METHOD OF AND APPARATUS FOR THE GAS-LIFT WITHDRAWAL OF A LIQUID FROM A SUBTERRANEAN SPACE

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ABSTRACT
A system for the gas-lift withdrawal of liquid from a subterranean location, especially an oil well, wherein the gas is introduced into a tubing drain at axially spaced circular slot to induce the liquid to flow upwardly through respective venturi-type nozzles immediately above each slot in accordance with the Coanda effect.

2 Claims, 1 Drawing Figure
METHOD OF AND APPARATUS FOR THE GAS-LIFT WITHDRAWAL OF A LIQUID FROM A SUBTERRANEAN SPACE

FIELD OF THE INVENTION

The present invention relates to a method of and an apparatus for the continuous gas-lift withdrawal of liquid from a subterranean location, especially an oil well, whereby the gas-lift process breaks up the liquid into a spray.

BACKGROUND OF THE INVENTION

It has already been proposed to withdraw liquid from an oil well when the pressure from below is no longer sufficient to lift the liquid (hydrocarbon mixture) to the surface by itself, by introducing a lifting gas under pressure to a location below the surface of the liquid in the subterranean space and thereby cause the oil to move upwardly along a string or casing. The lifting gas may be introduced under pressure substantially continuously or intermittently at various levels along this string so that, at each such level, there is an elevating effect.

It is also known to provide a system for spraying the oil concurrently with the lifting thereof by the use of ejectors operating with venturi principles.

Both of these techniques have the disadvantage that they require high working pressure and a high consumption of the lifting gas. When the oil is lifted in the form of slugs, i.e. units of the liquid moved as a mass, the slugs of oil alternate with the slugs of gas and there may occur a downward slippage of the crude oil along the inner wall of the casing reducing the quantity of oil withdrawn and leading to increased gas consumption.

OBJECT OF THE INVENTION

It is an object of the invention to provide an improved method of withdrawing oil or some other liquid from the subterranean location whereby the aforementioned disadvantages can be obviated.

It is another object of the invention to provide an apparatus for eliminating the drawbacks set forth previously.

SUMMARY OF THE INVENTION

These objects and others which will become hereinafter, in accordance with the invention, by the use of a Coanda effect in the gas-lift removal of petroleum and like products from the subterranean space, especially an oil well. According to the invention, the lifting gas is forced through an annular space between the casing and the lifting string, the space between the lifting string and the casing being sealed off at least at the upper end by a packing. According to the invention, the lifting or tubing string is provided at vertically spaced locations (i.e. spaced axially along the string) with circular slots having adjustable openings and by providing immediately above each of these slots a venturi-type nozzle or sleeve dimensions to permit the diversion of the fluid jet along the inner wall of the sleeve according to the Coanda effect and an upward entrainment of the liquid. The slugs of liquid are eliminated by causing them to strain into the gas at each of the venturi-type nozzles.

The venturi-type nozzles are of the convergent type and divergent type with profiles dimensions to permit, with upward displacement of the fluid, a deflection thereof along the walls of the sleeves in accordance with the Coanda effect. The sleeves are threaded at their upper end into the sleeves of the tubing string and at their lower end into couplings provided with lateral orifices opening at the edge of the sleeve and communicating with the space between the strings and the surrounding casing. The couplings have along their interiors below the level of these orifices, respective shaft collars and threaded portions in which is mounted a seat whose upper edge forms with the lower edge of the sleeve, the aforementioned circular opening which is adjustable in cross-section by the vertical displacement of the seat using a screwing action. A reducing or transition member serves for connection of each coupling to the pipe portion of the next sleeve.

DESCRIPTION OF THE DRAWING

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which the sole figure is a vertical axial cross-sectional view through a recovery well provided with tubing and gas-lift devices in accordance with the present invention.

SPECIFIC DESCRIPTION

In the drawing, a recovery well provided with the normal well casing 1 in which is mounted a tubing string 2 the length of which depends on the reservoir pressure of the pay bed and at the end of which perforations may communicate with the pay bed. Above these perforations, a packing 3 seals an annular space between the casing 1 and the tubing string 2, thereby isolating this annular space from the fluid entrained through the perforations into the string 2.

