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(54) **DEVICE AND METHOD OF ENHANCING PRODUCTION OF HYDROCARBONS**

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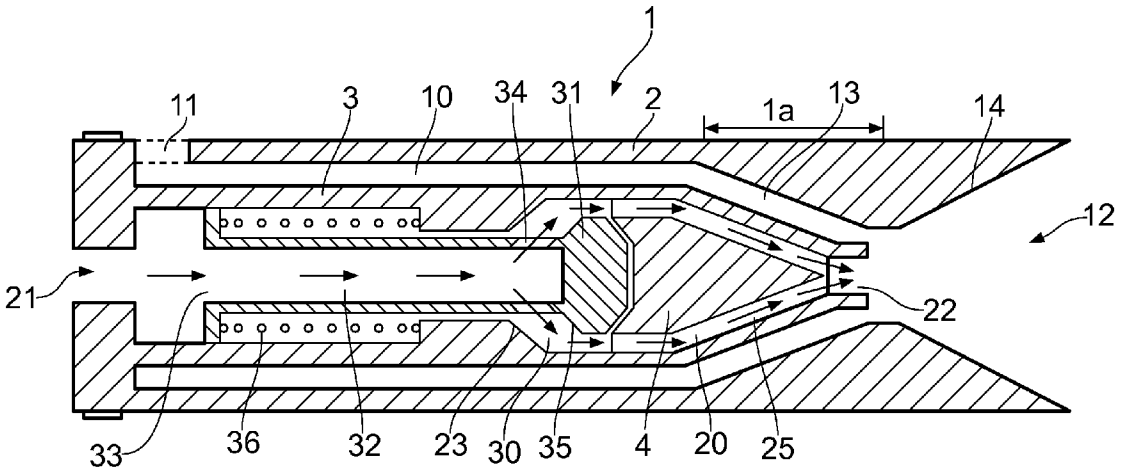
(57) **ABSTRACT**

A device and an associated method, of enhancing production of hydrocarbons from a wellbore by the use of a device, where the device is arranged in a side pocket mandrel. The method, and associated device, includes means for allowing a fraction of a main production flow to enter a first flow passage (**10**) in the device through an inlet (**11**) and to mix with the fluid from a second flow passage (**20**) in the device, before returning the mixed flow to the main production flow.



