

A 3D-model of the developed pigging tool was created and is shown on the Figure.

Vane channels 2 are connected with the inner cavity of the metal tube through the holes (highlighted by white circle) made over the diameter of

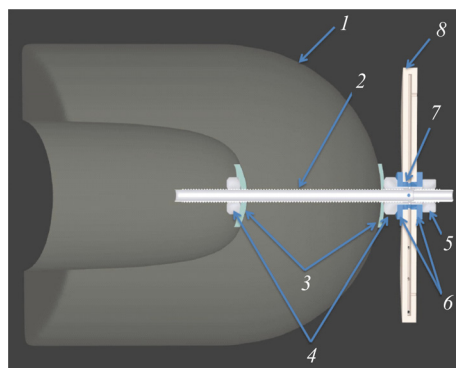


Figure. Cross-section of pigging tool for cleaning oil pipelines from wax deposits

the tube 2. Sleeve 8 has a channel aligned with the holes of metal tube and figural nut 4. There are hole are placed on the opposite sides of the vane.

Pig is installed in the pipeline through the launching chamber and retrieved through the receiving chamber respectively. Inside the pipeline pig moves under pressure difference between its inlet and outlet in the direction of liquid flow. Via through metal tube installed in the body manufactured with profound cut on one side the part liquid gets into the hollow vane with the holes, out of which flows with high velocity, creating a reactive force of rotation. That provides the scrapping of some of wall paraffin deposits by vane's ends. The paraffin mixes with liquid and becomes homogenized flow. Double bypass system of working fluid through the metal tube and the vane provides reliable blur and stem separated wax deposits.

The pressure difference and diameter of the tube determine rate of the pig advance in the pipeline. The work liquid from the tube enters ahead not yet cleaned pipeline side that provides blur and stem of separated wax from the inner pipeline surface. Thus, pulverous wax is not deposit onto the outer surface of pig ahead rotating vane and not pushed through the pipeline, but washed by liquid jet from metal tube, which facilitates wall cleaning. The pressure on the inlet of pig (could be up to 60 bars) creates grate contact between the body and pipeline walls. That does not allow wax deposits to enter the cleaned side and pushes pig which provides reliable cleaning.

Results and Discussion

A similar device, but without the bypass vane system has been tested on the pipeline Nojovka-Mishkino-Kiengop (Perm region-Republic of Udmurtia), which capacity after six years of operation was decreased by a half due to wax deposits. The operation took 15 days, but the initial pipeline capacity was restored [33]. Upgraded device has perforations in the longitudinal and transverse directions of the rotary vane creating jets of working fluid, which creates conditions for accelerating the passage of the device through the pipeline and provides more effective cleaning of the inner pipeline surface from the deposits.

High pig passableness is caused by its flexible body and short length (0,6 m).

The tool cannot be jammed in the offtake, like it happens with sphere pigs. That is due to its elastic long (in comparison with sphere) shape

which provides straight movement and do not allow to the tool turning away.

Proposed pigging tool can handle pipelines with small diameter, thus there is no problem with attachment of the tool in case we are talking about scrappers with spring arms and brushes.

There will not be huge pressure difference caused by the wax plug, which happens with pigs with no by-pass system.

The device has the manufacture simplicity; size of the body is molded to required diameter.

At the same upstream pipelines through launching and receiving chambers a simplified version of the pig without a bypass system is run, which leads to complete cleaning of the pipeline in areas of curvatures due to the short length of the flexible body.

For waxy lines it is wise to carry out initial chemical treatment prior to commencement of the pigging program.

Conclusion

The roughness of the inner pipeline wall and metal surfaces of well equipment creates favorable conditions for more intensive wax matter formations and other deposits.

Formation of asphaltene deposits occur on the inner wall of the pipeline. The thickness of deposits formed increases with time, which leads to an increase in hydraulic resistance during movement of liquids or liquid mixtures that leads to technological mode failure of wells, measurement and control equipment and pipeline oil collection and transportation systems. Intensive wax matter deposition can lead to a complete blockage of tubing and annular in certain areas, causing the need of work overs in order to dewaxing.

Increase of fluid velocity in a pipeline reduces the rate of wax formation contributes to detachment of sediment particles from paraffinization surfaces and their removal. By increasing the flow rate the cooling rate of transported in the pipeline liquid decreases.

Wax deposition removal from the inner pipeline surface could be done by mechanical means (scraper), thermal treatments (heaters, etc.) and hydrocarbon solvent (paraffin removers).

For the wax deposition with high concentration of resins and asphaltene (asphaltene type) removers of refining material and petrochemicals, including naphthenic and aromatic hydrocarbons should be used.

Reagents are depressant prevent crystal growth and the formation of solid structures. Such

agents are most effective at low concentrations of asphaltenes and resins.

For the wax deposition of complex structure the use of removers, representing a mixture of paraffinic and aromatic hydrocarbons is more efficient.

Improving of the efficiency of activities to prevent formation and removal of wax deposits requires the creation and operation system of the on-field and laboratory study, control of technological process, directly related to the difficulties during the collection and transportation of oil.

Absence of rubbing parts of the proposed pigging tool for cleaning oil pipelines from wax deposits and the small number of connecting nodes increase the reliability and service life of the pipeline.

The short length of the cleaning pig provides high-quality cleaning of the curved pipeline due to its flexibility.

The low cost and resource consumption make the proposed pigging tool more attractive in front of foreign analogues.

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