(54) Titre : INSTALLATION A JET DE FOND DE PUI TS POUR LE CAROTTAGE ET L'EXPLOITATION DE PUI TS HORIZONTAUX

(54) Title: DOWN-HOLE JET EQUIPMENT FOR LOGGING AND DEVELOPMENT OF HORIZONTAL WELLS

(57) Abrégé/Abstract:
The invention relates to the field of jet-pumping techniques for wells. The invention comprises mounting, on a flexible smooth tube (1), a logging tool (2), a sealing member (3) and a jet pump (4). The housing (5) of the pump (4) contains a nozzle (6) and a mixing
Abstract (continued):
chamber (7) with a diffuser (8). The outlet of the diffuser (8) is connected to the cavity of the tube (1), and the inlet of the nozzle (6) is connected to the space outside of the tube (1). The inlets of the pumped medium supply channel (9) and the nozzle (6) are provided with check valves (10, 24). The tube (1) is capable of moving within a tubing string (11) that comprises a packer (12). The diameter $D_1$ of the through channel of the packer (12) is at least 12 mm smaller than the inside diameter $D_2$ of the tubes (12). Openings (14) are formed in the tube (1) above the tool (2). A ball crane (23) for closing the tube (1) is provided on the tube (1) between the pump (4) and the member (3). The member (3) is made in the form of a cylindrical body (15) filled with an assembly of elastic liners (16) with bearing washers (17) and with a bearing pusher member (18) on the top. An insert (19) with a flange (20) and a mobile ring (21) is attached below the body (15), and a sleeve (22) is provided between the mobile ring (21) and the body (15). The diameter of the flange (20) is smaller than the diameter $D_1$ of the through channel of the packer (12). The ring (21) has a diameter $D_3$ that is larger than the diameter $D_1$. The lower surface of the ring (21) is coated with an elastic material. It is thereby possible to enhance the operational reliability of the equipment.
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Изобретение относится к области струйной насосной техники для скважин. На гибкой гладкой трубе 1 смонтированы каротажный прибор 2, герметизирующий элемент 3, и струйный насос 4. В корпусе 5 насос 4 установлены сопло 6 и камера 7 смешения с диффузором 8. Выход диффузора 8 подключен к полости трубы 1, вход сопла 6 - к затрубному пространству трубы 1. На выходе насоса 4 подвела откачиваемой среды и в сопле 6 установлены обратные клапаны 10, 24. Труба 1 имеет возможность перемещения в колонне насосно-компрессорных труб 11, выполненной с пакером 12. Диаметр D1 проходного канала пакера 12 не менее чем на 12 мм меньше внутреннего диаметра D2 труб 12. В трубе 1 над прибором 2 выполнены отверстия 14. На трубе 1 между насосом 4 и элементом 3 установлен патрубок 23 для перекрытия трубы 1. Элемент 3 выполнен в виде цилиндрического корпуса 15, заполненного набором эластичных прокладок 16 с упорными шайбами 17 и с упорным нажимным элементом 18 сверху. Снизу корпуса 15 закреплена втулка 19 с фланцем 20 и подвижным кольцом 21, между которым и корпусом 15 установлена манжета 22. Диаметр фланца 20 меньше диаметра D1 проходного канала пакера 12. Кольцо 21 имеет диаметр D2 больше диаметра D1. Нижняя поверхность кольца 21 покрыта эластичным материалом. В результате достигается повышение надежности работы установки.
DOWN-HOLE JET EQUIPMENT FOR LOGGING AND DEVELOPMENT OF HORIZONTAL WELLS

Field of the Invention

The invention relates to pump engineering, in particular to well pump units for logging and developing horizontal wells.

Description of Prior Art

A well jet unit is known, which comprises, all being installed on a pipe string upwards: a packer provided with a central channel, and a jet pump which body is provided with an active nozzle and a mixing chamber with a diffuser as well as a channel for supplying a working medium and a channel for supplying a medium pumped out of a well, a pass being made in the jet pump body with the possibility of installing replaceable functional inserts and a sealing assembly (see: RU Patent No. 2176336, P04P 5/02, 27.11.2001).

This well jet unit enables to treat a formation below the jet pump level in a well, including treatment with creation a pressure differential between pressures above and below the sealing unit. However, the capacity of the known well jet device is not used in full, since a big time is required for replacing inserts, and such time is often greater than a time of reaction between an acid solution and minerals of a producing formation.