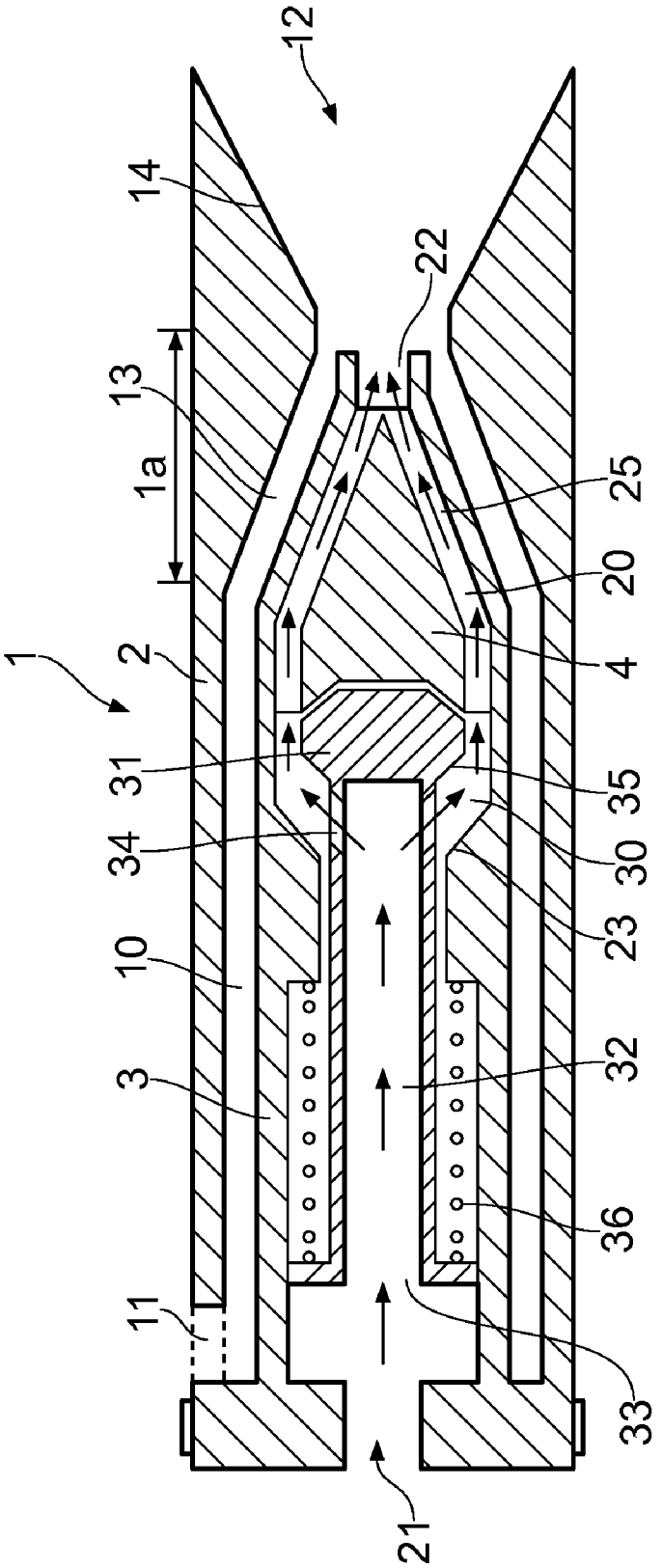


FIG. 1

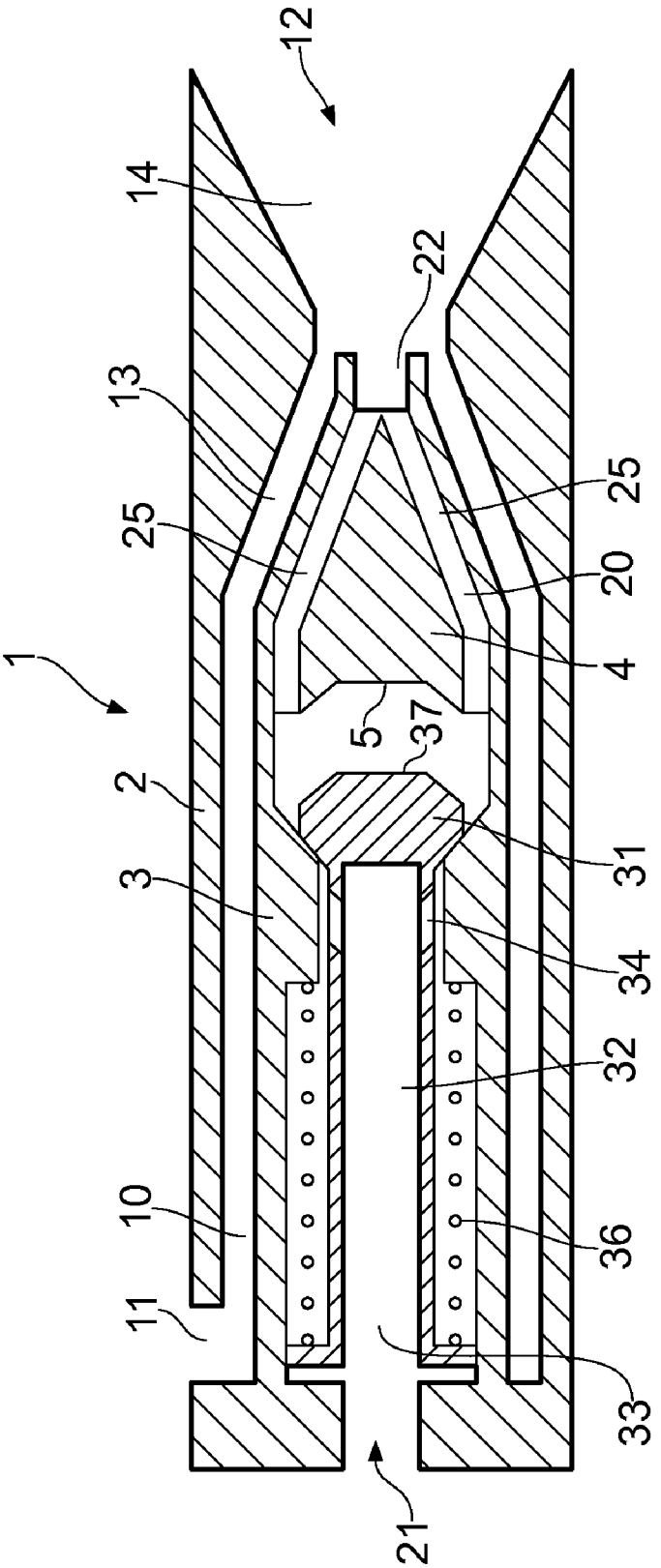


FIG. 2

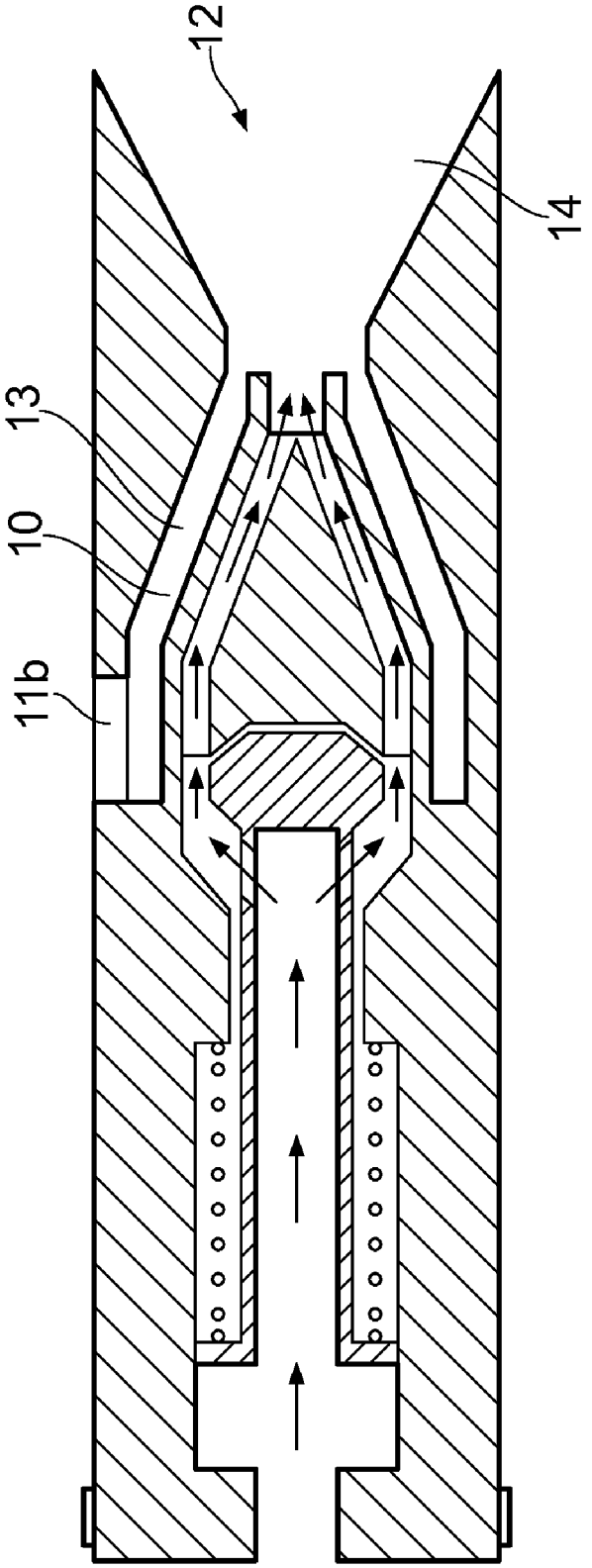


FIG. 3

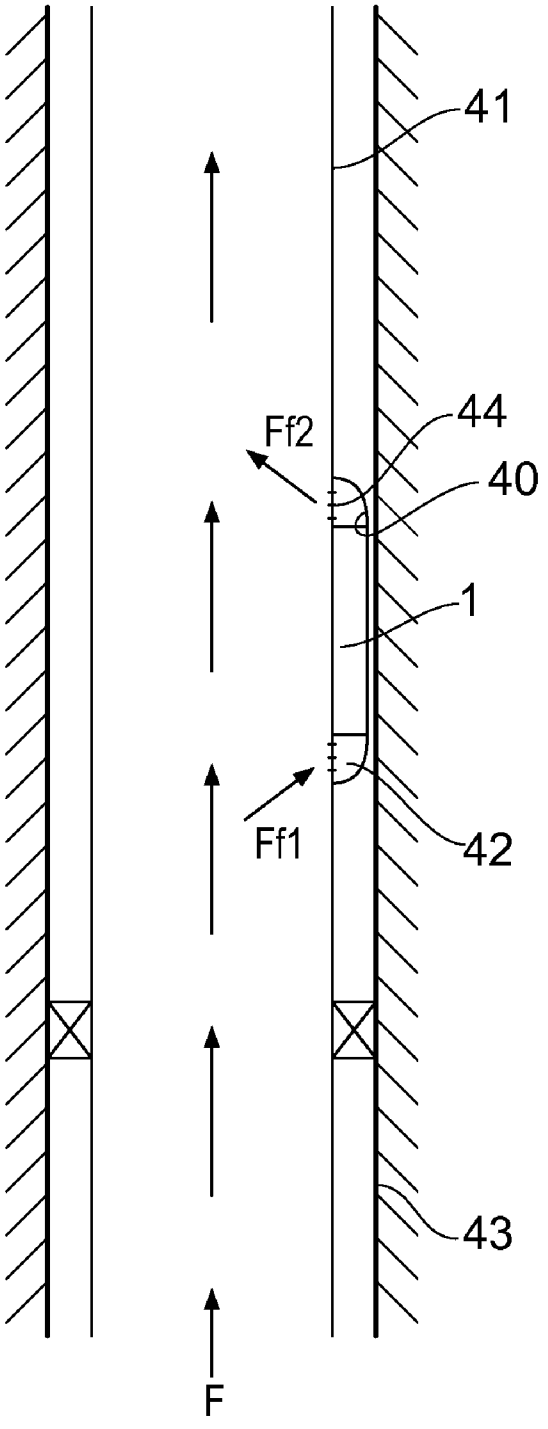


FIG. 4

DEVICE AND METHOD OF ENHANCING PRODUCTION OF HYDROCARBONS

FIELD OF THE INVENTION

[0001] The present invention relates to a device and a method of use in a wellbore for oil and or gas production from a formation, preferably in relation to gas injection as a gas lift valve.