Hence the liquid is thus permitted to enter the casing and pass upwardly through the string 2 which has formed thereon at predetermined levels, depending upon the working conditions of the well (i.e. the pressure behind the liquid), a number of venturi-type nozzles with convergent/divergent passages defined by annular walls. The divergent side of the nozzles are turned upwardly and the venturi-systems are dimensioned to ensure a Coanda-effect deviation of the liquid jet along the divergent inner walls of the nozzle as the liquid is lifted upwardly by the introduction of gas. Concurrently with this lift, there occurs a strain of the crude oil into the lifting gas as will be apparent hereinafter.

The nozzles 4 are mounted by screwing their upper ends through threaded coupling sleeve 5 to the tubing structure 2 while the lower ends are threaded and receive further couplings 6. The coupling 6 of each venturi-nozzle has, on its inner surface, a thickened portion a which forms a step or seat having an annular chamber b. At the level of this annular chamber b the coupling 6 is formed with a plurality of circular orifices c which enable the annular space (around the string 2 and within the casing 1) to be connected with the interior of the tube at the mouth of each venturi-nozzle.

A seating piece 7 is threaded into the interior of coupling 6 so that its upper edge forms together with the lower edge or mouth of the nozzle, an annular slot d whose axial width is adjustable (by the degree the seating piece 7 is threaded into the coupling 6) in accordance with the lifting gas slow rate required for withdrawal of liquid from the well.

The slot d is thus located at the level of the orifices c, i.e. in a common horizontal plane therewith.
stiffening of the coupling 6 is accomplished by introducing into the latter a reducing sleeve member 8, the upper portion of which is threaded into the interior of coupling 6 and which has a lower portion threadedly receiving the pipe of the next tubing section.

The tubing string formed in this manner is suspended at the well head by conventional techniques after the slots d have been adjusted to the predetermined width by screwing members 7 therein, depending upon the depth at which the slot is located, the flow rate and condition of the liquid etc. A pipe 9 provided with a valve 10 feeds the lifting gas under pressure to the annular space between the tubing string 2 and the casing 1 of the well.

The lifting gas is injected through pipe 9 under pressure and, since this annular space (between the casing 1 and the string 2) is limited by packing 3, the gas enters at the predetermined level into the tubing string 2 through the orifices c and slot d. The flow rate of the gas is directly proportional to the width of the slot d. After leaving slot d, the annular gas jet entrains liquid upwardly and adheres to the convergent surface of nozzle 4 in accordance with the Coanda effect to create a pressure drop which entrains the liquid upwardly concurrently with the spraying into the mass of the liquid gas. At the same time, the partial adhesion of the gas/liquid mixture to the surface of the divergent walls prevent or reduces the downward slip of crude oil.

We claim:

1. An apparatus for the lifting of liquids from a subterranean location, comprising:
   a well casing reaching downwardly to said location and formed with at least one opening at the bottom of said casing for admitting liquid thereto;
   a tube string within said casing and defining a space therewith substantially over the length of said string;
   packing means sealingly disposed between said string and said casing between said opening and said space to prevent entry of said liquid into said space, said string being opened into said casing below said packing means to permit entry of said liquid into said string; and
   means for feeding air under pressure into said space, said string comprising:
   a plurality of convergent/divergent nozzles vertically spaced along said string and having upwardly directed divergent portions and downwardly turned mouths leading to the respective convergent portions;
   a respective sleeve threaded onto a lower end of each of said nozzles and forming in the plane of the respective mouth an annular chamber communicating therewith, said sleeves being formed with apertures communicating between said space and the respective chambers;
   a respective tubular adjusting member threaded into each sleeve below the respective nozzle and defining with each nozzle an annular slot between the respective chamber and mouth, the axial width of each slot being variable by relative threading displacement of the respective member and sleeve;
   and
   a respective tubular spacer threadedly connecting and interposed between each of said nozzles and the sleeve of the next nozzle disposed thereabove.

2. The apparatus defined in claim 1, further comprising a tubular reducing member threaded into each of said sleeves and threadedly receiving the spacer disposed therebelow.

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