The closest to this invention as to its technical essence and achieved result is a well jet unit for logging horizontal wells, which comprises, all being arranged on a flexible smooth pipe upwards, a packer provided with a central channel, and a jet pump which body is provided with a nozzle and a mixing chamber with a diffuser, the diffuser outlet being connected to the inner cavity of the flexible smooth pipe via a channel for removing a medium mixture, as made in the jet pump body, the inlet of the jet pump nozzle being connected to the annular space around the flexible smooth pipe, and the channel for supplying a medium pumped out of a well being connected to the inner cavity of the flexible smooth pipe via an upper and a lower windows made in the jet pump body, and a check valve being arranged in the channel for supplying a pumped-out medium on its inlet at the lower window, a multiple-measurement
instrument being arranged on the lower end of the flexible smooth pipe, a sealing element shaped as a profiled ring being movably arranged on the flexible smooth pipe below the packer, and openings, which communicate the inner cavity of the flexible smooth pipe with the annular space below the packer, being made in the wall of the flexible smooth pipe above the multiple-measurement instrument (see: RU Patent No. 2324079, P04P 5/54, 10.05.2008).

This well jet unit enables to study horizontal wells and treat producing formations in them. However, an installed switch for working medium flows narrows the capacity of the unit in studying productivity of a formation during treating it. Furthermore, lack of the possibility of blocking the flexible smooth pipe during extracting the unit to the surface complicates the process of removing the unit from a well.

**Summary of the Invention**

The objective of this invention is to improve quality of works aimed at increasing well production rates by expanding the unit functionality, in particular, to perform operations on treatment of a producing formation without rearranging a flow string and to simplify the operation process of the well jet unit.

The technical effect achieved after implementing of the invention is improvements in reliability of operation and productivity of a well jet unit in logging and developing a well.

The said objective is solved and the technical effect is achieved due to the fact that the inventive well jet unit comprises, all being arranged on a flexible smooth pipe upwards, a multiple-measurement instrument embracing the flexible pipe, a sealing element arranged movably, and a jet pump, which body is provided with a nozzle and a mixing chamber with a diffuser, the diffuser outlet being connected to the inner cavity of the flexible smooth pipe, the inlet of the jet pump nozzle being connected to the annular space around the flexible smooth pipe, and check valves being arranged in the channel for supplying a pumped-out medium, as made in the jet pump body, on the side of its inlet and on the nozzle input; further, the flexible smooth pipe is arranged with the possibility of moving axially in a flow string provided with a packer for the purpose of sealing space between the flow string and a casing string, the said packer being provided with a through channel which diameter $D_1$ is at least 12 millimeters lesser than the inner diameter $D_2$ of the flow string; openings are made in the wall of the
flexible smooth pipe above the multiple-measurement instrument, and the inner cavity of the flexible smooth pipe is connected via the said openings to the under-packer well space; a ball cock, which is intended for closing the inner cavity of the flexible smooth pipe when the well jet unit is removed to the surface, is arranged on the flexible smooth pipe in its section between the jet pump and the sealing element; the sealing element is made in the form of a cylindrical body filled in its upper part with a set of elastic gaskets embracing the flexible smooth pipe, the said gaskets being provided with thrust washers arranged therebetween, and with a thrust pressure element; and a bearing sleeve is fixed in the body lower part and has a thrust flange in its lower end and a movable thrust ring arranged above the flange on the sleeve, an elastic sealing collar is arranged between the said ring and the lower part of the cylindrical body; the thrust flange diameter is lesser than the diameter $D_1$ of the packer through channel, the thrust ring has the diameter $D_3$ that is greater than the diameter $D_1$ of the packer through channel, and the lower face of the thrust ring is coated with an elastic material.

An analysis of operation of the well jet unit shows that reliability and efficiency of the device operation may be improved through optimizing the unit structure and, due to this, it is possible to achieve more clean near-well area, shorten time required for carrying out such works and expand the functionality of the device when testing and developing wells without rearranging the equipment used.

It is found that hydrodynamic action on the near-well area enables to use the well jet unit most efficiently when developing and repairing oil and gas wells during works on intensifying oil inflow from a producing formation. Further, the unit enables to clean a producing formation from mud particles and reaction products after treating a formation with chemical reagents, make control measurements both before and during treatment, which, in its turn, enables to assess technical condition and productivity of a well as well as properties of a medium pumped out of a well. While proceeding from an inflow studies, it becomes possible to assess treatment quality of the producing formation near-well area. Providing the unit with a multiple-measurement instrument arranged on, and embracing, the flexible smooth pipe, a sealing element arranged movably, and a jet pump which body is provided with a nozzle and a mixing chamber with a diffuser, as well as arranging the flexible smooth pipe with the possibility of moving axially in a flow string provided with a packer for the purpose of sealing
a space between the flow string and the casing string enable to carry out logging of the horizontal portion of a well in the differential pressure drawdown mode and remove reaction products from the formation.