BACKGROUND

[0002] There are some oil wells where the natural flow of hydrocarbons to the surface is not sufficient to permit or maintain commercial production. This may be due, for example, to the hydrocarbons' viscosity and/or weight, or the fact that the pressure in the oil well is too low to counteract the hydrostatic pressure of the fluid in the well together with the counter-pressure exerted on the fluid in the oil well by the processing installations.

[0003] For such oil wells a number of systems and different principles have therefore been developed which can increase the oil well's production by means of so-called artificial lifting. The two most commonly used systems today are water injection and gas injection. With gas injection natural gas under high pressure is injected into the annular space between the casing and the tubing. For this purpose a pressure-controlled valve, a so-called gas lift valve, is usually employed in order to be able to supply and control or check the amount of gas flowing into the actual production tubing. Pressure-controlled valves of this kind can also be used during a well start-up phase, where completion fluid can be found in both the well's annulus and in the tubing. Another similar area of application will be after a well shut-in, where fluid has filled up at least parts of the annulus or where production fluid has lain for some time and gas has migrated to the surface and where the pressure in the well is too low for the well to begin producing without receiving pressure support from gas injection.

[0004] How these pressure-controlled valves are configured and located in the well will depend on a number of parameters. For example, according to the tubing's size (diameter) and the injection pressure available, so-called gas injection points will be provided at one or more points in the tubing, whereby the specific configuration is arranged for an optimal gas injection. The gas lift valve(s) can then be controlled or checked according to several different principles, for example by a pressure, where it is the pressure differential round and/or across the valve which permits a controlled opening or closing of the valve.

[0005] These known gas lift valves will inject gas into the production tubing. One problem associated with such injections is that gas is a relative low density fluid compared with the fluids normally in the production tubing. Thereby only a large amount or a high pressure will give the necessary boost of the fluid in the production tubing. It would be beneficial if one could achieve the lifting effect by the gas lift valves with less amount of, or with a lower pressure in the gas injected into the well.

[0006] The known arrangements and systems will also only release a stream of high pressure gas into the production tubing, without controlling the stream's shape other than breaking the main injection stream into smaller streams and bubbles. Current release of high pressure gas like this may cause that a part of the stream of the high pressure gas may act against the production flow in the production tubing (i.e. the part of the stream will be injected in a downward direction in the production tubing), thereby decreasing the production flow. Hence leading to backflow or even inflow to the reservoir i.e. the injection pressure is working opposite of the natural flow direction.

[0007] WO 92/08037 A1 discloses a recovery method and apparatus for lifting liquid from an underground reservoir to a wellhead via a twin pipe arrangement extending from the reservoir to the wellhead and comprising one pipe arranged within another pipe, in which a first pipe conveys the liquid from the reservoir upwardly to the wellhead and the second pipe serves to convey a gaseous driving pressure medium e.g. hydrocarbon gas to operate the system; in which the first pipe has a specially designed jet pump arranged to receive a supply of the gaseous driving pressure medium from the second pipe which generates a pressure differential across the jet pump and thereby assists the uplifting of the liquid through pipe under reservoir pressure and reduces the hydrostatic load of the upwardly moving column of liquid, and after carrying out this pumping action, the gas is exhausted into the upwardly flowing column of liquid and moves upwardly with it in the manner of a gas lift.

[0008] US 2002/096332 A1 discloses a gas lift valve for use in an oil well producing by means of gas lift, said gas lift valve making use of a central body venturi for both controlling the flow of the injection gas from the annulus between the tubing and the casing of the oil well, and precluding a reverse flow of fluids from said oil well towards said annulus to occur.

SUMMARY OF THE INVENTION

[0009] An object with the present invention is to provide a device and an associated method which provide an alternative to normal gas lift valves, and operation of such, or an enhanced performance of a gas lift valve.

[0010] This object is achieved with a device as indicated in the following independent claim, where further features of the invention will become evident from the dependent claims and the description below.

[0011] The present invention relates to a device and a method of use in a wellbore. More specifically it relates to a device and a method for injection of fluids into a wellbore to enhance the production from the well. The device comprises an outer housing with two internal flow passages with separate inlets and a common outlet. The inlets are preferably arranged in a distance from the outlet, with an elongation of the outer structure extending in a direction from the inlets to the outlet, where the passages extend in a longitudinal direction of the outer structure. The inlets may also in one embodiment arranged at or close to one end of the device and the outlet at or close to the opposite end of the device, but other configurations are possible. The invention describes: A device for enhancing the production of hydrocarbons in a wellbore, comprising; an outer housing with two internal flow passages with separate inlets and a common outlet, a first flow passage fluidly connected to the inlet and in fluid communication with a main production flow from a wellbore, and a second flow passage comprising a pressure operated valve device, and where the second flow passage, downstream of the valve device, is leading to an ejector shaped part of the passages, forming an internal outlet of the second passage ending in the common outlet, where the device and passages are such configured that a fluid in the second passage acts as a driving fluid in the ejector shaped part in relation to the fluid

in the first flow passage, and then out through the common outlet, and where the device is arranged in a side pocket mandrel, and that the device is configured for feeding a fraction of the production flow from the wellbore into the first flow passage, and means for feeding fluid into the second flow passage, through the inlet, and to mix the fraction flow with the fluid from the second flow passage in the device, before the mixed flow is returned to the main production flow.

