Hydraulic switch device

The invention relates to a switch device which conducts one fluid stream to two or more independently operated hydraulic units. The invention will, for example, permit surface control with one hydraulic fluid stream of a number of downhole, series-connected, individually controllable admission valves, which are integrated in a production tubing which extends down into the sea bed for use, for example, in zone-isolated, perforated and/or open production areas in an oil/gas well.

With present-day surface control of four independently operated downhole admission valves, for example, the four valves each have to be supplied with their own hydraulic control power through individual high pressure lines. This requires investment in and maintenance of expensive lines, which also have to be pulled in and coiled up on deck every time the production tubing is raised. The requirements for adequate throughway between the inner fluid-conducting pipe and the outer casing creates difficulties when lowering a plurality of such lines.

It is known that the pressure varies in the different production zones. This may be reflected in reduced production, where, for example, in a lower zone there is extremely high pressure, while the upper zone has lower pressure. The oil will then be able to travel in circular movements between the reservoir zones, with the result that it will not be extracted. The problem is solved by control/adjustment of the influx from the individual zones outside the casing.

It is further known that the different zones contain essentially different quantities of oil, gas and/or condensate, with the result that one or more zones successively produce increasing amounts of water as the zone is emptied. With current technology the oil and water-containing consistency from several zones is produced until the average proportion of mixture is approximately 90% water. At this stage the bore hole has to be closed as no longer profitable according to a cost/benefit evaluation.

If, for example, a well system is planned with six branches to six defined production zones, during the production period heterogeneous mixtures of oil/water will flow from these zones, which have been shown to produce more and more water.

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The invention permits the total flow from the respective zones to be controlled by one hydraulic fluid stream from deck on the surface by activating one or more valves, which close one or more water-producing zones, with the added result that deposits of oil are forced into an adjacent advantageous zone. The zone or zones which produce undesirable amounts of water after prolonged production, and those zones which continue to produce acceptable oil concentrations are periodically registered.

By selectively shutting off the unacceptable water-producing zones in a well with, e.g., six branches, the likelihood of extending and thereby increasing the extraction of oil from a field is substantially improved. In extreme cases the last zone of, e.g., six will produce continuous amounts of oil far beyond the period when the five other zones have had to be closed. Estimates of this carried out by Rogalandsforskning amongst others indicate that the operating period of an oilfield can be extended from 3000 days to more than 5000 days, and with a progressively increasing volume.

If, for example, water injection is employed in surrounding geological formations, it will be possible to push the oil reservoirs towards the production zones in the area around the casing. If this reservoir control is employed together with the present invention, which permits regulated influx control, maximum exploitation will be achieved.

Mineral deposits which are deposited on the inside of the upstream pipe occur particularly when the water mixture in the oil reaches a certain level. The problem is reduced by facilities for controlling the water mixture, and the use of deposit-inhibiting chemical injections is also radically reduced, there being no need for such chemicals during a substantial part of the production phase.

Downhole pressure is typically around 350 bar, with a temperature of around 100°C. Vertical installation depth is usually from 900 to 8000 metres, while the measured extent may be up to 6000 - 16000 metres. The principles can also be used for H_2S and CO_2 environments where the question of material choice becomes crucial for translating the principles into practical implementation.

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A position meter or meters may also be inserted to indicate the degree of opening of the valve(s), thus giving the operator on the surface verification that the desired through-flow area has been achieved.

In order to obtain sequential co-operation of a number of, e.g., admission valves in the same well, an electro-hydraulic control system is currently employed, where an addressable solenoid valve only requires one fluid line from the control unit on the rig floor. The valves thus control the hydraulic power into respective valve chambers.

A method for addressing one hydraulic fluid stream by means of a sequential fluid-switching device to two or more independent or series-connected operated units, e.g. hydraulic admission valves or fluid switches, permits surface control of downhole series-connected, individually steplessly adjustable units, which are integrated in a fluid-producing pipe lowered in zone-isolated perforated and/or open production areas in an oil/gas well, without the use of lowered cables for electronic control.

Fig. 1A illustrates a hollow, cylindrical, e.g. four-fluid-switching device 1, which is mounted in a holding cylinder, which is placed in a production tubing. With power supplied from one hydraulic line 2 to the device's upper circular surface 3, the device 1 is pushed axially down towards a springing device 4 mounted between the switch device 1 and the holder's bottom location 5. Securely mounted on the holding cylinder's inner surface are two inwardly projecting guide lugs 6 spaced at 180° from each other or four at 90° apart. Round the switch device's 1 outer diameter there is cut out a 90° zigzag-shaped, wave-angled guide track 7, with a parking location 9 in each vertex 10, designed for control of the guide lugs 6.