Arranging a supporting ring with a pass opening intended for installing a sealing element in the flow string and making the sealing element as a set of elastic gaskets with thrust washers therebetween, which embrace the flexible smooth pipe, and a thrust pressure element on their top as well as fixing a supporting sleeve provided with a thrust flange in its lower end and a movable thrust ring arranged on the sleeve above the flange, provided that an elastic sealing collar is arranged between the said ring and the upper part of the cylindrical body, enables to install a jet pump in the flow string quickly and automatically and hermetically separate the well space below and above the jet pump, when the thrust ring interacts with the end wall of the packer through channel. In order to provide for the said interaction, the unit is made according to the above ratios of dimensions, and it important not only to ensure the said interaction, but also ensure reliable operation while prevent the unit from jamming, which is ensured via corresponding optimization of the dimension ratios for the above-mentioned elements of the unit design.

A jet pump arranged in a flow string enables to create by using it a series of drawdown values at a given differential pressure in a well under-packer area, use a multiple-measurement instrument for registering pressures, temperatures and other parameters of the well and a medium pumped out of that well, study and test a well, and register a formation pressure restoration curve for the well under-packer area without using a special functional insert. At the same time, it provides for the possibility of monitoring a differential pressure drawdown value by controlling a pumping rate of an active working medium. When testing a formation, the pumping mode may be adjusted by changing pressure of an active working medium supplied to the jet pump nozzle. At the same time, the provision of the channel for supplying a medium pumped out of a well and the nozzle with check valves enables to avoid a spontaneous flow of a working medium into the under-packer area when the jet pump is or is not operated.
The arrangement of the logging instrument on the flexible smooth pipe with the possibility for the latter of moving axially in a well without using a packer (a sealing element, which is put on the flexible smooth pipe, is used instead of a packer) enables to speed up and, consequently, simplify the process of moving a multiple-measurement instrument in a well, and, hence, simplify the procedure of testing and preparing a well for operation. Moreover, the arrangement of a multiple-measurement instrument on the flexible smooth pipe enables, due to the latter's elastic properties, to position the multiple-measurement instrument in an area of producing formations in horizontal sections of wells, which enables to get more reliable reactive information on condition of producing formations, inflow of a formation fluid and properties of the latter, and the arrangement of a ball cock on the flexible smooth pipe in its section between the jet pump and the sealing element enables to close the inner cavity of the flexible smooth pipe when the well jet unit is removed to the surface, which makes the procedure of removing the well jet unit to the surface easier.

In the result, works on studying and developing wells are intensified, which enables to study and test wells with good quality after drilling and during well-workover operations as well as prepare a well for operation after conducting extensive studies and tests in various modes and, due to this, improve the device operation reliability.

**Brief Description of the Drawings**

Figure shows a longitudinal section of the proposed well jet unit for logging horizontal wells.

**Description of the Best Embodiment**

The proposed well jet device comprises, all being arranged on a flexible smooth pipe 1 upwards: a multiple-measurement instrument 2 embracing the flexible pipe 1, a sealing element 3 arranged movably and a jet pump 4 which body 5 is provided with a nozzle 6 and a mixing chamber 7 with a diffuser 8. The outlet of the diffuser 8 is connected to the inner cavity of the flexible smooth pipe 1, and the nozzle 6 of the jet pump 4 is connected, on the side of its inlet, to the annular space around the flexible smooth pipe 1. A check valve 10 is arranged in the channel 9 for supplying a medium pumped out of a well, the channel being made in the body 5 of the jet pump 4, and is arranged in the inlet portion of the channel. The flexible pipe 1 is arranged with the possibility of moving axially in a flow string 11 provided
with a packer 12 for the purpose of sealing the space between the flow string 11 and a casing string 13. The diameter $D_1$ of the through channel of the packer 12 is at least 12 millimeters lesser than the inner diameter $D_2$ of the inner cavity of the flow string 11. Openings 14 are made in the wall of the flexible smooth pipe 1 above the multiple-measurement instrument 2 and are used for connecting the inner cavity of the flexible smooth pipe 1 to the under-packer area of the well.

The sealing element 3 is made in the form of a cylindrical body 15 arranged in its upper portion and filled with a set of elastic gaskets 16 with thrust washers 17 arranged therebetween, the gaskets embracing the flexible smooth pipe 1, and a thrust pressure element 18 is arranged on the top of the set; a supporting sleeve 19 is fixed in the lower portion of the cylindrical body 15 and is provided in its lower end with a thrust flange 20 above which and on the sleeve 19 a movable thrust ring 21 is arranged; a sealing collar 22 is arranged between the movable thrust ring 21 and the lower portion of the cylindrical body 15. The diameter of the thrust flange 20 is lesser than the diameter $D_1$ of the through channel of the packer 12, the thrust ring 21 has the diameter $D_3$ that is greater than the diameter $D_1$ of the through channel of the packer 12, the lower face of the thrust ring 21 is coated with an elastic material, and a ball cock 23, which is intended for closing the inner cavity of the flexible smooth pipe 1 when the well jet unit is removed to the surface, is arranged on the flexible smooth pipe 1 in its section between the jet pump 4 and the sealing element 3. A check valve 24 is arranged at the inlet of the nozzle 6 of the jet pump 4.