[0012] According to one embodiment the first passage at the internal outlet of the second passage may be configured additionally such that a suction pressure is created in the fluid in the first passage when fluid in the second passage is flowing through the ejector shaped part and out of the internal outlet of the second passage.

[0013] By having such a device positioned for gas injection in the well, where the second passage is arranged in connection with the injection gas and the inlet of the first passage is arranged in fluid communication with the fluid in the production tubing and the outlet is leading into the production tubing, one may by pressurizing the injection gas, open the valve device in the second passage, and the injection gas will flow into the ejector shaped part and thereby create a suction pressure in the first passage and therefore in the well fluid, which will move well fluids through the first passage and pressurize it and mix it with the injection gas before it is let out into the production tubing, thereby creating a lift for the fluids in the production tubing. The inlet of the first passage in the device may preferably be positioned relatively below the outlet of the device, when the device is positioned in a mainly vertical part of a well. Or if not a vertical part of a well, the inlet of the device connected to a point in the well positioned upstream of a point connected to the common outlet of the device. By doing this, well fluid in the well may also be moved, as part of the well fluid upstream of the outlet drawn into the inlet of the device.

[0014] According to another aspect the first passage downstream of the internal outlet of the second passage may be formed with increasing diameter towards the common outlet of the device. Such a shape will further mix the components and create a larger area for inflow into the production tubing enhancing the effect of the gas injection in the well stream. Some of the velocity in the mixed fluid will also in this part be converted to pressure in the flow as the flow decreases its velocity, thereby creating an increased pressure for introduction into the production tubing.

[0015] According to another aspect the common outlet may comprise one outlet. Alternatively there may be at least one, or several, outlets from the common outlet and out into a production tubing.

[0016] According to another aspect the internal outlet of the second passage may be arranged centrally within the first passage. The fluid in the first passage will in such a configuration mainly encircle the fluid flowing out of the outlet of the second passage at the internal outlet of the second passage. According to one embodiment the second passage in at least a part may be arranged within the first passage. The first passage may in such an embodiment be formed by an annular space arranged around the second passage. Alternatively the first passage may be formed by one or more passages arranged around a centrally positioned second passage, for instance four, six or seven arranged spaced for instance evenly apart around a circumference, alternatively they may be grouped around the circumference. In an alternative embodiment the second passage may encircle the first passage. The configuration of the different passages and internal outlet may vary dependent on the fluids to flow through the device and the production methods of the device.

[0017] According to another aspect there may be several inlets to the first flow passage. This will possibly give an easier inflow of fluids into the first flow passage of the device. There may also be only one inlet to the first flow passage.

[0018] According to another aspect the outer housing may comprise an outer sleeve element and an internal sleeve element, forming an annular space for the first flow passage, and the inner space of the sleeve element forms at least a part of the second flow passage. In one embodiment the pressure operated valve device may comprise a valve seat formed by a surface of the sleeve element and a valve element arranged at least partly within the sleeve element. In one embodiment the valve element may be moveably in the axial direction of the sleeve element. The valve element itself may comprise an internal flow passage forming part of the second flow passage. In such a configuration the flow in the second passage will then in an open state of the valve device flow in through the inlet and through a passage in the internal sleeve and in the inlet of the valve element through the internal passage in the valve element and out to a passage in the internal sleeve element and then through an annular passage between the internal sleeve element and the block element and then out through the internal outlet of the second passage and into the first flow passage. The sleeve elements and sleeve part of valve element will have complementary shapes but they may have a mainly circular cross section, but they may also have another shaped cross section as triangular, rectangular, hexagonal, octagonal or generally multisided, or combinations. They may also have different shapes as long as they are complementary. The annular sections of the first and second passage may have an even cross section around the circumference or an uneven cross section. It might in some embodiments also have a main annular shape, but which is not continued around a circumference, as for instance two halves.

[0019] According to one aspect the fluid within the first fluid passage is a well fluid, and the fluid within the second passage is an injection fluid. The device is configured such that an inlet of the first passage and the common outlet is connectable to the inside of the production tubing, and the inlet of the second passage is connectable to an injection fluid, for instance the annular space in a well, where the annular space is arranged to be pressurized by an injection fluid. According to an embodiment the injection fluid may be a gas and or water. There may be dedicated lines for injection fluids down to an inlet of the second passage.