In the lower edge of the holding cylinder there are provided two (or more) channels 8 and 8' spaced at 90° apart, which are open at one end in towards the switch device's 1 outer diameter, and at the other end towards the bottom of the holding cylinder. In the switch device's 1 cylinder wall there are provided four channels (or more) spaced at 90° apart; two of these 11 and 12 are located spaced at 180° apart and with the possibility for fluid to flow through from the top of the device's upper circular surface 3 down to the device's outer diameter immediately below the lower part of the device's guide track 7.

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The other two of these channels 13 and 14 are located spaced at 180° apart and with the possibility for fluid to flow through from the spring housing's fluid volume 15 up to the device's outer diameter immediately below the device's guide track.

In the four-phase operation, for example, when the device is exposed in phase B to a hydraulic downwardly pressing force on its upper circular surface 3, the switch device 1 will be forced by the guide lugs 6, which are engaged with the four-part zigzag-shaped guide tracks 7, to travel from a vertex 10 to an adjacent vertex in a helical movement with its lower circular surface towards the spring device 4 which is gradually stressed. When the measured travel has been completed, the spring device 4 is under stress and the guide lugs 6 have been moved to the parking location 9, while at the same time the switch device has successively completed a 90° turn. On account of this combined travel and rotation there will now be fluid communication between the hydraulic line 2 and the channel 8 via the channel 12. This now-established fluid communication is used, e.g., for controlling hydraulic tools connected to the output of channel 8 in the bottom of the holder's bottom location 5. Furthermore, there will now also be fluid communication between the channel 8' and the fluid volume in the spring housing 15 via the channel 14. This now-established fluid communication is used, e.g., for venting return fluid from hydraulic tools connected to the output of channel 8' in the bottom of the holder's bottom location 5.

The next phase C is activated by relieving the hydraulic control pressure 2. The guide lugs 6 are thereby released from the parking location 9, and the now prestressed spring device 4 forces the switch device 1 up, while in the same way as in the first phase, the guide lugs 6 in engagement with the zigzag-shaped guide track 7 will force the switch device 1 to continue its helical travel in a new 90° to 180° in the same rotational direction. In this phase there will now be the same communication situation as in phase A, but there is no fluid communication between the hydraulic line 2 and the channel 8. Nor is there any fluid communication between the channel 8' and the fluid volume in the spring housing 15.

The third phase D is identical with the first, with the switch device performing a new downwardly helical movement with renewed rotation from 90° to 270°.

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On account of this combined travel and rotation of the switch device 1 there will now be fluid communication between the hydraulic line 2 and the channel 8' via the channel 11. This now-established fluid communication is used, e.g., for controlling hydraulic tools connected to the output of channel 8' in the bottom of the holder's bottom location 5. Furthermore, there will now also be fluid communication between the channel 8 and the fluid volume in the spring housing 15 via the channel 13. This now-established fluid communication is used, e.g., for venting return fluid from hydraulic tools connected to the output of channel 8 in the bottom of the holder's bottom location 5.

The fourth phase (not shown) is identical with the starting position A, with the switch device continuing the upwardly helical travel in a new 90° with rotation to 360°.

Full rotation of the switch device has therefore been implemented by means of pressure supply and pressure relief performed in succession.

Instead of four-part zigzag-shaped guide tracks 7, full rotation of the switch device can be achieved by means of, e.g., three-part or six-part zigzag-shaped tracks, the deciding factor being the requirements and the practical constraints.

Fig. 2 shows that switching of a fluid stream is implemented by permitting the hydraulic line's power to pass a channel system 11, 12, 13 and 14 provided through the switch device 1, corresponding to one of the two fixed channel systems 8 and 8' in the holding cylinder, which systems pass the hydraulic power in sequence of rotation (I-IV) on to one of two different hydraulically operated units, such as admission valves or another fluid switch.

When, for example, an admission valve has been activated, and a shift to the next valve is implemented, at the same time with parallel use of existing channel systems sequentially, it is necessary to bleed the pressure from the first valve, which is carried out by a special filter screw directly into the production stream of oil/gas/condensate and/or water flowing through the hollow switch device.