The packer 12 is lowered on the flow string 11 to a vertical section of a well. Then, the packer 12 is released, and an acid solution and/or a hydrofracturing fluid are pumped via the flow string 11 to a producing formation of the well. After this, the multiple-measurement instrument 2, the sealing element 3 and the jet pump 4 are lowered on the flexible smooth pipe 1 to a horizontal section of the well. The sealing element 3 is arranged on the end wall of the through channel of the packer 12, and the multiple-measurement instrument 2 is arranged in the area of the producing formation of the well horizontal section, while registering the well geophysical parameters along the well bore, such as pressure and temperature in the under-packer area, including the area of the producing formation. Then, a pressurized working medium is supplied via the annular space around the flexible smooth pipe 1 to the nozzle 6 of
the jet pump 4, the well is drained, and reaction products and/or the hydrofracturing fluid are removed from the producing formation, while regularly measuring well rates at different values of differential pressure drawdown to the producing formation and continuously recording bottomhole pressure and composition of a pumped out liquid medium with the use of the multiple-measurement instrument 2. Due to a pressure of the working medium in the flow string 11, the thrust pressure element 18 exerts pressure on the elastic gaskets 16, thus expanding them and sealing an annular gap around the flexible smooth pipe 1. Simultaneously, under the medium pressure in the flow string 11, the cylindrical body 15 moves downward and expands the sealing collar 22, thus sealing the annular gap relative to the flow string 11. Then, without stopping drainage from the well, the multiple-measurement 2 is raised to the vertical section of the horizontal well, thus registering the geophysical parameters in the under-packer area, including the area of the producing formation.

After this the jet pump 4 is stopped, and the inner cavity of the flexible smooth pipe 1 above the jet pump 4 together with the annular space above the sealing element 3 is separated from the inner cavity of the flexible smooth pipe 1 under the jet pump 4 together with the under-packer area, while keeping a low bottomhole pressure under the packer 12, at which pressure a curve of formation pressure recovery is recorded with the use of the multiple-measurement instrument 2. Then a pressurized gas is supplied via the flexible smooth pipe 1, thus expelling the liquid medium from it and from the annular space around it, after this the ball cock 23 is closed, and the flexible smooth pipe 1 with the jet pump 4, the sealing element 3 and the multiple-measurement instrument 2 are removed from the well to the surface. Then a decision on either to continue studying the well or to put it into the operation mode.

**Industrial Applicability**

This invention may be used in the coal industry during operation of coal fields.
What is claimed is:

1. A well jet unit, comprising, all being arranged on a flexible smooth pipe upwards:
   a multiple-measurement instrument embracing the flexible pipe, a sealing element
   arranged movably and a jet pump which body is provided with a nozzle and a mixing chamber
   with a diffuser;
   the outlet of the diffuser is connected to the inner cavity of the flexible smooth pipe,
   and the nozzle of the jet pump is connected, on the side of its inlet, to the annular space
   around the flexible smooth pipe, and check valves are arranged in the channel for supplying a
   pumped-out medium, as made in the jet pump body, on the side of its inlet and on the nozzle
   input, the flexible pipe being arranged with the possibility of moving axially in a flow string
   provided with a packer for the purpose of sealing the space between the flow string and a
   casing string, the packer being provided with a through channel which diameter $D_1$ is at least
   12 millimeters lesser than the inner diameter $D_2$ of the flow string;
   openings are made in the wall of the flexible smooth pipe above the multiple-
   measurement instrument that connect the inner cavity of the flexible smooth pipe to the under-
   packer well space, a ball cock, which is intended for closing the inner cavity of the flexible
   smooth pipe when the well jet unit is removed to the surface, is arranged on the flexible
   smooth pipe in its section between the jet pump and the sealing element;
   the sealing element is made in the form of a cylindrical body filled in its upper part
   with a set of elastic gaskets embracing the flexible smooth pipe, the said gaskets being
   provided with thrust washers arranged therebetween, and with a thrust pressure element, a
   supporting sleeve is fixed in the lower portion of the cylindrical body and is provided in its
   lower end with a thrust flange above which and on the sleeve a movable thrust ring is
   arranged;
   a sealing collar is arranged between the movable thrust ring and the lower portion of
   the cylindrical body;
   the diameter of the thrust flange is lesser than the diameter $D_1$ of the through channel
   of the packer, the thrust ring has the diameter $D_3$ that is greater than the diameter $D_1$ of the
   through channel of the packer; and
   the lower face of the thrust ring is coated with an elastic material.