[0020] The present invention relates thereby to a device for injection of different fluids in a well bore, where the device through its design will increase a production flow in a production tubing. As should be understood, the device may also be used for injection of well stimulation fluids, water injection etc., in order to treat and/or stimulate the well and/or the production flow from the well.

[0021] According to another aspect the invention relates to a method of enhancing production of hydrocarbons from a wellbore by the use of the invented device, where the device is arranged in a side pocket mandrel and in that the method further includes the steps of; allowing a fraction of a main production flow to enter the first flow passage through an inlet and to mix with the fluid from the second flow passage, before returning the mixed flow to the main production flow.

[0022] The device comprises an outer hollow housing. The outer housing may be produced in one single unit, or it can alternatively be composed of several connected parts, such as a main part, a nose and/or an extension part. Inside the outer housing there may be arranged an internal body as a valve element in the second passage, where the internal body/valve element can be moved in a longitudinal direction of the outer housing. The internal movable body comprises at least one inlet and outlet, where the at least one inlet and outlet is connected by an internal bore. The internal bore may extend in the direction of movement of the internal body. In order to close the at least one outlet of the internal body in a closed position of the device, a seal system is provided between the outer hollow housing and the internal body. Furthermore, the device may comprise a latch mechanism and sealing means connected to the side of the outer housing for positioning in a well.

[0023] The movement of the valve element/internal body is operated by pressure differential across the internal body. The pressure differential is created by the device being subjected to a pressure acting on surfaces of the internal body, which surfaces may be exposed to the same or different fluids. These fluids may be well fluids or injection fluids on one side of the internal body and well fluid on the opposite side or combinations of these. In one embodiment of the present invention the pressure differential across the internal body may also be assisted by at least one predetermined pressure balanced elastic element in order to open and close the device.

[0024] Different parts forming the outer housing as nose/extension/sleeves/sleeve parts are connected to each other by appropriate means, for instance by threads, quick release coupling, detention sleeves etc. Furthermore, the different part may also be connected to each other by different means.

[0025] The outer structure may also be provided with one or more slots around its outer periphery along its length such as inlets to the first passage through the device, in order to allow a fluid to be imbibed into the device and/or to allow the fluid to be injected out of the device. The one or more slots may be round, oval or elongated, where the slots are designed in relation to the fluids to be injected, well parameters, pressure etc., and also be formed to direct the flow through the slots.

[0026] According to another aspect the one or more outlets of the internal body and/or outer hollow housing may be longitudinal and distributed over the periphery of the inner body/valve element or outer housing of the device. The distribution may be evenly or unevenly around the periphery of the internal body/valve element and the outer hollow housing. The form of the outlets may be even or odd around the periphery. The outlets may be longitudinal with a main longitudinal direction mainly parallel with a longitudinal axis of the valve element. The outlets may also be longitudinal with a main direction and at an angle relative to the longitudinal axis of the internal body or formed in a spiral or part of a spiral, or formed with another shape.

[0027] According to another aspect the outlets in the internal body and/or outer housing may be made beveled and angled from an internal surface and towards an outer surface of the internal body and/or outer housing in order to obtain stream line flow from the internal bore and to the outside of the device. Their function is to bring forth in the injected fluid the ability to penetrate the production flow in the tubing, thereby gaining a better incorporation of the injected fluid in the flow, in addition to the ejector effect in the device.

[0028] According to another aspect of the invention the valve seat and the valve element sealing surface in an open or partially open position are positioned on opposite sides of an outlet, when seen in a longitudinal direction of the device. The valve element sealing surface is positioned mainly outside the flow of injection fluid through the device, since it in an embodiment is at least partly covered by a part of the outer housing in the form of the internal sleeve of the outer housing. The valve seat is positioned outside the flow of injection fluid through the device, at least partly covered by the valve element/internal body. This gives that the outlets of the second passage are positioned between the valve seat in the internal sleeve and the valve element sealing surface.

[0029] According to another aspect of the invention the valve element may comprise a pressure surface exposed to the fluid in the first passage of the device, biasing the device towards a closed position.

[0030] According to another aspect of the invention the elastic element may comprise a spring element enclosed in a chamber, which chamber is filled with a fluid separate from the fluids both in the first and second passage of the device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] The present invention will now be explained with a non-limiting embodiment with reference to the enclosed figures, where;

[0032] FIG. **1** shows a cross section of a first embodiment of the invention.

[0033] FIG. **2** shows the embodiment in FIG. **1** in a closed state,

[0034] FIG. **3** shows a second embodiment,

[0035] FIG. **4** is a schematic drawing of the invention arranged in a side pocket mandrel in a wellbore.

DETAILED DESCRIPTION OF THE INVENTION

[0036] In FIGS. **1** and **2** there is shown a first embodiment where a valve device **30** in a second passage **20** of the device is shown in an open position (FIG. **1**) and a closed position (FIG. **2**).