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Fig. 3 illustrates a developed single-plane drawing of a guide track's 7 angular waved shape; here illustrated with four 90° equally angled and identical waves calculated for four-part rotation of the switch device 1. A guide lug 6 is parked in each of the guide track's outer vertices 10, where a parking recess 9 ensures the guide lug's stability between each switch phase while fluid-switching operations are performed. When a new rotation is initiated by the supply or relief of pressure, the guide lug 6 slides axially and therefore unimpededly out of the parking location 9 and back into the guide track, whose vertices 10 always deviate from the axial centre line to such an extent that the guide lug 6 forces the switch device 1 into one and the same rotational direction. The guide track's 7 angular shape with vertices 10 therefore permits one-way rotating travel, and only a step-by-step travel. If, for example, a switch change is desired from phase two to phase four, switching must be performed via phase three. Nor is it possible to switch back, for example, from phase three to phase two. In this case too switching must be performed from three to four to one to two.

The method also permits, for example, six-phase full rotation, which is achieved with six equiangular waves, each at 60°, or with six different angular waves, such as 90° + 60° + 45° + 60° + 60° + 45°.

The sequence of rotation (I - IV) is adapted to the switch device's 1 channel throughputs 11, 12, 13 and 14 in order to co-ordinate hydraulic power to respective hydraulically operated units.

The existing sequential correspondence between the switch device's individual rotating channels 11, 12, 13 and 14 and the holding cylinder's fixed channel systems 8 and 8' for pressure transfer to various hydraulic tools simultaneously utilises the same channel systems individually for sequential corresponding transfer of the return oil stream for bleeding.

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PATENT CLAIMS

1. A switch device which sequentially conducts one hydraulic fluid stream to two or more independently operated hydraulic units, characterized in that towards the upper circular surface (3) of a cylindrical, hollow switch device (1) in a parking location A, which is mounted in a holding cylinder inserted in a fluid-conducting pipe, power is supplied from one hydraulic line (2), which axially pushes the device (1) down towards a tension-springing device (4) mounted between the device's (1) lower circular surface and the holder's bottom location (5),
that securely mounted on the holding cylinder's inner surface are two inwardly projecting guide lugs (6) spaced at 180° apart or four spaced at 90° apart,
that round the device's (1) outer diameter there is cut out, e.g., a 90° zigzag-shaped wave-angled guide track (7), designed for control of the guide lugs (6),
that in phase B, when the device (1) is exposed to a hydraulic downwardly pressing force, for example in a four-phase operation, it is forced by the guide lugs (6), which are engaged with the four-part zigzag-shaped guide tracks (7) to travel from a vertex (10) to a parking location (9) in an adjacent vertex (10) in a helical movement down towards the spring device (4), which is gradually stressed, while at the same time the device (1) has performed a 90° rotation,
that in phase C, by relieving the hydraulic control pressure (2) the guide lugs (6) are released from the parking location (9) in each vertex (10), and the prestressed spring device (4) forces the device (1) up, while in the same way as in the first phase, the guide lugs (6) in engagement with the zigzag-shaped guide track (7) will force the device (1) to continue its helical travel in a new 90° to 180°,
that in phase D, identical with the first, the device (1) completes a new downwardly helical movement, with renewed rotation from 90° to 270°, and that the last phase (not shown) is identical with the second phase, with the device (1) continuing the upwardly helical travel in a new 90° with rotation to 360°, to come to rest in parking location A.

2. A switch device according to claim 1,
characterized in that a six-phase full rotation is achieved with six equiangular

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waves, each at 60°, or with six different angular waves, such as 90° + 60° + 45° + 60° + 60° + 45°.

3. A switch device according to claims 1-2, characterized in that hydraulic flow change is achieved by a channel system (11, 12, 13 and 14) provided through the device (1), which system, when the device is parked in one of the, for example, four fixed positions (9), corresponds to one of fixed transfer channels (8, 8') in the holding cylinder, which in the sequence of rotation (I - IV) transfers the hydraulic power to one of various hydraulically operated units, e.g. admission valves or series-connected fluid switches, and the switch device's (1) forced sequence of rotation (I - IV) is adapted to the device's (1) channels (11, 12, 13 and 14) and the transfer channels (8 and 8') which are arranged radially fixedly around.

4. A switch device according to claims 1-3, characterized in that the guide lug (6) unimpededly leaves the parking location (9) since the guide track's (7) vertices (10) always deviate from the axial centre line to such an extent that the guide lug (6) forces the switch device (1) in one and the same rotational direction.

5. A switch device according to claims 1-4, characterized in that the existing sequential correspondence between the switch device's (1) individual rotating channel throughputs (11, 12, 13 and 14) and the surrounding fixed channel systems (8 and 8') for pressure transfer to various hydraulic tools simultaneously utilises the same channel systems (8, 8', 11, 12, 13 and 14) individually for sequential corresponding transfer of the return oil stream for bleeding.

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