[0037] The device comprises an outer housing **1** where through there is arranged two flow passages **10**,**20**. The first flow passage **10** extends from an inlet **11** in the wall of the outer housing **1** and along the housing **1** to an outlet **12** at an end of the housing **1**. The second flow passage **20** extends from an inlet **21** at an end of the housing **1** which is opposite to the outlet **12**, to an internal outlet **22**, positioned within the housing **1** and which leads into the first flow passage **10**. This gives that the outlet **12** is a common outlet from the device for the two passages **10**,**20**. The outer housing **1** comprises an outer sleeve element **2** and within this an internal sleeve element **3** and within this sleeve element **3** an internal block element **4**, all forming parts of the outer housing **1** and fixed relative each other. The different elements forming the outer housing **1** may also be formed as one unit or of several parts.

[0038] There is between the outer sleeve element **2** and the inner sleeve element **3** formed an annular passage, forming part of the first flow passage **10**. There is also between the inner sleeve element **3** and the inner block element **4** formed an annular space forming part of the second flow passage **20**. There is within the inner sleeve element **3** also arranged a valve element **31**, formed with a mainly sleeve shaped part and an end part. The valve element **31** is formed with an internal passage **32**, forming part of the second flow passage

20, which has an inlet **33** at one end of the valve element and outlets **34** leading from this internal passage **31** and out to the internal space of the inner sleeve element **31** and the annular passage between the inner sleeve element **3** and the block element **4**. The second flow passage **20** will therefore from the inlet **21** first be formed by the inner space of the inner sleeve **3** thereby through the inlet **33** and the internal passage **32** of the valve element **31** and out from this through outlets **34** and to the inner space of the inner sleeve **3** again and into the annular space between the inner sleeve **3** and the block element **4** and to the inner outlet **22**.

[0039] The valve element **31** is arranged movable in the flow direction of the internal passage **32** of the valve element **31**, relative the inner sleeve **3** and thereby the outer housing **1**. There is arranged an elastic element **36** between the valve element **31** and the inner sleeve **3**, biasing the valve element **31** to one position. The internal passage **32** is formed by a cylindrical shaped part of the valve element **31**, which is open in one end forming the inlet **33** and closed in the opposite end, close to the outlets **34**. The outlets **34** lead through the wall of the cylindrical shaped part. The closed end of the internal passage **32** forms a pressure surface for pressure operating the valve element **31**. The closed end is formed by an end part of the valve element **31**. On the outside of the end part there is formed a sealing surface **35**. This sealing surface **35** is in a closed state of the device, as shown in FIG. **2**, in interaction with a valve seat **23** formed by a surface of the inner sleeve **3**. The valve element **31** is then moved axially relative the outer housing **1**. In a closed state the end part of the valve element **31**, has an outer pressure surface **37** exposed to the fluid in the first flow passage **10** in a closed state of the valve device **30**. Part of this outer pressure surface **37** will interact with a stop surface **5** of the block element **4** in an open state of the valve device, thereby keeping the valve element **31** still.

[0040] The annular space between the inner sleeve **3** and the block element **4** is formed as a tapered flow passage part **25**, which by its form increases the velocity of the fluid flowing through the second flow passage and out through the inner outlet **22**. The first flow passage **10** is from the inlet **11** formed with a first cylindrical shaped annular space between the inner sleeve **3** and the outer sleeve **2**, followed by a tapered flow passage part **13** between the same sleeves until the internal outlet **22** of the second passage. This gives an ejector shaped part **1***a* of the outer housing in addition to the shape of the elements forming the second flow passage which gives an ejector functionality of the device around the inner outlet **22**. This will give that the fluid within the second flow passage will act as a driving fluid and create a suction pressure in the first flow passage **10**, thereby draw fluid in through the first inlet **11** and into the first flow passage **10**, and out through the common outlet **12**.

[0041] In the shown embodiment the first flow passage **10** is downstream of the inner outlet **22** formed with a part **14** with an increasing diameter of the flow passage, as a truncated cone, towards the common outlet **12**. The larger diameter of the truncated cone is at the outlet **12**. This will reduce the velocity of the mixed fluid and thereby increase the pressure of the mixed fluid before it exits the device through the common outlet **12**.

[0042] In FIG. **3** there is shown a second embodiment with several similar features to the first embodiments, and only the differences will be explained. The first flow passage **10** has in this embodiment an inlet **11***b*, closer to the outlet **12** compared to the embodiment shown in FIG. **1** and FIG. **2**. The inlet **11***b*, leads more or less directly into a tapered flow passage part **13** upstream of the internal outlet **22** of the second flow passage **20**.

[0043] FIG. **4** shows a schematic view of the valve according to the invention arranged in a side pocket mandrel **40** in a wellbore **43**, on the outside of the main production tubing **41**, and in fluid communication with the production fluid F in the main tubing **41**. At least a fraction F_{f1} of the production flow F enter the valve (**1**) through the at least one inlet **42** and mixes with gas in the valve such as to reduce the weight of the at least one fraction of the production flow, before the mixed production flow F_{f2} returns to the main production flow through the at least one outlet **44**, and mixes with the undisturbed, remaining fraction of the main production flow. By doing this, the overall weight of the production flow is reduced due to the gas mixed in the flow, and the transportation of the production fluids to the surface becomes easier.

[0044] The amount of production flow entering the gas lift valve is dependent on several parameters including; the capacity of the topside compressor, the amount of injection gas, the temperature, and the depth of the side pocket mandrel. The operator calculates the optimum size of the orifice installed in the valve dependent on the desired production rate. Said given parameters and the operator, decide the amount of production flow entering the valve as well as the amount of gas injected in the valve.

[0045] The invention has now been explained with reference to two different embodiments. A skilled person will understand that there may be made alterations and modifications to these embodiments that are within the scope of the invention as defined in the following claims. In another embodiment the embodiment of FIG. **1** may in addition to the inlet **11** also have the inlet **11***b* arranged in relation to the first flow passage. Instead of a valve device as explained in relation to the first embodiment one may instead for instance have a ball valve arranged within the inner sleeve. There is also the possibility of arranging the first flow passage within the second flow passage.

1-12. (canceled)

13. A device for enhancing the production of hydrocarbons in a wellbore, comprising; an outer housing (**1**) comprising a first internal flow passage (**10**) and a second internal flow passage (**20**), wherein the two internal flow passages (**10**, **20**) comprise separate inlets (**11**,**21**) and a common outlet (**12**), wherein the first flow passage (**10**) is fluidly connected to the inlet (**11**) of the first flow passage (**10**) and in fluid communication with a main production flow from a wellbore, wherein the device comprises means for feeding fluid into the second flow passage (**20**) through the inlet (**21**) of the second flow passage (**20**), and wherein the second flow passage (**20**) is leading to an ejector shaped part (**1***a*) of the flow passages (**10**, **20**), forming an internal outlet (**22**) of the second flow passage (**20**) ending in the common outlet (**12**), where the device and flow passages (**10**,**20**) are such configured that a fluid in the second flow passage (**20**) acts as a driving fluid in the ejector shaped part (**1***a*) in relation to the fluid in the first flow passage (**10**), and then out through the common outlet (**12**), characterized in that the device is arranged in a side pocket mandrel and is configured for feeding a fraction of the production flow from the wellbore into the first flow passage (**10**), and to mix the fraction of the production flow with the fluid from the second flow passage (**20**) in the device, before the mixed flow is returned to the main production flow, wherein the second flow passage (**20**) comprises a pressure

operated valve device (**30**), downstream of which valve device (**30**) the second flow passage (**20**) leads to the ejector shaped part (**1***a*) of the flow passages (**10**, **20**).

14. Device according to claim **13**, wherein the first passage (**10**) at the internal outlet (**22**) of the second passage (**20**) is configured such that a suction pressure is created in the fluid in the first flow passage (**10**) when fluid in the second flow passage (**20**) is flowing through the ejector shaped part (**1***a*) and out of the internal outlet (**22**) of the second flow passage (**20**).

15. Device according to claim **13** or **14**, wherein the first flow passage (**10**), downstream of the internal outlet (**22**) of the second flow passage (**20**), is formed with increasing diameter towards the common outlet (**12**) of the device.

16. Device according to claim **15**, wherein the common outlet (**12**) comprises at least one or several outlets.

17. Device according to claim **16**, wherein the internal outlet (**22**) of the second flow passage (**20**) is arranged centrally within the first flow passage (**10**).

18. Device according to claim **17**, wherein the second flow passage (**20**) in at least a part is arranged within the first flow passage (**10**).

19. Device according claim **18**, wherein there are several inlets (**11**) to the first flow passage (**10**).

20. Device according to claim **19**, wherein the outer housing (**1**) comprises an internal sleeve element (**3**), forming an annular space for the first flow passage (**10**), and the inner space of the sleeve element (**3**) forms at least a part of the second flow passage (**20**).

21. Device according to claim **20**, wherein the pressure operated valve device comprises a valve seat (**23**) formed by a surface of the sleeve element (**3**) and a valve element (**31**) is arranged within the sleeve element (**3**) and moveably in the axial direction of the sleeve element (**3**), where the valve element (**31**) comprises an internal flow passage (**32**) forming part of the second flow passage (**20**).

22. Device according to claim **21**, wherein a fluid within the first flow passage (**10**) is a well fluid, and a fluid within the second flow passage (**20**) is an injection fluid.

23. Device according to claim **22**, wherein the injection fluid is a gas and or water.

24. Method of enhancing production of hydrocarbons from a wellbore, characterized in that the method includes the steps of; providing a device according to claim **1**, allowing a fraction of a main production flow to enter a first flow passage (**10**) through an inlet (**11**) and to mix with the fluid from a second flow passage (**20**), before returning the mixed flow to the main production flow.

* * * * *